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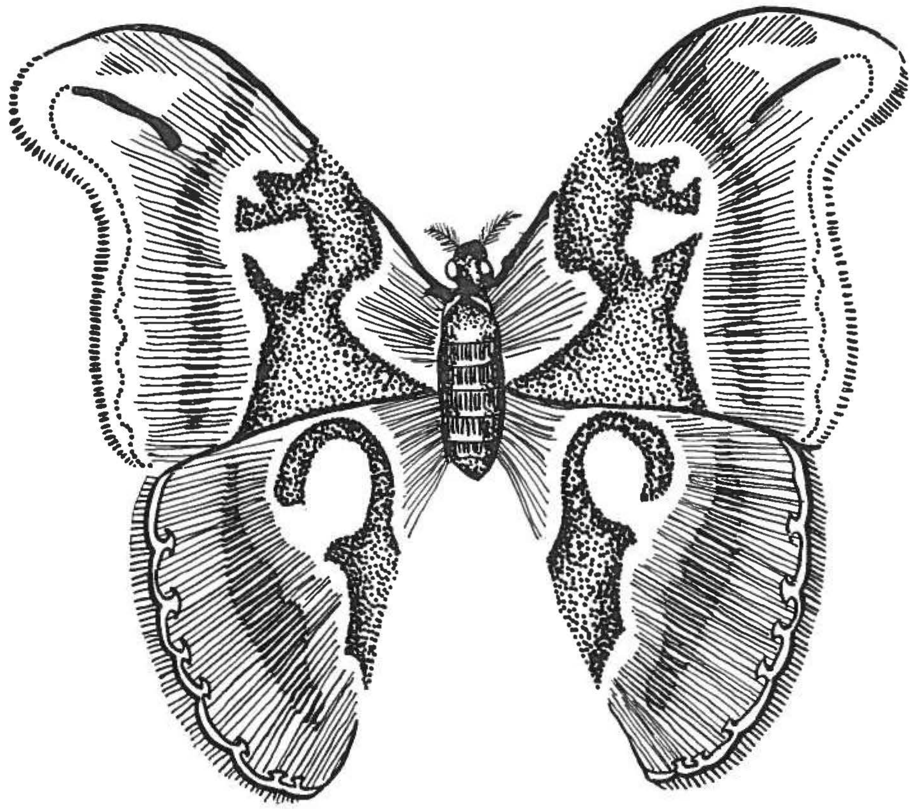

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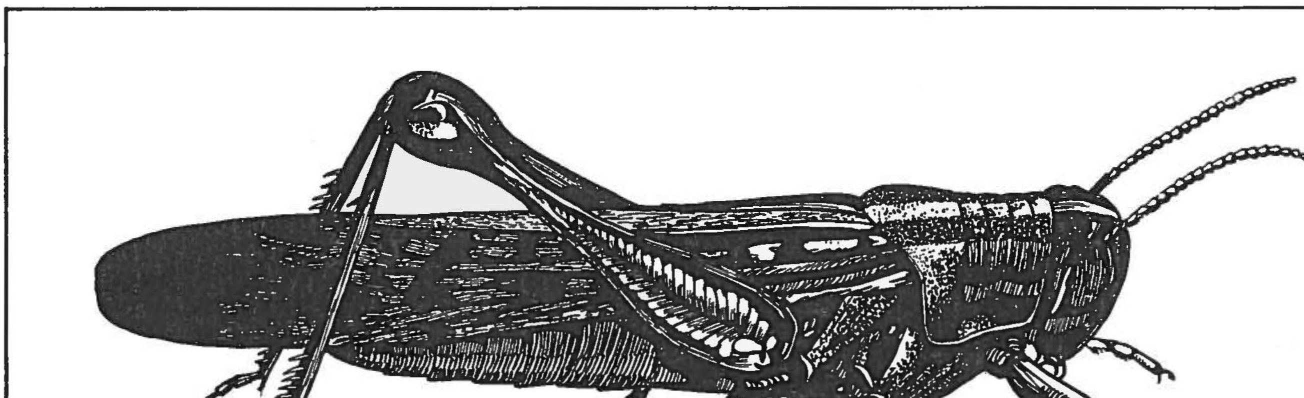

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VOLUME 3

1969

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THE MANITOBA ENTOMOLOGIST

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THE MANITOBA ENTOMOLOGIST

An official publication of the Entomological Society of Manitoba, an organization to foster the advancement, exchange and dissemination of entomological knowledge

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THE MANITOBA ENTOMOLOGIST

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AN INTEGRATED APPROACH TO ENVIRONMENTAL MANAGEMENT

A Symposium Presented to the Entomological Society of Manitoba

on the Occasion of Their Twenty-Fourth Annual Meeting,

November 7-8, 1968

INTRODUCTION

By C. H. Buckner, Moderator
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For the first time in the 24-year history of The Entomological Society of Manitoba, you have elected to entrust a non-entomologist as your editor. From the very outset, when I was first approached to assume this position, it was a mystery to me why you should consider a mammalogist for this important post. It was with some reservations that I accepted this challenge, and had it not been for my many entomologist friends who assisted me in my initial months as Editor, your publication would surely have foundered. Having found myself in this peculiar role, I searched for a means that I might best contribute to the welfare and advancement of our Society. My first term as Editor was completely preoccupied with the mechanics of publishing Volume 1 of The Manitoba Entomologist, and this was my first contribution of consequence to our organization. The second is surely this symposium, for I have taken the major responsibility for its execution, from conception to the version you now have before you.

I suppose that it is inevitable that I should take a major role in organizing a discussion of a topic principally beyond the confines of the entomological discipline. The history of my professional career has ostensibly been one of the outsider looking in, first as a lone mammalogist in a group that was entomology oriented, and more recently as a member of a minority group of biologists within a larger group with foresters predominating. Looking, as it were, from the outside in, my most striking observation has been the relatively provincial attitude of our associates. Allegiances have been mainly discipline oriented, and so it is no accident that I have played an organizing role in the following dissertation that will carry us largely beyond the confines of entomology. Of the distinguished authors that follow, it is of interest to note that all but three have major competence beyond the entomology discipline. I would also like to point with pride to the fact that all the participants of this symposium, including both oral and written contributions, were drawn from our own province. There are many observations to heed and lessons to be learned from our associates in other disciplines. Several of our contributors are competent, not only in research, but also in research management, and their views are both pertinent and welcome. I regret that several of the speakers were unable to submit printed copy: however I welcome the written contribution that was not presented at our meeting.

So many of our biological problems today require a multiplicity in approach. It is in many cases no longer a convenience to work beside scientists of other disciplines; it is often a necessity to integrate our researches with them. Science has become big business, and unless we can integrate ourselves into its system we will likely be by-passed in favour of those willing to do so. There is indeed a place in modern science for the individual researcher, but in general his place is rapidly being taken by integrated research teams. Many of our contributors have had a very intimate knowledge of the organization involved in forming successful research teams, and as entomologists we would be well advised to attend the observations and understandings of those who have demonstrated success in their approaches to integrated research. In this way we are less likely to become frustrated through lack of understanding of research management and financial budgeting problems involved in team research. It is hoped that through examining the following contributions, our niches might be more clearly revealed.

Today we stand at the portals of space. Our physicist associates have demonstrated the advantages and results of an integrated approach to its conquest. We, as biologists, have lagged in the advancement of the frontiers of our respective disciplines. We argue that the complexities are too great to overcome by conventional methods, that each system, component, and organism is unique, and that the snail's pace advances of our sister sciences shackle us. Most of our contributors have faced these problems at the integration level, and the success of the flow of our discipline is inextricably related to the solutions posed by these authors. The role that the entomologist will play in the future is not likely to bear much relation to his role in the past, and his place may well be marked in the following contributions.

INTEGRATED RESOURCE MANAGEMENT A NECESSITY NOT A LUXURY

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ABSTRACT

In the present era of advanced technology and rapid population growth, with its heavy demands on resources and high potential for rapid degradation of the environment, an integrated approach to resource management is imperative. In the past the single-minded approach to resource management has resulted in numerous failures and serious consequences of which several examples are described.

Some problems in resources development and utilization in Manitoba are outlined and the difficulties encountered in evaluating demands in cost-benefit analyses are emphasized.

A resume is given of the recent reorganization within the Manitoba Department of Mines and Natural Resources undertaken to meet the demands of a multi-disciplinary approach to management of natural resources. The traditional division according to resource sectors has given way to a functional organization of three divisions: (1) research, planning and programming (2) field operations and (3) mines and departmental services. The activities, responsibilities and interrelationships of these divisions are outlined.

Finally the role of long-term planning and the need for flexibility in such planning is discussed.

Multiple use is a phrase coined a good many years back now, and there can be little doubt that it was first used to describe the ecological approach to resource management. As a concept it has contributed mightily to progress in the resources field. However, as it achieved some popularity and acceptance it was also seized upon by some not so concerned with proper resource use as with making further inroads into our pool of natural resources for their own specific interests. The concept was twisted in some cases to read all types of resource utilization on every piece of land. We have now, hopefully, seen our way through that hazard, and with the growth in the art and science of ecology have come to a better understanding of resource management – I have chosen to use the phrase "integrated resource management". It is to be hoped that this is so, for time is not on our side today in the wise use of our natural resources for an ever burgeoning world human population.

There is nothing new in sounding the alarm over use of natural resources. Historically there have always been those who saw the threats imposed by profligacy in resource use. Here on the North American continent we look back to the concerns of the day of Theodore Roosevelt with grateful hearts and trace the growth of conservation – that great concept but sadly misused term – that has given us today a heritage of potential power in both the private and the public sectors unparalleled in history outside of religion or ideologies such as communism. Why then the present day concern? Because despite all those scientific and technological advances that have seemed to make mockery of earlier warnings, despite all that has been accomplished in conservation, the margin for allowable error is today less than ever before – viewed in the total world context. The costs of failure are far greater.

Dr. Ian McTaggert Cowan expressed it well in an address in 1966 when he said:

> "Since the dawn of civilization we have been engaged in a relentless drive to alter the environment to suit our purpose. Although the real battle has moved now to other frontiers we still talk in terms of conquest. We still haven't become mature enough as a people to think of ourselves as only a tiny part of a vast and incredible universe, a part of nature not an adversary. The challenge now is not so much to master nature but ourselves.
>
> "A further hazard of the times, a novelty of incalculable importance that was born of our struggle to alter nature, is our new found capacity to implement decisions with unprecedented rapidity. In one 24-hour period man-made machines can remove acres of forest, pollute millions of gallons of water or the air of half a continent, spray several townships with poisonous materials and shift thousands of people."

Because man's ability to alter his environment is so great administrators bear a grievous responsibility. There is little time for correction of error and no place for ". . . off-the-cuff, irresponsible decision by the partly informed". It can equally be stated there is no room for the internecine struggles that are from time to time found within and between resource departments – and it might be added universities and specialists generally. The pressures of world populations and the growth in demand, particularly in the more developed countries, for more of everything including items of calculated obsolescence, make any complacency, inefficiency or inter-disciplinary empire-building within the natural resources use context a matter of concern.

Lest it be thought this is overstating the case let me point out just a few examples of the human factor in this resource equation. A prominent expert in the field of management, who spoke recently in Winnipeg, (Sayles, 1968) suggested that the speed of technology is such as to encourage us that we can meet the challenges confronting us but -- the real problem lies in the difficulty in bringing about internal change in those agencies charged with applying technology. Experts, he said, feel they should not be responsive to outsiders because of their expertise. But if one believes in ecology how can one divorce any speciality from the environment. Some experts, so he said, still feel their field is the important one, that we cannot afford the luxury of multi-use. Curiously, many organizations are increasingly using contractors or consultants to do multi-purpose studies while their internal boundaries are becoming ever more distinct and fixed. Dr. O. M. Solandt stated (1966) that the ecologist has always, often without explicitly stating it, been a "systems thinker".

Political scientist Caldwell (1963) sees in ecology an integrating force of the highest value in formulation of public policy. Is it asking too much today that all those who have had the benefit of special training and experience in the various disciplines should lead the way in the ecological approach to management? Surely not.

Every one of you will be familiar with at least some of the rather classical examples of single minded approach to resource management that have resulted in failure -- and in some instances serious consequences. It may do no harm to repeat some of them here. I am here indebted to Dr. Stanley A. Cain by drawing upon his address given to the Latin American Conference on Conservation of Renewable Natural Resources this year. I quote from his paper.

> "Around the turn of the century in the United States after we had pretty well cut over Eastern and Great Lakes timber, and inroads were being made in the Gulf States and the West, there was a surge of afforestation programs in fear that we would run out of timber. Many of these plantations were complete failures because of the use of ill-adapted species or strains from climates quite different from the new plantings. Even as we developed more sense about this, it took a few more decades to realize that most conifers grow better with intermingled plantings of broadleaf species because of their effect in maintaining mineral balance and structure in the soil.
>
> "In the early post-war years Britain undertook an extensive groundnut program in East Africa and lost some millions of pounds because the interrelations of savanna vegetation, savanna climate, and savanna soils were not understood. The planners with a proper feeling for the nutritional need for more oil and protein among native peoples had ground prepared, peanuts planted, and hearts broken when the dry season soils became like concrete.
>
> "Again in the early post war years UNESCO started a Hylean Amazonian program that was to develop a new breadbasket for the world's hungry people. There were international political troubles, but a central cause of failure was an inadequate understanding of tropical rain forest ecology, including lateritic soils. Something similar happened to Ford's rubber plantations and other efforts at monoculture in an area of the world's most complex natural vegetation.
>
> "Much of the devastation and deterioration of soils in East Africa is due to dependence on cattle. Dr. Fraser Darling and others have pointed out that more useful animal flesh suitable for human consumption is laid down on the several species of native ungulates, and this is done without loss of range productivity. Something similar can be done about much of our treatment of the arid and semi-arid Western United States where over-grazing by cattle and sheep has seriously depleted range productivity. We, too, have participated, even continue to do so, in what has been called the Saharaization of the land.
>
> "A pesticide program in Nova Scotia was embarked upon to control spruce budworm. The budworm was inadequately controlled, other insects had damaging exploded populations, valuable insect-eating birds were killed, and salmon almost disappeared from the streams.
>
> "In Pakistan, in the U.S. Southwest, and many other arid and semi-arid places faulty irrigation practices have ruined the soil for crop production by accumulation of salts at the surface and the development of shallow hard pans.
>
> "In parts of South Florida the combination of over-drainage and over-draft of aquifers for irrigated agriculture has destroyed the productivity of the soil, in some cases in a few years' time."

In a recent issue of Newsweek (July 22, 1968 P. 84) there was an article entitled "Nature out of Balance" in which was cited a situation paralleling the well-known bees, mice, cats, old maids relationship. Health officials in Borneo launched a campaign to kill the flies in rural villages. D.D.T. did the job for them. However, the lizards eating poisoned flies accumulated heavy dosages of the D.D.T. and the cats eating the lizards died. Rats previously killed by the cats proliferated and now threaten plague – a classical example of the one problem-one solution approach going astray. As an aside, the same article told of a University of Washington program where a mathematical model has been developed respecting whales, and covering every known facet of their existence, etc. They have been able to predict the annual catch within 1% – thus demonstrating how very important can be the various factors in their environment.

We can all think of many more examples, some rather close to home. The successes of monoculture have led us into many traps, wherein we have found a continuing cost in time, effort, dollars and possible degradation of environment as the price of high production and high standard of living. It is important however to point out that "... It is not reasonable to criticize past actions on a basis of present knowledge, although we may have ample cause to regret them because it is so costly to correct our mistakes." (Cain, 1968) But as Cain goes on to say "... Today it is unreasonable not to manage our land resources so as to avoid destructive soil erosion, our water resources so as to curb destructive flooding, our forests and grasslands so as to maintain their natural productivity, and our fish and wildlife so that they will continue to supply us and give us pleasure. The knowledge that permits sound management of natural resources stems from all of the natural sciences: botany and zoology with their many subdivisions such as physiology, nutrition, genetics, and pathology, chemistry and physics, especially as they bridge the life sciences through biochemistry and biophysics, geology, soils, climatology and meteorology, as related to living natural resources.

> "Indispensable as they are, these separate scientific disciplines cannot yield an ultimate understanding of nature because they are essentially analytical and too compartmentalized. They must be made to work together. They must be interrelated as their objects of study are in nature. What is being appreciated gradually is that ecology is the science capable of synthesis because its attention is not directed at things, processes, and conditions as though they existed in isolation but at the interrelations among them."

The point that bears repeating here is that we can no longer afford the luxury of the single discipline approach -- if ever we could. Nor can we excuse the one problem-one solution approach, because we know better and we have the expertise to do better. It remains then that we must re-think some of our old ideas and approaches, we must restructure our work forces and we must innovate and keep on innovating, because the pressures are so great and change comes at us at such a pace.

It is in the light of this that I wish to speak briefly to you about what we are attempting in the Department of Mines and Natural Resources here in Manitoba. Before doing so however, let us look at just a few of the actual, practical problems that we face. The test for many is "what is the relevance of all this to us, here in Manitoba, today".

In southwest Manitoba we have a marsh, one of the finest in the Province. The Crown owns a quite large acreage, but some of the area is privately owned. It should, in the view of many, be maintained as a duck and muskrat area, but it involves other interests. Farmers on one side wish the area drained, to prevent flooding of their lands -- and probably to make more land available for agriculture. Farmers on another side wish the water levels to be maintained high, since their hay lands are high and need a high water table. There is recreation potential in the area, including possibly sport fishing, there is trapping, there is or could be hunting, either directly or indirectly. Water resource people alone trying to develop a benefit cost report, will find it easier to derive figures for agricultural benefit than for such intangibles as water tables and outdoor recreation (including hunting). We have the analytical skills, by and large, to do the job but we must as Dr. Cain says, bring to bear the ecological approach in order to synthesize, to deal not just with ". . . things, processes and conditions as though they existed in isolation" but rather as parts of a whole.

We have looked at a marsh. Let us now consider the Interlake area, where there is the FRED program. On the natural resource side alone there is land that should be drained and land that should be flooded or maintained flooded. There is wild land that should be turned to agriculture and agricultural land that should be turned to wildlife -- and land upon which cattle and wildlife compete. There is or may be wildlife depredation arising from juxtaposition of wildlife and agricultural lands. Recreational land use is important, so close to Winnipeg with half the province's population. There are fishery needs and forestry needs. And above all, this whole project is for people, with their needs for income, transportation, education, recreation and so on. Patently, this project cannot be carried to successful conclusion through analytical techniques alone within narrow disciplinary lines.

Finally, just a brief mention of yet another kind of real situation faced by a natural resource department. Here we have an Indian-Metis settlement, in an area of limited resource potential. Already the human population is such that a good living for all is difficult if not impossible. Yet one is faced with inadequate or uneconomic harvesting of the available resources due to low educational level, inadequate skills training, inadequate capital, and cultural and social factors -- to name just the major factors. There is an understandable reluctance, even fear, on the part of these people to move -- to gain acceptance outside they must be even more capable than the norm of those with whom they must compete yet they have not the requisite skills. Not a resource problem some may say. I say it is a resource problem, to the solution of which must be harnessed all our expertise, and working with others in education, health, housing and the social sciences, etc. This is the new look, the new dimension in integrated resource management.

We have just undergone a reorganization within the Department of Mines and Natural Resources, in an effort to meet this challenge. For whatever value it may be to others I give you a brief resume of it here. No claim is made for perfection, we have much yet to do to achieve our goal of true integration and long-term planning. One may however be supported by the thought expressed by Dr. Benjamin Spock in Weekend Magazine (February 17, 1968 P. 21); "... This shows you shouldn't try to build a perfect world because if you succeed, the next generation would be quite bored with it. In 20 years their idea would be something quite different. So all you need to worry about is getting rid of the worst imperfections and the worst injustices". Dr. Spock is not a resource manager. But we can apply his thinking to agree that we are not working or planning toward the definitive solution of all resource management problems; we are rather working toward rational and optimal programs that will tend to maximize opportunities for a good life for our citizens today while maintaining adequate resource capital for whatever the future may bring to those who follow us.

We have, in the Department, moved from the traditional organizational pattern of several resource sectors (usually Branches) dealing with their particular problems (often in isolation) right to the field level -- to implementation. Now we have a functional organization, with research, planning and programming in one division, field operations in another division, and mines and departmental services in a third division. Now the function is more important than the discipline or resource specialty. As earlier stated, we are still flexible and learning.

Starting with departmental services, the purpose of the group seems fairly obvious. We have Management Services (including administration, finances and personnel), Surveys and

Manitoba Government Air Service. What is not so obvious is that an attempt is being made to move all those administrative, clerical and regulatory functions not immediately essential to the day-to-day work of other parts of the Department to this Division. Particularly this is so with respect to Research, Planning and Programming Division. Experience indicates that in most agencies too large a proportion of the time of highly trained experts is taken up with routine work. Where faced with both operational routine and planning the operational matter (which could become a crisis) will take priority. The effort here then is to remove both the requirement and the temptation.

(It should be reported here that the Mines portion of the Department's activities is here included to form a Mines and Departmental Services Division. This is for organizational convenience and to maintain a Mines identity. However, by techniques that will become apparent later, all the facets of the "minerals" activities are closely integrated with the research, planning and programming functions.)

The Field Operations Division directs the field staffs and operations. Having had their say in determining needs and priorities for action, and in the practicality of the plans and programs developed, it is their role to get on with the job. The success or failure of the Department, in the short term, depends on their ability to get things done and to present a valuable "image" to the public. Much of the ability to foresee and to forecast comes from face to face contact. Here then, from the field operation force, who deal with people, must come a vital input for research, planning and programming.

It is in the Research, Planning and Programming Division that the greatest changes are taking form, toward truly integrated resource management. So far, old boundaries have been somewhat maintained -- for recruiting, for convenience, and because we are charting new waters. So we have Conservation Education (likely to become Resources Extension), Land Use Planning, Fisheries, Forestry, Wildlife and Project Planning and Economics in this Division. However, superimposed now upon those functions which remain (or seem to) peculiar to each sector is the task of thinking total resources, not just a single resource (or even discipline). We visualize a home base type of operation, whereby each individual will have a home base in his particular sector but may at any point in time be part of a project team (the leader if his interest seems paramount) which could include others from not only his own Division but other Divisions as well (perhaps a field staff member and/or someone from Mines). Teams will form, break up, and reform as circumstances may dictate, and the position descriptions of individuals will be in terms of objectives rather than the time-honoured but stereotyped form we all know so well.

It may be worth recording why Conservation Education has been included with the research, planning and programming function. It is our firm conviction that many programs that fail do so not so much for lack of technical input as failure to enlist public support. As C. P. Snow has stated (1960): "To get anything done in any highly articulated organisation, you have got to carry people at all sorts of levels. It is their decisions, their acquiescence or enthusiasm (above all, the absence of their passive resistence) which are going to decide whether a strategy goes through in time." We believe then that conservation information and education must make an input right from earliest planning through programming, and not be asked to carry off a program at the eleventh hour when adverse public reaction is already evident.

Just recently Water Control and Conservation Branch has been a welcome addition to the Department. Natural Resources management is not very meaningful without water; the addition of water experts of all kinds to the resource team will prove most valuable. It is too early to say just how integration will take place, but the same approach of total resource planning and programming will be followed.

One would be naive to suggest that such major changes will be made and this new organization established without mistakes and problems. However, organization is the base upon which one builds change, and any organization that becomes fixed is already in danger of decay. The new look described is surely an evolutionary thing, setting the stage for further progress. Thomas Jefferson once said that "Error of opinion may be tolerated where reason is left free to combat it." With the good will and free reason of top quality staff all reasonable things are possible, and I do not foresee any insuperable obstacle to continuing refinement of the integrated approach to resource management.

As a postscript I might just add a word or two about long-term planning. It has been taken as read that such is a necessity, that integrated resource management is on such a base. Dean Rusk was quoted in Time as saying "The pace of events is so fast that unless we can find some way to keep our sights on tomorrow we cannot expect to be in touch with today". This is particularly true in the resource field, where the elements are so complex and today's decisions can seriously affect not only the lives of citizens today but the resource base of those 50-100 years hence. It is of course fallacy to believe that even 5-10 year plans can be followed slavishly -- one cannot foretell exactly what will happen and to be rigid in planning denies the very changing nature of our universe. But planning does force us to think ahead. The task is to try to look ahead and plan accordingly, to chart a course, but to remain able and ready to improvise to meet the unanticipated. Thus it is an essential part of integrated resource planning and programming to constantly monitor for the unexpected, to forecast or to foresee and to be ready with "fast foot work" to meet the challenge of change. This flexibility does not deny the philosophy, rather it reinforces the fact that integrated resource management is not a luxury in these explosive times. It is a necessity.

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Snow, C. P. 1960 — "Science and Government". Harvard University -- The Godkin Lectures at Harvard University

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THE AGRICULTURAL RESOURCE IN THE PRAIRIE PROVINCES[1]

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ABSTRACT

The parameters of the agricultural resource are examined in relation to historical developments, human and physical resources and potential. The renewable resource area, of which agriculture is a major segment, must be examined in total to ensure the maximum efficiency in utilization based on socio-economic goals.

INTRODUCTION

The Western Canadian agricultural industry has reached a crisis point in its relatively short history. Technological advances, both at home and abroad, have provided the means for greatly increased production of food and fibre on essentially the same land base. Markets for traditional Canadian exports are decreasing. Increasing pressure on customer markets from long-time competitors as well from the newer "surplus" countries makes it essential that Canada re-examine resources devoted to agriculture in relation to the potential markets, both domestic and export. To ensure that agriculture contributes the maximum possible to the Canadian economy while those in the industry receive a just share the goals must be established in concert with those for other segments. In this way the maximum benefit will accrue to all Canadians.

Many meanings have been attributed to agriculture in various contexts and it is difficult to define a complex industry in discreet terms. However, the following definition used in this discussion seems appropriate: "Agriculture is a human enterprise aimed at the practical objective of increasing the efficient production, and maximizing the effective utilization of food and fibre of natural origin (exclusive of that produced by fisheries and forestry) for society".

Agriculture is one of Canada's basic natural resources. The soil, water and clean air are an essential part of this natural resource and history provides a caution in this respect. Fallen civilizations give adequate testimony to the abuse of our natural and other resources. The future of any area will be determined by the uses to which resources are directed. Canada must plan now for the effective use of its renewable resources if present and future generations are to derive the maximum benefits from their rightful heritage. Everyone must share the concern for the future and must give serious consideration to the means of protection for wild life and forests, the prevention of soil erosion, the elimination of pollution of air and water and to minimizing waste in all resources.

THE HISTORY OF WESTERN AGRICULTURE

Relatively little of Canada's agricultural history has been related in the history books even though it has played such a significant role in the development of the Canadian West. A quotation from the writings of J. Henri Fabre, a renowned entomologist, expresses the

[1] Contribution No. 384, Canada Department of Agriculture, Research Station, Winnipeg, Manitoba.

thought very well. "History . . . celebrates the battlefields whereon we meet our death but scorns to speak of the plowed fields whereby we thrive; it knows the names of king's bastards, but cannot tell us the origin of wheat. That is the way of human folly".

The first attempts to grow cultivated crops in Western Canada were associated with the fur traders and particularly the factors at the posts and forts located on the water routes which afforded more protection from the elements than areas on the open prairies. However, these efforts were merely supplementary to the fur trading operations. It was not until the arrival of the Selkirk settlers in 1812 that farm scale operations were initiated at the junction of the Red and Assiniboine rivers. Lord Selkirk was granted 116,000 square miles of land by the Hudson's Bay Company and brought settlers from Scotland to colonize the area and to initiate agriculture. These settlers were the vanguard of many people from various lands to follow in the next 150 years.

The first wheat, a winter variety, was sown in the fall of 1812 in the settlement. Some spring wheat was also sown in 1813. Although these crops were generally a failure due to inadequate weed control and poor cultural methods, it was the initiation of the great wheat production empire that remains as one of Canada's major agricultural endeavours. Grasshoppers, storage insects, fungi and rodents were major hazards to production and the safe-keeping of food crops in these early days and these same hazards cause serious losses even today. Other hazards, such as early fall frosts, floods and hostile traders served to discourage a number of the settlers but a few persisted and were successful in initiating the agricultural industry in Western Canada.

On three occasions before 1850, attempts were made to develop experimental farms to provide scientific direction to the agriculture of the region. For various reasons, primarily mismanagement and the lack of practical direction, all of these endeavours failed before making any significant contribution to pioneer agriculture. It was not until 1886 when the federal parliament voted into law "An Act Respecting Experimental Farm Stations" that a viable and successful research program for agriculture was established throughout Canada. The Research Branch of the Canada Department of Agriculture, the present day organization which expanded from the initial five experimental farms, remains the largest single research organization in Canada although universities, provincial governments and private industry are also making significant contributions.

Forty-five years after the establishment of the farming community in the Red River Valley, the governments of the Province of Canada and of Great Britain began to show greater interest in the prairie expanse and initiated attempts to determine its agricultural worth. The fur traders had given the impression that the regions west of the Red River were useless except for fur production. The government of the Province of Canada, although without authority as yet in this territory known as Rupertsland, commissioned Professor Henry Y. Hind to conduct a study in the area in 1857 and to report on the agricultural potential. His report was optimistic concerning the potential of the Park Belt but showed only moderate optimism about the treeless plains. At the same time, Captain John Palliser, a servant of the British government, reported that there was relatively little hope for agriculture surviving on the prairies but was enthusiastic about the Park Belt. These reports did not settle all the arguments about the future of the area but they provided the first scientific information on the potential of the area. However, it was not until 1876, a significant year for Canadian agriculture, that it became apparent that wheat and cattle would become important items of production on the prairies. The first export lot of wheat, 857 bushels, was shipped from the West to Eastern Canada and the first cattle were marketed from British Columbia in that year. Cattle were turned out for the winter on grassland in the foothills of the Rockies the first attempt at winter grazing. The railroad reached Winnipeg in 1879 and provided the means for much increased immigration of people of many nationalities, particularly Central Europeans.

In this period, agriculture reached the "critical mass" stage and continued to develop rapidly for the next 75 years until it became the primary industry in Western Canada.

THE SOILS

With minor exceptions, the "settled" areas and adjacent lands of Manitoba, Alberta and Saskatchewan have been mapped by soil survey and described on a soil series basis. The area contains approximately 75 per cent of the arable land in Canada and the soils fall within seven major orders in the classification: 1. Chernozemic (soils formed under grass); 2. Podzolic (soils formed under trees); 3. Solonetzic (soils formed on saline material); 4. Gleysolic (poorly drained soils); 5. Brunisolic (less well developed usually formed under trees); 6. Organic (soils with over 18 inches of uncompacted peat on the surface); and 7. Regosolic (young immature soils). However, the grouping of the soils, based on soil-climatic zones, is used most commonly in discussions. Five major zones are recognized as follows: 1. Brown; 2. Dark Brown; 3. Black; 4. Grey Black; and 5. Grey Wooded. The Brown and Dark Brown zones are semi-arid grasslands, totalling 60 million acres, of which 42 million are considered arable and 38 million are presently cultivated. The Black and Grey Black zones are arid to humid parklands and discontinuous forest, totalling 55 million acres, 35 million of which are arable and 26 million presently cultivated. The Grey Wood zone comprises the largest block. It is relatively humid forest land of approximately 200 million acres, 30 million being considered arable but only 13 million presently cultivated. The soil use categories described here are based on present technology. Major breakthroughs in plant capabilities or management techniques or a shift in the cost-price relationship would require a further examination of lands with the possibility that much more land could be used for agricultural purposes. In many of these areas low natural fertility, poor drainage, high salt content and low moisture holding capacity are limiting factors to production. New techniques developed through research could change these characteristics very rapidly if the economic incentive was sufficient to justify the effort.

The Canada Land Inventory, a major project sponsored under the Agricultural Regional Development Act, is assessing all land use on the basis of: 1. agriculture; 2. forestry; 3. wildlife; 4. recreation; 5. present use. The first four categories plus urban development and highway networks are in competition for the available land. The ultimate use of the land will depend on decisions based on the economic and social values as determined by society. The major point is that we must develop adequate knowledge through research so that governments and society can make logical decisions concerning the use of our land resource. All areas must be protected so that, in total, nothing is lost irretrievably or misused to the detriment of any or all of the community.

CLIMATE

In Western Canada, total rainfall, distribution of precipitation, the length of the frost free period and the amount of heat units during the growing season are the major factors determining what agricultural crops will or will not be produced.

The average annual precipitation in the eastern prairies and the park belt average about 20 inches, of which 75 per cent falls during the growing season. The average water deficit for crop production is less than 3 inches. In the central prairies, the annual precipitation averages from 14 to 16 inches annually with a deficit of 6 to 7 inches. In the southwestern region of the prairies, annual precipitation averages 12 to 13 inches and the water deficit is 10 or more inches. Moisture is the major limiting factor in this area, both to crop growth and the type of crop. Wheat is the major crop in the region.

Other climatic factors having a major influence on crop growth are frost free period, heat degree days above 42° F., light, and the distribution of these factors throughout the plant growth stages. Variations from 90-100 days frost free period and over 215^{0} heat units to less than 60 days frost free period and less than 1700 heat units in some isolated areas are experienced throughout the region. The graduation of higher heat units and longer frost free periods to the lower values generally follows a south to north orientation. Within this general region, however, there are wide variations in temperature in localized areas due to air drainage patterns, proximity to water bodies, topography, etc. In general, as the incidence of frost increases and the number of heat units decreases, the range of crops that can be grown becomes more restricted.

THE PEOPLE

Land regulations in the newly acquired territories of Western Canada, developed by the government of Canada in 1872, invited homestead applications from all adults prepared to pay 10 dollars per quarter section and to meet a 5 year residence requirement to qualify for the title. There was no immediate rush of settlers since the railroad was not completed and many potential immigrants were not prepared to accept the isolation. In addition to the Metis, Scotch and English established before 1872, the Mennonites, seeking religious freedom, came from Russia, and were the first immigrants from Europe to arrive in numbers. They had come from the plains of Southern Russia and settled willingly on the treeless plains south of Winnipeg. Next to come in numbers were the Icelandic people who combined farming and fishing on the shores of Lake Winnipeg. With the increasing numbers of settlers from countries in Europe and outside, the Canadian West was developing into a multi-cultural country. Jews came to Canada from all parts of Europe in the early 1880's and settled in the West. Hungarians, Germans, Scandinavians and Americans came in search of land. The Mormons from Utah, the second religious sect to migrate to Canada arrived in 1887 and settled in what is now southern Alberta. The Ukrainian settlers came in large numbers from 1891 to 1898 and their descendants now form one of our largest ethnic groups. The Doukhobors came from southern Russia in 1899 to escape religious persecution and settled in north-eastern Saskatchewan, establishing the town of Veregin named after their leader. The annual entry of immigrants reached a peak of 400,870 in 1913, many of them seeking land for agricultural purposes. The West settled by people of diverse background, each contributing a cultural distinctiveness which forms part of our present day Canadian heritage, has given Canada a cultural legacy unmatched elsewhere in the world. The initiative and persistence of these pioneers, in the face of many hardships, has been largely responsible for the development of the agricultural industry in the West in addition to making contributions in many other areas of endeavour.

RESEARCH FOR AGRICULTURE

Agricultural research has made a truly substantial contribution to the well being of Canadians -- more so than is generally recognized. It has paved the way for the transformation from a predominantly rural to an urban society. For example, in 1871 the size of Canadian farms averaged 98 acres and 75 per cent of the population lived on the farm, while in 1966 the average farm size was over 400 acres and only 12 per cent of the population were engaged in farming. Research has made possible the development of a large and complex industry involved in the processing and marketing of farm products and in the provision of a growing range of production inputs and services to farmers. Agricultural research has brought large benefits to food consumers in the form of abundant supplies and favorable prices, placing Canadians among the most privileged of nations in the world.

The record of agricultural research has been outstanding because leaders in the field recognized the fundamental needs of the agricultural industry and planned a program of research to meet these needs. In the earlier years, research in the biological and physical sciences was closely associated with the immediate and practical problems of the farmer. When the agricultural colleges were first established, the curriculum was designed to produce "general practitioners" who either returned to the farm or who, in their research and extension activities, were expected to work closely with the farmer.

Gradually, however, agricultural research has been characterized by an increasing degree of specialization and complexity. The advances in disciplines such as genetics, chemistry, physics, physiology, etc. led to the development of more sophisticated scientific investigation. This, in turn, led to "specialized departments" which permitted tremendous advances to be made in particular and isolated areas of basic research because major efforts were expended in relatively narrow areas. Concommitantly, the increasing specialization led to less communication between disciplines and between research and the problems of agriculture. The extension systems have tried to bridge the gap but it is a tremendous task of increasing complexities and will require the most up-to-date skills and equipment if it is to be accomplished successfully. New concepts, new techniques, and new organizational units, involving cooperative research embracing all disciplines, will be required to meet the needs of this evolving dynamic industry. Canadians have met the challenge in the past and, given the resources, will do so in the future.

A survey conducted by the Science Council of Canada's Study Group on Agricultural Research indicated that there is a total of 1976 professional man-years devoted to all phases of research in agriculture or 11.2 per cent of the man-years devoted to all research in Canada. Of this total 85.0 per cent were in the life sciences, 8.0 per cent in economics, 5.0 per cent in engineering and 2.0 per cent in rural sociology. The federal government had over one half (54.1 per cent) of the biological sciences researchers on staff and a smaller proportion in economics (32.2 per cent), engineering (20.4 per cent) and rural sociology (11.4 per cent). In total the federal government staff was slightly over one half (50.1 per cent) of all scientists engaged in agricultural research in Canada costing, on the average, 34,778.00 dollars per research scientist.

The division of effort, based on dollar expenditure, follows approximately the same distribution. In 1966, the federal government spent 53.1 per cent of the 74,652,000 dollars devoted to agricultural research, the provinces 10.5 per cent, universities 29.0 per cent, and industry 7.3 per cent. This represents about 12.7 per cent of our national budget for research and development in all fields. By contrast, in the U.S.A. expenditure is shared as follows: industry 53.9 per cent; university and state 26.6 per cent and federal governnent 19.5 per cent.

In estimating the costs of research for the future, it will be necessary to incorporate an "inflation-sophistication" factor representing a rise in cost of salaries and services used in research plus the cost of research *per se* (instrumentation and complexity of science). This factor is in addition to any expansion contemplated and is necessary just to maintain a stable force. In Canada this factor has been estimated at 6 per cent per year in the period 1957-67, but, as might be expected, it will fluctuate between disciplines and between years. The above figures are those for Canada as a whole. A prorated figure for Western Canada can be obtained with the exception of that for the 3 prairie universities which do relatively more agricultural research than comparable universities in other parts of Canada.

The relative research roles and the balance between governments, industry and universities have been discussed at length. Overlapping roles between these agencies are unavoidable and to some extent, desirable. All agencies may at some time, perform research, development and teaching functions. However, each agency must have a central role which distinguishes it from other units and this function should involve primarily its self-interest. The central role of the university is to teach and the kind research associated with teaching should exploit the freedom unique to universities, generating knowledge without regard to any particular social objective. All other principle research agencies owe their main responsibility to mission-oriented research and to the goals of the organization. Ideally, the federal government should undertake those projects of national significance which go beyond political and administrative boundaries while the provinces and industry initiate and conduct research closely related to regional problems and product development, that is their primary goals representing self-interest. In any comprehensive research program their must be a place for scientists to follow their interests and intuition in search of scientific knowledge. This is the investment in "risk capital" of science to foster the unpredictable and improbable discoveries which provide the basis for new developments in mission-oriented research.

The balance that should pertain between so-called "basic", "applied" and "developmental" research is hard to establish and the categories are even more difficult to define in any meaningful way. All are integral parts of healthy research programs. Agricultural education and research is concerned with the scientific management of a multi-component system, consequently the whole range of research will be required, depending on the knowledge already available and the needs of the program. The resource components are land, water, labour, and capital; the disciplinary components are the natural sciences, economics, engineering, and sociology. It involves the application of the systems analysis approach derived from the concepts of cybernetics which have been applied so successfully in other areas of endeavour. Except in limited cases, these concepts have not been adopted or applied in agricultural research.

The research needs of any industry can be identified and a program developed based on the relative socio-economic goals of the nation. In agriculture, the more important considerations are: 1. the urgency of the problem; 2. the chances of success; 3. exploitation of the potential; 4. the need for research information for regional development; 5. the availability of human resources to conduct the project; and 6. the potential for overall contribution to science and to society. Other criteria are often used in addition to the above and their use will provide added assurance that the research goals are relevant to the needs.

In the past, Canadian research organizations have planned and developed programs in the individual sectors of the renewable resources with little or no coordination between them. The Canadian Agricultural Services Coordinating Committee (CASCC) has undertaken this function for the agricultural sector and has made steady progress. The main disadvantages at present are: 1. the membership does not include industry or producer groups; 2. meetings are held annually and thus there is only limited time to deal with top priority issues; and 3. CASCC has inadequate supporting staff, both professional and clerical, to discharge a total monitoring and priority setting function. However, with very little additional monies, these deficiencies could be overcome and CASCC could become an even more effective coordinating agency.

The total renewable resources research program would benefit from the formation of a body that could develop the capability of monitoring the national research effort and to detect and promote change in response to the priorities and opportunities. A Renewable Resources Research Council, coordinating the research in forestry, fisheries, water and agriculture would provide Canada with some very real advantages. Such a body, representative of all the interests involved, could effectively establish goals and priorities within and between sectors of the renewable resources. Information produced from such a coordinated program would provide a sound basis for policy development for resource use and would provide the maximum benefit possible for all Canadians.

THE FUTURE

What the future holds for agriculture will depend, not only on the productive capacity of the soil, but on the continued initiative and ingenuity of its people. The productive potential is bright indeed. It is possible, that with the full use of known technology the productive capacity of western agriculture could be doubled using the present cultivated acres. At the moment, the land base in Western Canada can produce well beyond the available markets. Research must be initiated to determine the market potential and the bio-economic facts in relation to our products. For the future, even more revolutionary changes in productive capacity and types of products are in the offing. The plant protein "synthetics" replacing meat and other animal products as well as the deciphering of the genetic code and D.N.A. "engineering" will generate terrific conflicts and upheaval if the appropriate policies are not developed to ensure an orderly introduction of this technology into the agricultural industry. In addition, other equally revolutionary developments are in prospect.

The disruptive aspects of this technology can be lessened, and perhaps eliminated, if we accept our responsibilities and develop the necessary sociological research to determine the impact of such technology on the community. These results can then be used to develop policies and incentives to maximize the benefits for all Canadians.

Pollution of the environment is fast becoming a major hazard to human well-being and is a greater threat to our existence than the spectre of mass starvation which has received so much publicity. Agricultural activities may become a major contributor to pollution if research is not planned and developed now in order to avoid prohibitive corrective costs. For example, as greater productive potential is achieved in the plant species, greater amounts of artificial chemical nutrients will be necessary to sustain this conversion of energy to food. Present application techniques for fertilizers are wasteful in the extreme and much of the plant nutrient is left to become a pollutant in lakes, streams and underground waters. Another example is the lack of adequate manure disposal facilities associated with concentrated animal and poultry operations. Agricultural pollution is only a small proportion of the total but it is a segment for which agriculture must accept full responsibility. Research planned and developed now will provide solutions whereby such problems can be avoided before the corrective costs become prohibitive.

Research on the comparative advantages of the agricultural resource and its economic parameters in relation to other renewable resources is urgently needed. Such information will provide the basis for the development of effective policies for resource use. The priorities for land use must be based on economic and social goals rather than on traditions and guidelines of the past. The real challenge for the agricultural industry is to produce adequate food and fibre of acceptable quality on a land base which permits an adequate return in relation to other segments of the economy. Only in this way will Canadians continue to enjoy the relative abundance of our food products at reasonable prices.

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A PROCESS FOR IMPROVING PROGRAM INTEGRATION

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ABSTRACT

Planning, programming and budgeting is gaining increasing acceptance by management as a process for improving the integration of environmental management decisions at all levels of operations. The principle features of this process are outlined.

INTRODUCTION

Scientists will discern elements in planning, programming and budgeting (often called program budgeting for short) that are common to the procedures that they have long used in planning. What may be less familiar to them is the broader application of the process to embrace the environments that nations and various levels of government and industry within nations seek to manage, or at least to influence. The description of the process given here is similar to general descriptions provided for the information of departmental and other senior managers who are being given responsibility for implementing it. It is probably not an overstatement to say that the application of this process will have an increasing effect on all of us – in our work and in our private lives.

The basic point about program budgeting is that managers can determine policies most effectively if they choose rationally among alternative courses of action, with as full knowledge as is practicable of the implications of the alternatives open to them. In its concentration on outputs and benefits as opposed to just a consideration of the funds required, it differs greatly from traditional forms of planning, programming and budgeting.

Much emphasis is given to techniques of analysis, but care is taken to avoid giving the impression that analysis can be a substitute for managerial judgment. Analysis is expected to give rise to better decisions only because it is likely to bring forward a greater range of alternative courses of action and to make their probable effects more apparent. The manager still must choose, usually taking into account considerations that it is not possible to include in an analysis, and determining their weighting as a matter of managerial judgment.

Governments are faced with the fact that there are many possible ways of improving the quality of life, but that because of limited resources only some of them can be followed. That is, choosing to do some things means that other things will have to be left undone. This obvious and simple fact does not suggest the complexity of considerations having a bearing on these choices. This complexity is great, and warrants the application of modern techniques of gathering and analysing information for improving the quality of decisions.

Techniques for planning, programming and budgeting have become common management tools in private business. Increasing numbers of governments are now beginning to use these tools so that informed decisions will replace the improvisation that certain executive and legislative actions have seemed to reflect.

PROGRAM BUDGETING

To state it in terms of the annual meeting theme, the PB process offers improved procedures for integrating policies and actions for environmental management. But more than this, it relates the benefits of alternative choices to their costs.

The major elements of the PB process are:

(1) information systems
(2) specific objectives
(3) systematic analysis to assess feasible alternative ways of attaining objectives (this includes projected costs of programs over an adequate period of time)
(4) program and budgetary proposals directed towards achieving objectives
(5) annual formulation of plans for each program.

Each level of planning (department, branch, etc.) has an information system (MIS - management information system - is the commonly used abbreviation) to supply data of many kinds for the development of program objectives and plans, for the monitoring of achievement of program goals, and for the reassessment of program objectives and suitability of plans for achieving them. The data in an MIS can be analysed by various procedures. A list of some of the kinds of information that an MIS might include will suggest the range of analytical possibilities for which information may be required and selected.

(1) policies, objectives and plans of relevant levels of responsibility
(2) legislation and regulations - internal and external
(3) findings and recommendations of committees, commissions, etc.
(4) descriptive (non-quantitative) information of various other kinds
(5) quantitative information
(6) models of various systems and sub-systems
(7) findings of research studies including projections and forecasts.

The effectiveness of the PB process obviously will depend directly on the quality and sufficiency of the data fed into the total operation.

Total resources of government are limited in terms of the collective demands of departments and branches, and there must be a continuing process of deciding how many dollars to allocate to each program. Program budgeting provides a rational and effective process for allocating available financial resources to programs.

A government or agency will develop a framework that includes hierarchical and other features as its structure for decision making. For example, the government of a nation might group its activities into a number of main areas, or functions such as:

(1) general movement
(2) foreign affairs
(3) defence
(4) economic measures
(5) social measures
(6) education, culture and recreation.

Its next two levels might be sub-function and functional program. If an individual program fell wholly within one functional program it would constitute a fourth level, and so on. An example of four levels of such a decision making structure is given below.

Function	- economic measures
Sub-function	- primary industry
Functional program	- forestry
Program	- forestry branch (dept. A)
	- wood products branch (dept. B)

Government planning that leads to allocation of resources among functions includes reaching a consensus on the sort of society that government wishes to build, and the process for achieving this kind of consensus must be political. Choices of values must be made that cannot be derived from scientific or logical deduction. But once the political decisions have been made, value judgments become much less a part of the decision process and benefit-cost analysis exerts a progressively greater influence on resource allocations as areas of decision responsibility narrow.

To sum up, characteristic features of the PB process include the following:

(1) It is generally end-product oriented, that is, it concentrates on ends rather than means.

(2) It ensures that efficiency in allocating funds becomes intimately related to goal (objective) determination.

(3) It provides for greater flexibility and discretion in operations, plus a more effective accountability mechanism.

(4) It demands a long forward view in making resource commitment decisions.

(5) It is politically neutral (the process, not necessarily the input).

(6) It is, in short, a new way of managerial thinking.

SOME IMPLICATIONS OF PROGRAM BUDGETING

When operating under the PB process, management cannot avoid investigating and making explicit what it considers most urgent or beneficial to be done as between programs or as between activities in the same program. The next higher level of management would take this into account when allocating resources.

Consideration of priorities for programs within its jurisdiction by a particular level of management could lead to elimination of unrewarding activities and result in the reallocation of funds to more beneficial activities.

Research will have to be treated on the same basis as other programs, and potential benefits related to cost. The difficulties of doing this as compared with certain other kinds of program are recognized but are not permitted as an excuse for avoiding this application of the process. Corporations have devoted considerable effort towards overcoming these difficulties. Research managers and scientists in government and universities will undoubtedly face the same need to come to grips with them.

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THE ECOLOGICAL SIGNIFICANCE OF STRESS[1]

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ABSTRACT

We suggest that environmental modifications which act as stresses are additive and may also interact. Therefore the results of such modifications cannot be predicted on the basis of simple one-variable experiments. Local modifications of the environment should be preceded by pilot modifications in real time, in the real environment before capital is invested. Large scale modifications of the environment must be avoided since they will result in extinctions, changes in numbers and a decrease in the stability of the system.

INTRODUCTION

In medical parlance, stress has been defined as a forceably exerted pressure. We consider an environmental stress to be any factor operating within the environment which exerts a forceful pressure on the organism or population, and the result, (Prosser 1963) is an environmental circumstance which induces adaptation.

Throughout the eons for which life has existed on Earth, adaptation has continued until some organism is able to live under almost any combination of physical, chemical, and biologic conditions found in the environment. The most adaptive organism is probably man (Potter 1969). It is the very means, however, by which man has achieved this considerable scope to adapt - his technology - that constitutes a potential threat to his continued well-being. Man successfully adapts to his immediate environment because he can engineer or manipulate the environment to suit his immediate requirements, but at a rate which is faster than that at which his inherent biology may be able to adapt. The growing public concern about pollution, conservation, and weather modification, to cite but a few examples, is testimony to this. DDT and other pesticides, noxious fumes from industrial operations and automobile exhaust, noise, and crowding, have been shown to have deleterious effects (Fyfe, *et al.* 1969; Fay 1968; Winkelstein, *et al.* 1967; Burns and Littler 1960). These factors produce stresses. A comprehensive physiological theory describing the deleterious effects of stress was discussed by Selye (1957). Recently, there has been a growing awareness that an environment free from stress is not necessarily a "good thing". We are beginning to appreciate that the organism or population requires that its environment impose a degree of stress upon it in order to achieve maximum operation efficiency. Potter (1969) has proposed the term optimum stress to describe the amount of pressure forceably exerted on the animal or population which enables it to achieve maximum operational efficiency.

This paper is an attempt to place the effect of stress (es) within an ecological framework. An environmental entity which is not lethal in the toxicological sense of that term, but affects the range or scope of activity of an organism or population is, ecologically speaking, a stress. Initially a stress may optimize, but eventually it will reduce the potential range and/or scope of activity of the animal and the population. Of even greater ecological significance is that individual stresses may interact and synergistically affect the organism.

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[1] AECL 366/69

THE MODEL

The Individual Organism

The study of an organism's function embraces two generally recognized sub-divisions (Fry 1947). These are: 1) how the organism works, 2) what the organism does - its activities, or as Odum (1959) says "its profession or niche". Fry considers the first division to be metabolism, the energy - supply processes which allow the organism to continue to exist as an individual and respond to its surroundings. The organism's metabolism must also provide energy for its activities such as food-seeking and breeding. Considerable confusion exists between **true** metabolism and the measurement of an activity which is considered to be equivalent to a measure of metabolism. In this context, Fry's analogy is apt: The combustion of gasoline and the production of the ignition spark are the metabolic processes of the automobile while motion is its activity (Fry 1947). The activity of the machine is the result of its **integrated** metabolism, as is the activity of the animal and the population of which it is a part. The effect of environmental stresses on the organism and population is the **cumulative** effect on the fraction of the individual's energy production that is utilized for activities. That is, it is the effect on the difference between the total metabolism at a given time and the minimum energy required to maintain the individual's integration.

The relationship between maximum and minimum levels of metabolism and the scope for activities, is shown in Figure 1. It is based on Fry's development of metabolic effects caused by environmental identities. Essentially, we view stress as operating in the guise of one or more of Fry's environmental identities (Fry 1947). The situation depicted in Figure 1 is perhaps never attained outside the laboratory. It is one in which the organism is allowed complete expression insofar as its response to environmental factors, eg. moisture or temperature, is concerned. At the lowest level of potential activity, the minimum and maximum metabolic rates are zero. At the other end of the range, (right side of Figure 1) the minimum rate of metabolism absorbs the total metabolic capacity of the organism and therefore coincides with the maximum metabolic rate. Like Fry (1947), we would emphasize that the coincidence of the two rates at the upper end of the metabolic range is **not** occasioned by the operation of any limiting factor or stress. The horizontal distance between the points of coincidence of the minimum and maximum rates (left and right sides of Figure 1) represents the potential range of an environmental condition over which the organism might be active if no stress is imposed. Fry has called this range the **potential range of activity**. The area between the maximum and minimum metabolic rates represents the animal's **scope for activity** (Fry 1947).

Fry (1947) defined environmental identities (factors) according to the manner in which they may influence the organism. His major categories of effect were:

Lethal factor	-	an environmental identity which effects the destruction of the organism's integration.
Controlling factor	-	an environmental identity which influences the metabolic rate of the organism by conditioning the medium in which its metabolic processes occur.
Limiting factor	-	an environmental identity which governs the organism's metabolic rate by virtue of its operation within the metabolic pathway(s).
Directing factor	-	an environmental identity which allows or requires a response by the organism which is directed in relation to a gradient.
Masking factor	-	an environmental identity which prevents a second identity from affecting the organism to the extent that it would in the absence of the first.

It is in the role of one or more of these factors that we believe stress (es) operates, and it may be in the guise of masking factors that many stresses exert their least obtrusive, but from the viewpoint of the population, most significant environmental effect.

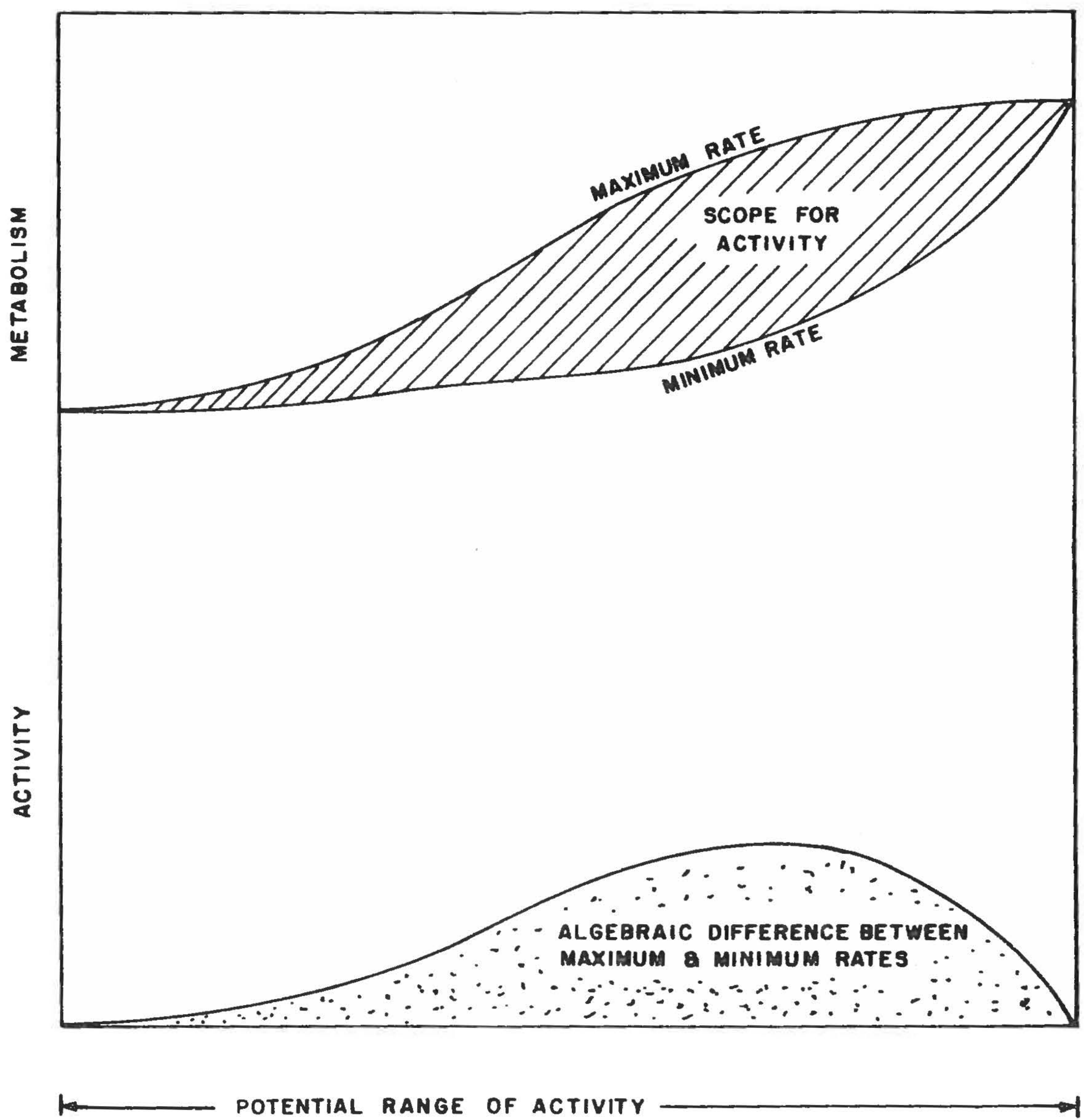

FIGURE 1. The interaction of the organism and its environment according to Fry (1947).

Figure 2 shows the need, imposed on the basic conditions depicted in Figure 1, for further physiological regulation caused by two stresses. It is assumed that one stress is operating as a limiting factor, and the other as a controlling factor. The extra metabolic requirement imposed by the need for additional physiological regulation has been added to the minimum metabolic rate, consequently raising the baseline and reducing the animal's scope for activity. Figure 2 also shows the manner in which a stress which is a controlling factor may operate as a lethal factor by reducing the possible scope for activity. For example, an identity such as temperature could cut off both the upper and lower end of the potential range of activity (Fry 1947) and act as a lethal factor.

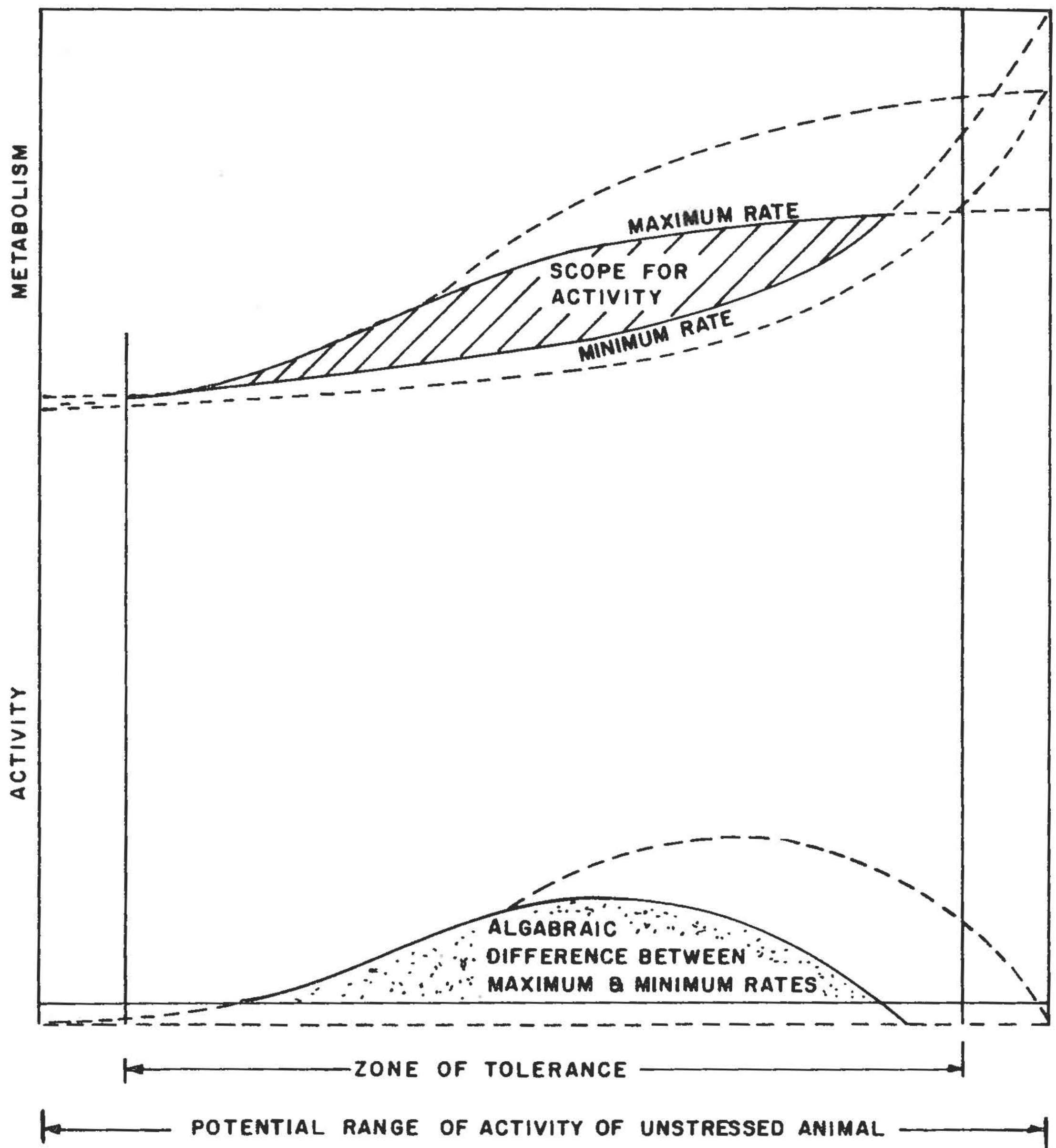

FIGURE 2. Effect of two stresses acting as controlling and limiting factors (Fry 1947) on conditions shown in Figure 1. Note the decreased scope and range for activity. The broken lines show the initial state depicted in Figure 1.

We can think of individual stresses, none of which is toxicologically lethal, as being additive in the manner that the total radiation dose delivered by radioactive mixed fission products is the sum of the doses of the radionuclides comprising the mixture (ICRP 1959). Depending on the magnitude of the individual stresses present, the result may affect either or both the potential range of activity and the animal's scope for activity. When operating as a masking factor, a particular stress may "mask" the effect of a potentially lethal factor and thereby appear to be an optimum stress. Pretreatment with ionizing radiation, for example, extends the animal's survival time in a lethal temperature (Ophel and Judd 1966) or in a lethal concentration of DDT (Erdman 1966). Fry (1947) has pointed out that physiological regulation may be obtained as a by-product of the metabolic energy used for activity. He cites as an example the heat produced by muscles performing work being used to maintain body temperature above that of the environment. Such regulation, according to Fry, does not subtract from the scope for activity. In most cases, however, although the energy expenditure may not be great it must be considered. Maintenance of individual or population integrity in any given combination of environmental stresses requires the expenditure of a certain minimum amount of energy. As the total amount of energy required increases, a point will be reached at which the energy output needed will demand the maximum metabolic rate of which the organism is capable, effectively reducing the scope for activity to zero. The individual will continue to maintain its integration, but if there is no surplus energy available for mate-seeking and breeding, the population will decline and eventually die.

The Population

The foregoing discussion has been limited primarily to the individual organism. To construct a viable theory for the operation of a population in the field, it is necessary to consider the action of a multitude of stresses on the population as a whole. Two features that distinguish a population from a mere collection of individuals are: 1) a population has a birth rate that is at least equal to its death rate. 2) it has a spatial structure that is maintained through communication between the individuals making up the population. This structure-communication complex varies from some organisms whose individuals come together only to mate, to plant populations which communicate and maintain a structure through the introduction of chemicals into the soil, to the long term structure and complex communications of breeding Passerine birds and wolf societies.

The important point for this discussion is that both reproduction and the maintenance of the structure - communication complex require metabolic energy. Therefore, a member of a population requires an additional increment of "maintenance energy" to remain a member of this viable population. This will, of course, decrease the amount of energy available for activity. Under some environmental conditions it will also preclude the possibility of an individual becoming part of a viable population although it may still exist as an individual (Marshall 1962, 1966).

Another requirement is an expression which encompasses the multiplicity of stresses present in the population's environment. Several terms have been used to describe the totality of factors affecting a population. For our purposes the most useful term is niche as used by Slobodkin (1966) and originally defined by Hutchinson (1957):

> "Consider two independent environmental variables X_1 and X_2 which can be measured along ordinary rectangular coordinates. Let the limiting values permitting a species S_1 to survive and reproduce be respectively X'_1, X''_2 for X_1 and X'_2, X''_2 for X_2. An area is thus defined, each point of which corresponds to a possible environmental state permitting the species to exist indefinitely. If the variables are independent in their action on the species we may regard this area as the rectangle ($X_1 = X'_1$, $X_1 = X''_1$, $X_2 = X'_2$, $X_2 = X'_2$), but failing such independence the area will exist whatever the shape of its sides.
>
> We may now introduce another variable X_3 and obtain a volume, and then further variables $X_4 \ldots X_n$ until all of the ecological factors relative to

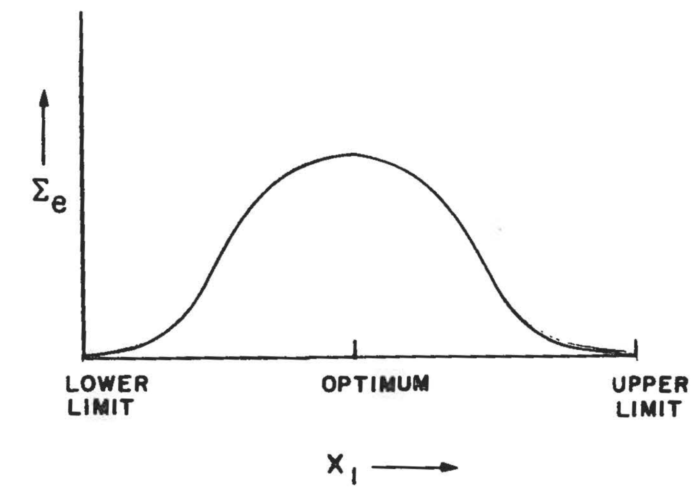

FIGURE 3. The relationship between a single environmental identity (X_1) and the "goodness" of the habitat (Σe).

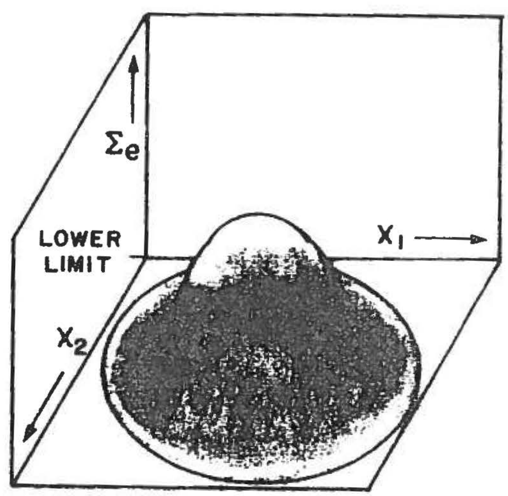

FIGURE 4. The relationship between two interacting environmental identities (X_1 and X_2) and Σe.

S_1 have been considered. In this way an n-dimensional hypervolume is defined, every point in which corresponds to a state of the environment which would permit the species S_1 to exist indefinitely. For any species S_1, this hypervolume N_1 will be called the **fundamental niche** of S_1."

Some of the limitations Hutchinson (1957) places on this mode of expression of the niche are: 1) all points inside the hypervolume imply equal probability of survival of the species, and all points outside imply zero probability of survival. 2) all environmental variables can be linearly ordered; although this is not possible at the present time, there appears to be no reason why it should not be theoretically feasible.

Hutchinson used his definition of niche primarily to examine the interactions between two species. Since we are interested in using it to examine the relationship of a population to its environment, we adopted the following modifications. Since populations of a species vary in their environmental requirements and optima, we use **populations** wherever Hutchinson stated species in his defintion. Secondly, we do not assume independence of the variables $X_1 \ldots X_n$, because in a real situation many of the variables will interact and it is no more difficult to imagine an irregular hypervolume than a regular one.

Hutchinson also assumed all points falling inside his hypervolume implied equal probabilities of survival of the species. We have modified this assumption to allow for a continuum of probabilities of survival, or a scale of "goodness" of habitat. This variable, which is really the sum of all the environmental conditions as they affect the animal we call Σ e. Figure 3 shows the range of the environmental stress X_1 and the ordinate gives the resulting Σ e. Figure 4 shows two stresses X_1 and X_2 plotted on the X and Y axes. The result of their interactions, Σ e, is given on the Z axis. As the number of stresses is increased $X_3 \ldots X_n$, Σ e is plotted in dimension $X_n + 1$. The numerical values of Σ e can be read from dimension $X_n + 1$ and arranged in numerical order to give an index of the "goodness" of the environment throughout the range of the variables. This has been done in Figure 5 where we plot the theoretical rate of increase (r_e) under given environmental conditions. It can be seen that re is proportional to Σ e from the point where the number of births does not make up for the number of deaths, to a point where the population reaches its maximum rate of increase (r_i) or biotic potential. At this point any further increase in Σ e will not cause a further increase in r_e. It is apparent, however, that the long term average value for r_e's of real populations in the field must be 0 or they would soon reach ridiculous numbers. If the average r_e is negative, the population will become extinct. The difference between an observed r_e of 0 and the theoretical value (r_i) we call the **population safety factor**, since it represents the rate at which a population could recover if its numbers were catastrophically reduced.

If an additional stress is introduced into the system, for example ionizing radiation or pesticides, the values of Σ e will be decreased and the r_i line will be shifted to the right. It can be seen in Figure 5 that this will not affect the observed r_e's of most of the populations. Some r_e values will become negative and the populations extinct while others will continue to function but with reduced safety factors.

If we consider the relationship of numbers of animals per unit area to Σ e (Figure 6) we have a function that is similar to that shown in Figure 5. The density of animals that could be supported increases with increasing Σ e. Nevertheless it appears that many animal populations are regulated below a level which could theoretically be maintained on a given area. If an additional stress is added which degrades the environment, a few populations will become extinct and others will exist at slightly lower levels. Most of the populations, however, will not be affected.

Our model suggests that the number of animals in the population or the growth rate of that population will not in most cases be affected by a slight increment or decrement in the quality of the environment. Near the margin of a species' distribution or in areas where the environment will barely allow a population to exist, a slight change in the environment could cause a catastrophic change in the population.

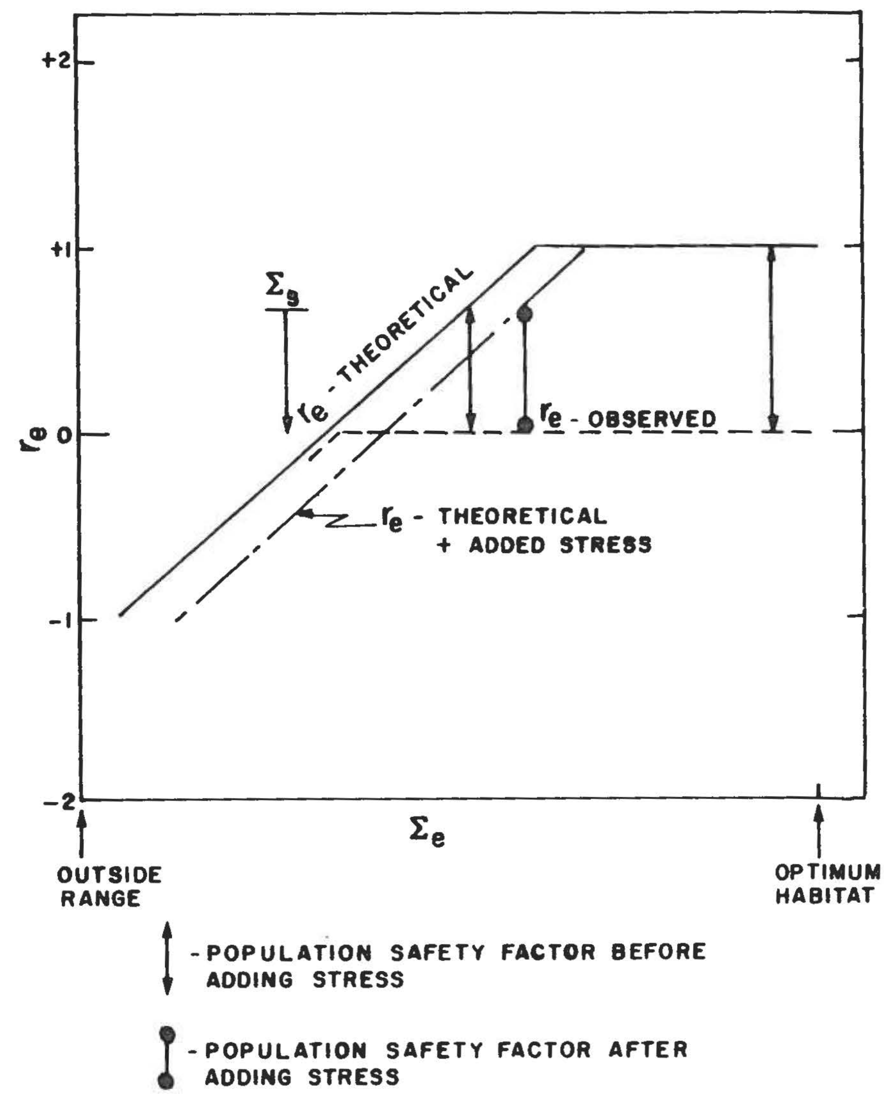

FIGURE 5. The relationship between the theoretical rate of increase (r_e) and Σe. The effect of an added stress is also shown.

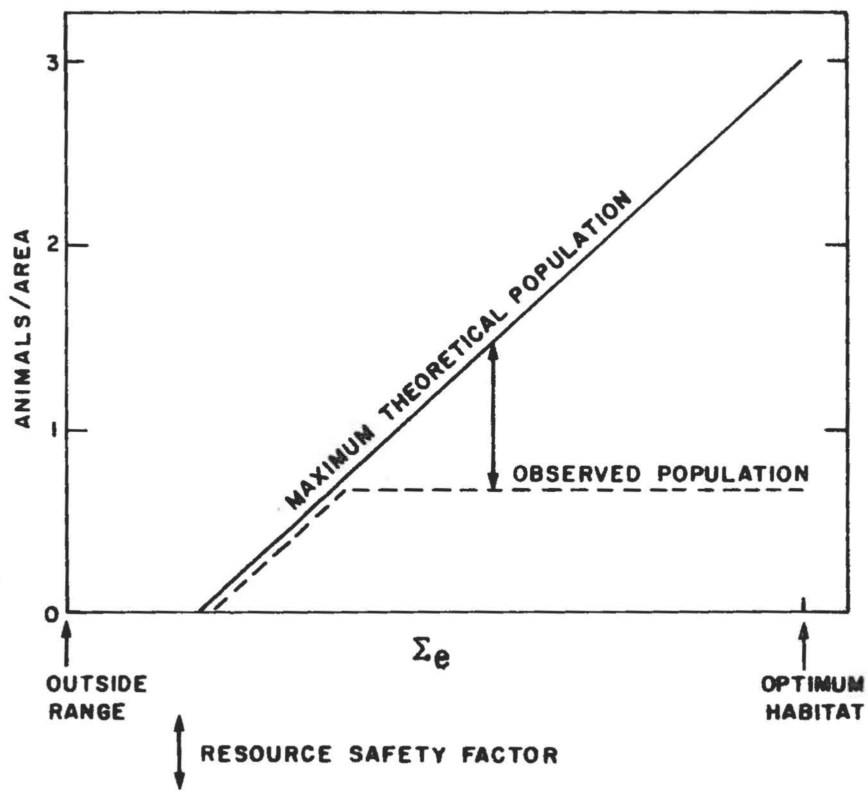

FIGURE 6. The relationship between density of organisms and Σe. An added stress would move the maximum theoretical population line to the right.

DISCUSSION

If the model we have presented is to be of use, it must allow us to organize present knowledge in a manner which affords useful prediction of the outcome of environmental modifications, and suggest experimental designs which allow more rational determination of the effects. This model predicts that most populations should maintain their numbers even when they are cropped or environmental conditions change. The model also indicates that some populations, usually those near the edge of the species range, will be sensitive to environmental change and/or overharvest. Support for this view is the fact that in spite of the fantastic environmental change that man has caused in his biosphere, only a very few species have become extinct or have erupted. Those that have changed drastically, the sea otter and the bison for example, were probably over-exploited. When these animals were protected from mans highly efficient predation, they increased greatly in numbers, demonstrating that it was overharvest and not niche degradation that caused their decline. Other populations, such as those of the Bald Eagle, the Eastern Bluebird, and the oyster in Chesapeake Bay, do not increase when protected. Probably they are trying to exploit niches so compressed that the population safety factor is near zero. The documented cases of changes in distribution and abundance of many organisms during the last fifty years could probably be ascribed to known changes in the available habitats.

At the present time man must continue to modify his environment since technology probably is not advanced enough to operate on a closed recycle system, even if it were economically feasible. The problem is one of limiting the damage caused by environmental modification. Let us accept, for the sake of argument, a level of modification that does not change the distribution or abundance of organisms, but only speeds the rate of turnover within a population or reduces the population safety factor. This criterion would not permit any world wide changes to be made, since, according to our concept of the system, every species near the edge of its range is already operating with a zero safety factor and is therefore susceptible to local extinction. Local extinctions are not necessarily bad per se but if the theory which suggests that complexity of the community produces stability, and simplicity of the community results in instability (Odum 1959) is correct, any extinctions will simplify the community and therefore lead to instability.

At the local level, stresses probably could be added to the environment without causing an unacceptable decrease in stability in the community. However, each modification must be examined for its probable effects. Testing a new environmental modifying agent as a single variable without testing its interactions with other agents will only allow a value judgement of the potential effects to be made. Although interactions of several agents can be tested in the laboratory and predictions can be made about the likely effects of the particular stress, the present state of ecology does not produce predictions that have the required low levels of error.

At the present time it appears that the only way to determine the effect of a potentially modifying factor on the environment is to introduce it, and measure its effect by full scale experiments. Drug manufacturers perform large scale tests of drugs on human populations and engineers build pilot plants. Before industry and society accepts a new industrial plant, process, or chemical, on-site pilot experiments should be carried out. This may involve raising the temperature of a river or testing a chemical on thousands of acres of land. Such experiments may be expensive, but they would not only advance ecology more rapidly to the state of a predictive science, but would also allow the determination of the environmental impact of a new plant or process before large amounts of capital are invested.

Although we have considered environmental stresses to lead to niche degradation through contraction of the hypervolume, there is no reason why there might not also be niche improvement. In other words, the same technological abilities which are responsible for damage to the biosphere through decreased complexity and stability, could also be used to increase these two factors. The future of our biosphere is more a matter of attitude than of technological ability.

CONCLUSION

Our immediate objective is to emphasize the fallacy of attempting to regulate the release of effluents and other stresses into man's environment solely on the basis of their acute toxicological or sociological effects. We present a model which suggests that environmental modifications which act as stresses are additive and may also interact. By decreasing the niche hypervolume within which the population operates they reduce the population safety factors and the scope for activities of individuals.

This model implies:

1. Any large scale environmental modification will cause some local extinctions or changes in numbers. This effect will be greatest on the margin of a species' range, and on species that are low in numbers because of habitat degradation.

2. Subsequent modifications will have even greater effects because the population safety factors and the stability of the system will have decreased. The possibility that two stresses may interact synergistically must also be considered.

3. Most local modifications of the environment will have relatively small effects on the distribution and abundance of organisms because most populations have a significant safety factor.

4. Therefore:

a) Large scale ecological modifications must be avoided.

b) Local modifications should be preceded by pilot modifications in real time, in the real environment and before capital is invested, to discover interactive effects that cannot be predicted.

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THE ORGANIZATION OF A STUDY OF A BIOLOGICAL SYSTEM

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ABSTRACT

Biological systems are complex and a multi-disciplinary approach is needed to provide the information essential for intelligent management of natural resources. A committee of scientists planning and directing research on the role of a forest insect in its ecosystem has proven to be a successful method of organizing a 'team' approach within a government research organization. This 'committee' approach is compared to the 'leader-oriented' approach to organization of research teams within government and university stituations.

INTRODUCTION

Traditionally, many biologists have been concerned mainly with characteristics of individual organisms rather than of biological systems such as populations, communities and ecosystems. However, in recent years more and more recognition has been given to the necessity for research into the operation of biological systems in order to solve complex problems facing mankind. Management of any system without a sound knowledge of its operating principles is obviously hazardous, thus research is needed to provide information for intelligent management of our natural resources.

The investigation of a complex system requires the integration of many talents in a co-operative approach if useful results are to be achieved in minimum time. The "team approach" is widely recognized as the best to solve complex research problems and is used in many disciplines. However, opinions differ widely on the best organization for team research. I have participated in a team approach to solving a complex forest entomological problem for a number of years, and this paper will comment on organizing and conducting the investigation of a biological system.

ORGANIZING FOR RESEARCH

I would like to emphasize that the organization of the team investigating a biological system must reflect the organization of the system. An important characteristic of the ecological system is that its parts form an intricate web of interactions; indeed, Watt (1966) defines an ecological system as "an interlocking complex of processes characterized by many reciprocal cause-effect pathways". Therefore, the mere division of aspects of a large and complex problem among a number of investigators does not constitute a team approach. Like the ecosystem the team must be characterized by an interlocking of thought and action in the development and operation of the investigation.

Two types of investigations can be recognized: problem-oriented and systems-oriented. Although the problem-oriented approach focuses its attention on a single organism or facet of the system while the system-oriented approach attempts to describe the entire system, the differences are more important on the theoretical than on the operating level. Since a system under investigation comprises an interlocking network of organisms and processes, the selection of a single problem or organism as the "target" does not prevent the investigators from adopting a holistic approach to the ecosystem. Examples of this are available in the investigations of the spruce budworm problem in eastern Canada (Morris 1963), the western pine beetle in California (Stark 1966) and in the larch sawfly problem which I will now describe.

DEFINITION OF THE LARCH SAWFLY PROBLEM

The larch sawfly has long been recognized as the major factor affecting the growth of larch in North America. During the first half of this century extensive tree mortality and growth loss, attributed to this insect, were described and attempts were made to reduce these losses through the introduction of biological control agents. Chemical control experiments were also tried but were too expensive and too ineffective to be applied on a large scale. By the early 1950's it became apparent that the larch sawfly was the major obstacle to the maturing of large volumes of young tamarack, and fear of larch sawfly damage had led to the almost complete exclusion of this fast-growing conifer from forest planting programs. It also became apparent that without detailed knowledge of the population dynamics of the larch sawfly, there was no hope of developing an economic method of reducing the damage.

DEFINITION OF THE SYSTEM

The basic elements of the system which needed to be studied were: (1) larch, (2) larch sawfly, (3) other factors affecting the growth and survival of larch and (4) factors determining the abundance of larch sawfly and its impact on larch. Each of these headings, of course, includes a large number of interacting facets which determine the characteristics of the system.

ORGANIZATION OF THE PROGRAM

In 1955, as the results of a decision to consolidate larch sawfly research for Canada in Winnipeg, four scientists, each with different areas of special competence, began to plan the investigation. During the initial planning, and throughout the subsequent history of the program decisions have been made by a committee consisting of a varying number of participating scientists. Continuity of approach and dedication to the program have been insured by close involvement in the decision-making process. The committee decided that initially our resources would have to be allocated in three areas:

1. Application of existing techniques to the continuing collection of data on the larch sawfly and its environment.
2. Development or adaptation of techniques to extend the number of parameters measured in 1.
3. Experimental studies of the characteristics of the system components and elucidation of the paths of interaction between them.

These areas were considered necessary to produce the basic data for the analysis and description of the system which would lead to a model that could be used for simulation and optimization.

At the beginning of the operation, the greatest need was for the development of techniques. Although considerable research had been done on the larch sawfly, its parasites and its predators, little emphasis had been placed on sampling techniques. In addition to the development of sampling techniques for the larch sawfly, techniques for estimating the abundance and effectiveness of its mortality factors and the impact of larch sawfly on the growth and survival of trees had to be developed. Weather was recognized as an important, pervasive element in the whole system. Although meteorlogical equipment was available, such equipment had to be selected for its ability to measure parameters related to the system and adapted to operate in remote areas.

All three aspects of the initial program began simultaneously, but as standard techniques for collecting continuing data on the major elements of the system were developed, more time could be devoted to experimental studies. In addition, preliminary analyses, which are necessary to check on the data and to reveal new relationships, became an essential part of the program. In this respect, the decision to develop a highly skilled group of technicians to maintain the data-collection program was essential to allow the scientists enough time to experiment and analyse the data.

Throughout our operation, the assignment of specific projects to members of the group has been made on the basis of the priorities of the study and the abilities and interests of the individual. Additional specialists have been enlisted to study specific aspects of the problem and the assistance of others in the process of analysis is anticipated.

GENERAL COMMENTS ON ORGANIZATION

In considering the development of the larch sawfly project I have come to believe that several points need to be emphasized in the organization of a team approach to a complex problem.

1. The need for breadth and flexibility in approach and operation. The organization must draw upon the maximum range of knowledge and ability at the beginning and continually draw into its orbit personnel capable of extending its knowledge of the system. These people can be utilized full- or part-time for varying periods but will be essential to the attainment of the final result.
2. The need for continuity, both in maintaining the line of investigation and in building up a comprehensive body of information on the system.
3. The need for constantly reviewing the progress of the investigation toward its final objective, the synthesis of results into a meaningful description of the system which can be used for simulation and planning.
4. The need for material support and encouragement by the supporting organization, which is of course basic to the success of any program.

Differences in the type of organization may influence the extent to which these four needs are fulfilled. While the larch sawfly research team uses a committee approach within a government research organization, other systems investigations in forest entomology have been developed around a single leader, either within a government organization or at a university. Thus the team approach to the spruce budworm problem in eastern Canada, which produced an immensely useful description of this insect pest and its role in the spruce-fir forest community (Morris 1963), was conceived and directed by Dr. R. F. Morris within a research agency of the Canadian Government. Within universities, Dr. H. Klomp at the Agricultural University, Wageningen, Netherlands and Dr. G. C. Varley at Oxford University, England, have personally developed holistic approaches to the study of specific forest insects. These studies have made significant contributions to the knowledge of population dynamics (Klomp 1966, Varley 1967). Stark (1966) has described the organization of a study of a biological system within a university based on his work with the western pine beetle. He emphasizes the need for one or more senior researchers to plan and guide the efforts of associates and graduate students in studying portions of the problem and to build up their results into a comprehensive body of knowledge of the ecosystem.

With these examples in mind, some of the advantages and disadvantages of the type of organization of the team and their location can be examined in reference to the needs of the systems research listed above.

First, an organization with a dominant leader can be expected to show the maximum cohesiveness in the planning and operation of the program. This leader may also attract able subordinates to study specific aspects of the problem and draw upon them for ideas in planning and in analysis of the results. However, even strong leadership may have its weak points: the breadth and flexibility of an individual's approach to the problem is limited by his training and his ability to evaluate the varying viewpoints of his subordinates. The subordinates may also feel more involved and dedicated to their specific portion of the problem and less inclined to consider methods of studying the whole system. Continuity may also become a problem, through individual mobility or mortality, and replacement of a leader may be difficult.

The structure of the committee will greatly affect its success. Galbraith (1967:65) distinguishes between "representative committees" and those designed to test and pool information. A committee composed of members selected to represent special interests is severely limited, because a contribution to a decision by any one member can be made only at the expense of another member. When the committee is designed to pool and test information as a basis for making a decision, a synergistic effect often appears: the interplay of information and ideas between the members produces results greater than the simple summation of their individual contributions.

The ability of a committee to integrate a wide range of information in developing a logical approach to problem solving may also make it easier for the committee to obtain and maintain the usually large amount of support that is necessary to conduct systems research. Decisions are made only after proposed allocations of resources are examined in relation to the objectives from many viewpoints. A decision of an individual may be challenged by another higher in the hierarchy, and is too easily reversed. Such challenges to a committee decision are much more difficult, since the superior must be prepared to reverse the judgment of a wide variety of specialists acting jointly. The personal competence of the superior is unlikely to span the range of information available to the team and time prevents him from doing the massive job of probing that would be needed. Thus the greatest power of decision lies with the greatest breadth and depth of information, a group or committee rather than individual. As J. K. Galbraith (1967:67) succinctly describes the situation "Group decision, unless acted upon by another group, tends to be absolute."

The development of systems research in universities as opposed to governmental research organizations is a matter of serious consideration at the present time. In both areas a wide range of talents can be found and if these can be brought together, a program of satisfactory breadth and flexibility could be developed. However, as Stark (1966) observes, a university-based organization has difficulties in keeping the study flowing smoothly and in the right direction due to its strong dependence on the short-term efforts of graduate students in conducting research. Support for a sufficiently large staff of highly skilled, permanent technicians which can be devoted to collecting continuing data on the system may also be difficult to obtain. The weakness in continuity, however, is partially balanced by the depth of knowledge and intensity which may be directed by staff and students to the study of specific aspects of the system. In addition, while long-term support may be difficult to obtain, grant-supported research at the university is flexible and may get money much more readily for short-term studies.

In conclusion, I think that the best organization for the study of a complex biological system would be a committee of scientists, all active in the planning and operation of the study. Continual monitoring of the natural system, well-replicated, should be the realm of a highly skilled sub-professional team, working under the committee's direction. Continuity can be best assured by basing the study in a governmental research organization but the best over-all results would be obtained by including university scientists, both as members of the committe, and as associates who undertake experiments on special aspects of the problem.

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THE ECOLOGISTS' APPROACH [1]

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ABSTRACT

The present-day role of ecologists is considered, particularly with respect to other scientific disciplines, study of the environment, and resource management. To illustrate this role, a marsh ecosystem research program is discussed. Despite the pressures of human population and environment pollution, Miss Walker cautions against stress that might adversely affect the research process.

Ecology deals with the interaction of organisms and their environment, and is often referred to as environmental biology. The word "environment" covers a multitude of things, and includes organisms and their surroundings which are modified by them. The environment includes other organisms of their own kind and of other species. There are relationships, always adjusting and changing, between individuals within a population and with individuals of different populations. In fact, the interests of the ecologist extend into the areas of plant and animal biologists, taxonomists, physiologists, behaviourists, meteorologists, geologists, physicists, chemists, pedologists, and sociologists. Ecologists need to relate to all these and other established and respected disciplines. Ecology is a multidisciplinary science. It has to be to reach the heart of environmental biology. For many years ecology has been criticized for a lack of quantitative data and conceptual strength. This situation is improving, for modern ecology has shifted from the descriptive phase to the study of function. The modern ecologist quantifies his data wherever possible: he studies nutrient cycles, energy flow, functional niches, population growth. He draws increasingly upon statistics, chemistry, and physics to develop tools with which to probe into the ecosystem. Today it is essential that ecologists ally themselves with climatologists, soil scientists, ethologists, taxonomists, systematists, and geneticists.

With all due respect to the advances made in molecular biology, it is true to say that the most important current level of biological study is the organism and its environment. Even in non-biological circles, this is being realized. Man's impact upon his own environment is being felt more keenly day by day, and today Man, rather than nature, exerts the decisive influences on the shape of the future. Because of the increase in radioactive fallout, we have become conscious of nutrient cycles: because of loss of life from lethal doses of pesticides picked up through food chains, we have become increasingly aware of chemical poisons and other pollutants that are being cycled through ecosystems; because of increased urbanization, we are becoming more concerned about the need for open spaces and the need to protect environments. Constancy in environmental conditions generally represents, if not a good position, at least a non-deteriorating one, and we are suffering from deteriorating conditions on many fronts (Slobodkin 1968).

The future of human life on the earth demands more knowledge about the ecosystem than we yet possess, and for this we turn to ecologists. Edward Deevey (1968) has stated that

> Human societies are now so large, so complex, and use resources so rapidly, that they are in danger of drowning in their garbage. The problem is

[1] **Presented as an invitational paper at the Manitoba Entomological Society meeting, 1968.**

> inescapable; there is no rug under which it can be swept. All sinks are temporary; like cesspools, they have a way of becoming septic when overloaded. 'Waste resources' have seriously polluted the Great Lakes, and even the ocean cannot process all the garbage it now receives.
>
> Most men understand these matters in principle. In detail nobody understands them well enough. Partly, this is because living systems are amazingly complex and are turning out to be interlocked in unexpected ways.
>
> When garbage is smoothly converted to resources, we speak of a system's 'output' as 'production'. When interruptions occur in the same systems, we call the pileups 'pollution', and notice that the 'production' is declining. Pollution, then, is deflected production. It can be channelled or controlled. . . . .

There should be more concern over the fate and state of our environment. There may even be some truth in the comment ecology is too important to leave to the ecologists.

In the opening paragraph of his article "Aspects of the future of ecology" Slobodkin (1968) summarized the situation in stating

> The future of ecology is tied to the future of mankind in an intimate and uncomfortable way. That is, physical and biochemical systems can be reasonably well insulated from environmental changes while, to the degree that ecology is concerned with naturally occurring interactions between organisms, it is highly vulnerable to all sorts of changes, most of which can be traced directly or indirectly to the activities of men. To study climax forests in America would have been reasonably simple one or two centuries ago, had it been of interest at that time, but a study of that sort is now almost impossible. To permit such study one or two centuries hence will require that we now establish reserve areas and maintain them in a natural state for the next one or two centuries. This will immediately bring up the administrative and political problems associated with the establishment of such areas: the conflicts of land use requirements that now exist and the very difficult questions relating to changes in land use pressures that are likely to arise in the next two centuries. Thus, even if one begins with the purest and most intellectual of ecological problems, one is very quickly forced to consider practical and political problems. Conversely, it is abundantly apparent that a most difficult and important practical problem facing humanity at present is an ecological one, at least in the sense that its satisfactory solution will necessarily require consideration of intellectual problems which are identical, at least in form, with those that concern ecologists. I am referring to the cluster of problems associated with the high density of human population on earth.
>
> There is a dangerous possibility that the full complexity of the interaction between ecological thought and the practical business of mankind's survival will not be realized soon enough and with sufficient clarity by any of the decision makers involved. . . I am convinced that while ecology may, in fact must, continue to develop as an intellectual discipline, there must also be an increasing interaction between ecology and public affairs in the broadest sense. This interaction not only has intellectual appeal in its own right but is of overwhelming practical significance.

Slobodkin continues, saying that

> The scientific problems of ecology constitute major intellectual

> challenges, involving the development of theories and analyses that are not trivial consequences of physiology, genetics, or other branches of biology, but must be developed on their own. . . . . Extant ecological problems . . . will require the painstaking collection of appropriate kinds of data, the development of suitably ingenious experiments, and the development of new theoretical constructs.
>
> I do not believe that any man can acquire full professional competence in all of the areas relevant to ecology. . . . it is necessary that we produce men equal to the best in their own areas but also capable of appreciating, evaluating, and communicating with other specialists . . . . We cannot afford the obfuscatory jargonal mysteries which in the past have protected incompetence in the various academic disciplines.
>
> . . . It must be recognized at the outset that conflicts of interest do exist with reference to almost all ecological decisions, that, for example, not all species can be saved from extinction but at the same time destruction of natural areas is dangerous and may have practical as well as aesthetic consequences.

It is necessary to attack the problems of pure ecology and to begin to understand the complex of factors involved in ecosystems, before management plans can be prepared and legislation devised for the protection and preservation of environments.

Information is needed about: individual species and their interactions with each other, the causes and effects of population fluctuations, and the environmental requirements of various species. Living systems are not usually linear and small changes in environmental conditions may have vast effects on organisms. As yet, we have little of the basic information to develop theories and models of natural systems.

At the University of Manitoba, we are embarking on a study of marsh ecosystems at Delta, Manitoba. Wetlands are of considerable importance in our province, occupying 40,000 square miles (16%); yet, our knowledge of them is meagre indeed.

This long-range marsh ecology research program is aimed towards a greater understanding of the dynamics of marsh ecosystems. Problems selected for initial study involve: the primary productivity of algae and dominant emergent plant species, the relationship of the vegetation of the forested ridge which lies between the marsh and Lake Manitoba, the developmental history of the marsh, and sedimentation processes. Other investigations include: the importance of parasites and their life cycles in various animal hosts, and studies of fish and birds, both of which are the top carnivores in many marsh food chains.

Quantitative assessment is being stressed, and it is hoped to develop new techniques for determining productivity. The dynamics of each component in the marsh ecosystem must be understood before any development of the potential of marshes as production areas can be contemplated.

The traditional concept of the naturalist and scientist is that of a relatively solitary individual unobtrusively making his observations, devising experiments, and glad to be left alone to pursue them. For centuries the scientist was considered not to be a contributor to human welfare. Only when it was realized that no knowledge was without potential value did society begin to pay some attention to the scientists involved.

At the present time, we are faced with a tension in the political atmosphere that has, unfortunately, included the scientific environment. Research today has overtones of urgency which may be necessary in some fields, but should have no place in many areas of science. The unfolding and expanding of the trained and critically disciplined imagination is essential in research. Time is very important, time to muse and ponder over the various ramifications and implications that emerge from the problem under investigation. Some of the best thoughts and most pertinent questions have emerged when writing up a project.

Ideally, the investigator should feel free to go back and take whatever time he may need for further work, for collateral reading, for extensive re-writing. He should feel free to put his manuscript away and, later, to reassess it with a fresh eye before submitting it for publication. Mental digestion must have time to take place. Nevertheless, time remains an essential element of the environment in which research is done (Friedmann 1960). However, deadlines should not prevent thought from maturing. Neither deadlines nor the need for a grant should be allowed to cut short investigations or precipitate publication. In ecology, the concerted interest and attention of scientists working in various fields must be brought to bear on environmental problems. Some long-term projects are essential -- two or three years is just not long enough.

As Slobodkin has stated "The future of ecology is intimately associated with practical problems." The ecologist must learn to communicate with politicians, economists, and engineers before it is too late. All must realize the need for a natural environment, in the familiar sense, if life of the quality we consider important is to continue.

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THE HUSBANDRY OF INFORMATION FOR ENVIRONMENTAL MANAGEMENT

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ABSTRACT

Proper management of our environment implies an understanding of the role of its various components, individually and collectively. The use of appropriate mathematical models in conjunction with computers has made it possible to study complex environmental variables with a view to improving management procedures. Our ultimate aim, of course, is to accumulate sufficient information so that environmental occurrences can be predicted within specified probability limits. When these techniques have been perfected we should be able to control our environment more efficiently with consequent long-term benefits for mankind.

The theme of our talks is large and complex and it will take some time merely to focus on its essential aspects. To begin with I adopt an anthropocentric but I hope enlightened point of view in regard to the meaning of the word "environment". That is to say, I presume we are concerned with the environment of man. The complexity of our subject is revealed among other ways in the fact that the environment of man often depends quite critically on the environment of many other organisms since these organisms are significant components of the environment of man.

The term "management" usually implies "good management". We are of course all in favour of good management. The catch is, do we know what good management is? Certainly we have to specify what criteria we have in mind before the measure of goodness of a management program begins to make sense, and to lend itself to estimation. Perhaps as a rough rule we might think of the greatest good for the greatest number as a generally acceptable criterion. This doesn't solve the problem of management however, because even when we know what is best for most we often do not know how this can be brought about. The accumulated wisdom of centuries including the organized research characteristic of this century have provided considerable insight into what sort of environment is good for us and even some plausible general ideas that might help to bring it about. The fact is that the environments of man are often far from optimal and specific solutions are urgently needed. Even when a sector of man's environment appears to be under good management, we cannot be sure that it could not be managed even better. Besides, some essential factor may be changing - then what innovations will be required to avoid a regression in management? It may be that there are no ultimate answers to such questions but there is no doubt that some answers are much better than others and we need to know how to find such "better" answers. I believe that if anyone says that man's environment is beyond our complete understanding that he may be speaking the truth but if he says we cannot improve our understanding then I think he has tuned out from his responsibilities. Besides, he is then quite wrong. Evidence of progress in developing improved management techniques is increasing and a science is emerging.

There are two seemingly opposite approaches to the improvement of program management. One is to find people who have an intuitive knack for dealing with complex problems and to put them to work at it. In large degree this has been the procedure through history. It has survived partly because it sometimes works and partly because there was no alternative. Its weakness is that the method of selecting the right man is largely a lottery and even in success it is as temporary as the life of man. The art of a purely intuitive genius is subject to hereditary decay and, by definition, pure intuition cannot be transmitted through language. These two factors would present an impasse were it not for the marvellous capacity of the human mind to construct models that mimic essential features of problems in the real world. Of course it is only too easy to construct models that are inappropriate for the problem at hand but when a model is found defective it can be discarded and the discovery of a defect often suggests an improvement. Models can be expressed verbally but are more useful if expressed in a mathematical form so that they can be analyzed for consistency and investigated to yield predictions which might be useful in management. Several relatively new mathematical disciplines with exciting possibilities are developing rapidly under the facilitation of modern digital computers. These include the various techniques of mathematical programming especially dynamic programming and Monte Carlo simulation of complex processes.

We have to bear in mind however that although the computer has enabled attack on many problems that could hitherto hardly be contemplated, many of our real problems are too large or complex for present-day computers. But even problems that are not too large for the computer may be very difficult for other reasons and we should attempt to specify what these obstacles are.

First, recall that everything depends on finding a model appropriate to the problem. The sort of model required is called an abstract system. It has a set of specified states and can receive a set of inputs. For each state in a deterministic system a value in a set of outputs is associated with each input. But stochastic systems are more realistic in which the output values can be specified only by a probability distribution. Another complication is that a specified change of stage may occur after certain inputs, changing the output distribution quantitatively and perhaps also qualitatively. For real systems, the inputs are usually also specifiable in a probabilistic way and the system may evolve through one set of states to another according to some developmental cycle. The life cycle of an insect exemplifies some of these statements. A gustatory input elicits feeding in the hungry state but not in a satiated state that follows feeding. Given nourishment the insect system develops through stages and becomes a new system after metamorphosis.

If we presume that a tractable model or abstract system can be formulated so as to represent such a real system in a plausible way, we are only safe at first base. One of the requisites of an appropriate model is that at least one of its variables correspond to observable phenomena - that is measurable, or countable events inherent in the natural system that presents our problem. Usually, perhaps almost always, there are essential variables in the abstract system that are either difficult or, in the present state of experimental art, impossible to observe. Such variables must be assigned postulated or hypothetical values if the model system is to be investigated quantitatively.

If there is any scope for managing the system, either the model or the real thing, there must be at least one input variable that can be manipulated by man and at least one output variable that one wishes to have approach as closely as possible to a maximum (say a yield) or a minimum (a pollution or other cost). The problem then is, at what level should one set the controllable input variable at each change of system state to optimize the outcome. If one can construct a program that instructs a computer what to do to solve the problem without overtaxing its memory or taking too much costly time, we might say we are on second base. If we know how to collect the experimental data needed for the observed input variables with sufficient reliability, without undue cost in money or time, we may say we are on third base. If the computer optimized output proves to correspond to reality then we have made a home run.

To summarize what has been said so far: - to manage any system, such as an environment we must have first an appropriate system model and then we must have information concerning the essential variables that can be observed, good guesses for those that cannot be observed and means to control at least one input variable. These requirements are very demanding because they are technically and mathematically complex and the methods needed are still only partially developed. The gleaning and processing of information about observable variables is the phase of the management process that I will try to discuss. The foregoing outline of the system concept was intended only to provide a motivation and a perspective for the statistical problems.

Most of the familiar techniques of statistical analysis are concerned with judgments concerning whether different "treatments" yield different results. This is obviously necessary whether or not one has a clearly defined model of the system under study. Very powerful techniques such as Analysis of Variance and Regression and super efficient experimental design such as Factorial Analysis have been available for about three decades. These methods are largely applied to means computed from measurement data and are economically very important for example for crop and livestock yield data. Unfortunately the immediate economic importance of these methods has, I think, tended to eclipse methods for dealing with proportions which seem to me more appropriate in ecological studies important to environmental management where emphasis is on population analysis.

In reaching decisions in management of any system it is common sense to use all of one's relevant experience available both before an experiment or survey is done and after the results are in. During the reign of R. A. Fisher it was an almost universal dogma that statistical methods could deal only with data and that no subjective estimates could be tolerated. The futility of trying to exclude subjective judgments is however revealed in the absurd rule of thumb in classical statistics which rejects the null hypothesis at a probability of 5% but accepts it at 6%. Of course one has to do something like this to arrive at a decision but that does not argue away the subjectivity of the procedure.

Theory for decision under uncertainty has been available for two decades thanks to Abraham Wald but in its classical form it does not provide explicitly for using background or subjective information available from related systems before data generated directly from the system under study is forthcoming. We should welcome a formal procedure for computing uncertainty that takes into account all the information available including the subjective part prior to any new experimental enquiry or survey. An appraisal of prior information is needed anyway before one can rationally decide whether more enquiry is needed. Such a procedure has been available for two hundred years since it was conceived by the Reverend Thos. Bayes F.R.S. and was used by the great astronomer, LaPlace.

As far as I can gather the proscription against the subjective use of Bayes theorem was a sour fruit of the scientific philosophy called 'logical positivism'. The words "cause" and "apriori" are used in many older discussions of Bayes theorem and these words were under a philosophical cloud during the flowering of statistical science in the first half of our century. But if 'cause' is replaced with "hypothesis" and 'apriori' is replaced with "initial" or "tentative", these metaphysical objections evaporate. At least the number of neo-Bayesian statisticians is growing and several books on this approach are now available. As yet the majority still operate by the classical rules.

The formal equivalence of subjective and objective probability has been demonstrated by several scholars, especially de Finetti and Koopmans. In addition to application of subjective probability techniques in decision theory they are also fitting into the modern theory of information in both a useful and an intellectually satisfying way. Perhaps most important, they make it possible in principle to build plausible models of adaptive systems for changing environments. These are still under development for example at the Massachusetts Institute of Technology, but they appear promising and are also essential to a realistic rationale for management of dynamic systems in an uncertain environment. The methods are not always simple and for complex problems will require the use of large computers.

In order to justify my emphasis on new approaches to statistical inference I should point out that many of the standard methods are severely restricted on one way or another. On the one hand there is often an assumption that the distribution of the basic variable is normal. One cannot be sure of this in small samples from unfamiliar systems so that the normality assumption must often be subjective in this case. In an attempt to escape this, non-parametric methods have been developed that do not make any assumptions about the shape of the probability distribution. Some of these methods are simple to use and attractive especially to behavioural scientists. However, they are, like the classical parametric methods, wasteful of prior information and lose advantage when sufficient knowledge accrues to fit a fairly definite shape to the distribution. It is only the Bayesian approach that allows one to use the same method to monitor and guide the growth of knowledge and insight of a system from initial stark uncertainty to a stage where one can rationally consider how the system might advantageously be managed. This does not mean that all the standard methods be scrapped but it does mean that a more satisfactory rationale for statistical inference is at hand for the days ahead when we will, I believe, increasingly feel the need for guides to wise decisions rather than only a criterion to determine whether some data should be published or not.

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INTEGRATED APPROACH TO PEST CONTROL

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ABSTRACT

It involves the harmonious use of chemical, biological, genetic, physical, and other available methods of pest control. In an integrated approach to pest control chemical pesticides will be one of the many tools in combating pest problems. In order to carry out a successful integrated pest control program an interdisciplinary approach in research pertaining to pest control will be necessary. Since the development of chemical pesticides with greater selectivity and specificity against key insects will become increasingly important, close co-operation between industry and government researchers will be essential in order to minimize the tremendous development cost of such pesticides. Greater emphasis on dosage rates and timing of applications will be most important. Industry and research scientists fully realize that the integrated approach to pest control problems is a sound one. Until such time that satisfactory biological, physical, genetic or other programs are developed for major economic pests, chemical pesticides will continue to play an important role as short term pest management tools, and in increasing crop production throughout the world.

The term Integrated Control which in recent years has become a subject of increasing importance, especially in the control of orchard pests and certain other economic pests of field crops, vegetables, forests and insect pests attacking man and animals is not by any means a new concept. One of the oldest examples of integrated control is the use of cultural measures such as crop rotation, summer fallow and the proper timing of such cultural measures to prevent the simultaneous occurrence of host plant and pest organism. Integrated control is sometimes misunderstood as biological control by some people but Integrated Control by no stretch of the imagination precludes the use of pesticides. In an integrated approach to pest control the use of pesticides will be continued but in harmony with ecological and technical measures and in a manner that will be compatible with biological control and other control schemes being used to reduce pest populations and maintain them at levels below economic thresholds. The concept of integrated control therefore supplements or augments the activities of beneficial insects (Metcalf 1966).

It is well recognized that pesticides have played a vital role in increased crop production and have lowered the incidence of human illnesses throughout the world. The pesticide sales in the United States and Canada have already exceeded $200 million and will continue to increase each year.

While the importance of chemical pesticides is generally recognized and there is every likelihood that the use of pesticides will continue to increase in the future, there has been in recent years a great deal of concern over total reliance on pesticides for pest control. In past years, entomologists were mainly interested in controlling target pests but showed little concern about the ecosystem and the interaction of pest insects and mites, plant diseases, parasites and predators, host plants, weeds, soil and its management, and other important aspects. Similarly plant pathologists were mainly concerned with plant disease control and the researcher on weed science was mainly interested in weed control. In an integrated approach to pest control it will be necessary for us to take an interdisciplinary approach in research pertaining to pest problems.

NECESSITY FOR AN INTEGRATED CONTROL APPROACH

The importance and necessity of an integrated pest control approach is not only a subject of discussion nationally, but internationally. The Food and Agriculture Organization of the United Nations sponsored a symposium on integrated pest control that was held at its Rome headquarters in October 1965 and was attended by 87 representatives from 34 member countries and seven international agencies. Similarly a symposium on "Pest Control by Chemical, Biological, Genetic and Physical Means" was organized at the meeting of the American Association for the Advancement of Science held in Montreal between December 26 - 31, 1964. Scientists of various disciplines were brought together to discuss the current status and the future opportunities of pest control.

With increased knowledge and sophistication in the control of insects, diseases, weeds, nematodes, etc. by chemical and other means now available an integrated control approach is a necessity in modern agriculture. Regardless of a scientist's field of study he would have to evaluate a given compound in relation to the total environment of a pest species. In other words we can no longer afford to choose a pesticide only on the basis of its activity against a target pest, and ignore its affect on non target organisms in a complex agro-ecosystem. Within our own organization we have had to modify our thinking with regard to broad spectrum insecticides and miticides. There was a time when an entomologist assessed the performance of pesticides on the basis of percentage kill of the target insects or mites. Today, the first question they ask is how safe is it against parasites, predators and to humans?

They are now demanding compounds that will not kill the entire target pest population, but would leave a few for the beneficial insects to feed upon. Similarly, plant pathologists are now looking at new approaches to the use of chemical pesticides that could be utilized in more subtle ways, be applied less frequently or in smaller dosages, or could exploit advantageously the peculiarities of the pathogen, host or environment to bring about the desired effect (McNew 1964). Weed research scientists too are looking for herbicides with increased specificity and selectivity. In addition to chemical pesticides which have provided us with clean, high quality, unblemished food at reasonable prices, other approaches to the problems of pest control are now seriously being considered in an integrated control program. We in the chemical industry fully realize that in an integrated approach to pest control, chemical pesticides will be one of the many available tools for combating pest problems. It is also quite clear that in an integrated control program selective chemical pesticides will be used against key insects only when necessary and with greater emphasis on dosage rates and timing of applications. Integrated control programs may make more effective use of insect parasites, predators or pathogens. They may also use the pests themselves for self destruction as demonstrated by the control of screw worm by the sterile male technique. Other chemical, biological genetic and physical means may also be developed. Although it is obvious that the need for pesticides will decrease in an integrated approach to pest control, both industry and research scientists fully realize that the integrated approach to pest problems is a sound one. Until such time that satisfactory biological, physical, genetic or other programs are developed for major economic pests, chemical pesticides will continue to play an important role as short term pest management tools.

PROBLEMS ASSOCIATED WITH THE INTEGRATED CONTROL APPROACH

In order to initiate a successful integrated control program, it is essential that there is an effective control measure available to control the key insect either with a selective pesticide or by non chemical means. In addition, parasites and predators should be present in the population in sufficient numbers for the control of secondary pests. If these pre-requisites for a successful integrated program cannot be met then there is nothing to integrate.

The integrated control approach to pest control can only be successful if decisions are based on economics of pest control, knowledge of economic injury levels, data on life tables for major economic pests, availability of selective pesticides, and constant vigilance and alertness on the part of the farmer.

Integrated control of orchard pests which Pickett in Nova Scotia pioneered a few years ago is now actively being pursued in some areas of British Columbia and in the Pacific Northwest area of the United States. In an integrated program on apples in British Columbia the key insect is the codling moth. Considerable progress has already been made on the control of codling moth by the sterility method and the project is advanced to the stage where a large scale demonstration is planned (Madsen 1968). Another successful integrated program which is now being practised on a commercial basis is the control of McDaniel spider mite on apples in British Columbia and Washington. The predatory mite *Typhlodromos occidentalis* is very effective in controlling the McDaniel mite and is also resistant to organic phosphorous insecticides.

It was therefore possible to develop a spray program that would encourage the increase of predator mites. In 1968 some 56 Naramata growers in British Columbia followed an integrated control program for orchard mite control with the aid of a mite count service which was established in the area. This service included the help of a fieldman and a lab assistant, and participating growers were provided bi-monthly and in some cases weekly mite counts of predatory mites, McDaniel mite, European Red mite and rust mite. Since thorough knowledge of orchard pests and their identification is essential in an integrated control program the mite count data provided the grower with a regular check of his orchard and psychologically assisted him to have confidence in the integrated program. While the program was generally considered successful a few orchards did suffer mite damage. The most severe mite damage occurred in orchards where the grower did not check the mite population in the various parts of his orchard. This would therefore indicate the necessity and importance of extension education and demonstration plots to enable the growers to appreciate the complexity and value of integrated control.

Another problem reported by Madsen was the increase of pests such as leaf roller and leafhoppers when the use of broad spectrum insecticides was discontinued in an orchard. In view of the complexity of the integrated control approach it would be foolish to think that the adoption of this practise will solve all our pest control problems. While there has been tremendous progress made in the control of pests using new methods such as autocidal and microbial control techniques, the use of chemosterilants and attractants, and by biological, genetic, and physical means it will require additional knowledge and field investigation before these techniques can be used practically. In the meantime pest problems that are confronting us today must be solved and chemical pesticides will continue to be used as pest management tools.

DEVELOPMENT OF SELECTIVE PESTICIDES FOR INTEGRATED PEST CONTROL

It is obvious from the foregoing discussion on the integrated approach to pest control that the chemical industry is confronted with a tremendous challenge to produce compounds that are highly specific and selective in activity. There are already a number of selective pesticides on the market and new ones are being synthesized. The main question that arises is whether the chemical industry will continue the development of selective insecticides in view of the tremendous development cost involved.

The cost of developing broad spectrum pesticides in 1964 was $2,918,000 (Gasser 1966) and this cost was considerably increased in 1968. The development cost for a selective pesticide with a narrow spectrum is approximately the same and the use will be restricted as compared to a broad spectrum pesticide with a greater sales potential. Naturally chemical companies that happen to discover a selective pesticide which controls a key pest will realize the benefits as it will readily fit in an integrated control program. Management of basic pesticide manufacturers frown upon the tremendous costs of development of a pesticide, the time required to develop and market a pesticide, and the risk that the pesticide may become obsolete due to pest resistance. In view of these problems it is debatable whether chemical manufacturers will make a concerted effort to develop selective pesticides.

If pesticide manufacturers do synthesize selective compounds for integrated control the field testing of these compounds must be carried out in as diversified a manner as the crop insect complex demands. This could be accomplished by close co-operation between industry and government researchers. By doing this it may be possible to reduce part of the high cost of developing selective pesticides for integrated control programs.

In conclusion it seems clear that teams of chemists, toxicologists, plant breeders, entomologists, plant pathologists, plant physiologists and geneticists should approach the problem of pest control and development of selective insecticides, fungicides, nematocides and herbicides. With this concerted effort it is possible that in the not too distant future we will be able to produce tailor made compounds for control of specific pests. This can only be accomplished if industry and research scientists at national and international levels recognize that pest control as a science has become very sophisticated and requires a greater co-ordinated effort in order to integrate all the available knowledge of pest control.

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POSSIBLE EFFECTS OF CHANGES IN THE ENVIRONMENT ON GRASSHOPPER POPULATIONS [1]

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ABSTRACT

The effects of environmental changes on grasshopper populations in the Prairie Provinces are reviewed. Possible effects on grasshopper populations of changing the environment by reducing summer fallow acreage, increasing use of mineral fertilizers and weed killers, modifying road construction, and increasing acreage for cattle pasture are discussed.

Some grasshoppers have become economic pests as a result of changes in the environment brought about by agricultural development (Uvarov 1956, 1958). The species that periodically cause economic damage to agricultural crops in Manitoba are *Melanoplus sanguinipes* Fabricius, *Melanoplus bivittatus* (Say) and *Camnula pellucida* (Scudder). Environmental changes that alter the populations of the above species will be considered here.

BASIC ECOLOGICAL REQUIREMENTS OF GRASSHOPPERS

Grasshoppers develop most rapidly in a warm, dry environment. The minimum temperature for development is near 60°F (15°C) and the maximum about 104°F (40°C) (Parker 1939). The optimal range of humidity for development is 40 to 70% r.h.

Laboratory studies have shown that *M. sanguinipes* develops most rapidly on dandelion, wheat, and mustard (Pickford 1962); *M. bivittatus* on wild lettuce, garden lettuce, alfalfa, and red clover (Tauber *et al* 1945); and *C. pellucida* on grasses, particularly tall wheat grass, Russian wild ryegrass, Kentucky bluegrass, and Canada bluegrass (Putnam 1962).

Each of the three species of grasshopper has special requirements with regard to oviposition sites. *M. sanguinipes* lays its eggs in soil near the roots of grass, grain stubble, alfalfa or weeds (Shotwell 1941); *M. bivittatus* in bare patches among sod clumps, alfalfa or weeds; and *C. pellucida* in sod, usually Kentucky bluegrass, *Poa pratensis* (Bird and Romanow 1966) or *Agropyron smithii* (Criddle 1921).

CONDITIONS FOR POPULATION INCREASE

An ambient temperature of at least 80°F (26.7°C), an adequate supply of hosts and long periods of sunny, dry weather favor rapid development to the adult stage, and if the food supply remains adequate, oviposition will be high. In agricultural areas, it is unlikely that a food shortage will occur since new crops are planted each year.

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There is a direct relationship between the number of hours of sunshine per day and rate of grasshopper development. In general, conditions of drought favor grasshopper outbreaks. Usually, a grasshopper population requires two to three favorable years to increase to epidemic proportions.

CONDITIONS FOR POPULATION DECREASE

Cool wet weather, a shortage of suitable food and restricted oviposition sites tend to decrease populations. Cool weather retards development and inhibits oviposition. Wet, warm weather promotes disease caused by *Entomophthora grylli* Fres. in *C. pellucida* and *M. bivittatus* (Pickford and Riegert 1964): in wet, cool weather a reduction of grasshopper growth and survival occurs. Heavy rainshowers also affect nymphal survival adversely through drowning or chilling (Dempster 1963).

Hatching is delayed by wet weather, partly by the low temperatures and partly by the shading from the dense lush vegetation that is produced under these conditions. Late hatching delays adult emergence (Pickford 1960), and late adult emergence reduces oviposition since the time available for oviposition is reduced.

CHANGES IN THE ENVIRONMENT

Environmental changes that have altered grasshopper abundance have been caused mainly by agricultural development. In Montana, grasshopper population growth is enhanced in overgrazed pastures (Pepper 1956): when grass is short, more sunlight falls on the grasshoppers and their temperature increases. Consequently their metabolic rate increases and they eat more of the already limited supply of grass. Similarly, cereal grain fields have been exploited by *M. sanguinipes* because this species prefers a semi-open type of habitat with areas of bare soil amongst the vegetation for basking and oviposition (Putnam and Handford 1956).

A study of grasshopper populations in the Red River Valley indicated the effects of changes that have been brought about by drainage (Bird and Romanow 1966). Prior to settlement the Red River Valley was a wet marshy area with poor drainage. At the end of the 19th century, when the Prairies were being opened up for agriculture, drainage projects were begun. These were completed in 1907. Large ditches were constructed to carry off snow water and excess rainfall; the soil dried more quickly in the spring and made the establishment of a grain growing economy feasible. In the first quarter of the 20th century, *C. pellucida* was the dominant grasshopper pest. However, during the second quarter of the century, this species appears to have been displaced by *M. bivittatus.* Bird and Romanow (1966) suggest that this displacement of *C. pellucida* resulted from a decrease in pasture acreage in the past 30 years and the associated decline in the abundance of favored food plants, *Phleum pratense* and *A. smithii*. The decline in pasture acreages was associated with the increased mechanization of farm operations and the decreased use of horses. The construction of deep ditches along municipal roads caused another disruption of the environment. When first constructed the ditches presented areas of bare soil between the fields on each side of the road. This soil was colonized in the first stages of succession by annual weeds followed by a gradual invasion of grasses. Eventually most of the roadsides became covered with brome grass, couch grass or bluegrass. Where annual plants are dominant, conditions are ideal for *M. bivittatus* since this species feeds on the weeds and lays eggs in the bare soil between the plants. The newly emerged first instar nymphs probably feed on nearby weed seedlings. When the population is dense, the hoppers soon move into the fields of grain adjoining the roadside. Roadsides that become overgrown with grasses cannot support large numbers of *M. bivittatus* but can support large populations of

C. pellucida if patches of Kentucky bluegrass or Canada bluegrass are present. Nymphs of *C. pellucida* also move into adjacent grain fields soon after hatching.

Roadside ditches present essentially the same problem today as they did when first constructed. The structure of the ditches changes continually because soil is washed in from the fields or the slopes of the roadsides and is blown in during dry periods. At the same time the flow of water is restricted as the density of the grasses increases. Therefore ditches are continually being rebuilt and the roadsides regraded. Reconstruction of the ditches destroys the stable plant community of grasses. The plant succession begins again and consequently, the conditions favorable for the development and oviposition of *M. bivittatus* are restored. A survey conducted in 1968 in the Red River Valley showed that ideal habitat conditions for *M. bivittatus* were present on about 10 per cent of 300 miles of road allowance covered in the survey.

Another study which illustrated changes in grasshopper populations associated with habitat changes was conducted in the southwest region of the province near Melita (Bird *et al* 1966). This region has been semi-arid, subject to periodic drought and, before settlement, was covered by short grass prairie. After the native sod was broken for agricultural use, the light sandy loam soil became susceptible to wind erosion. During the last major drought from 1929 to 1934, soil blown into drifts along the fencerows provided ideal sites for oviposition, especially on south and west-facing slopes. Weeds, which became abundant on farms abandoned during this time, were fed on freely by the grasshoppers. Crops adjacent to the roadsides also provided food for the grasshoppers.

Since the outbreak in the 1930's there have been two less severe outbreaks. Bird *et al* (1966) attribute the decreased severity of these most recent outbreaks to those changes in farming methods specifically designed to control soil erosion and weeds. For example, hedges planted around the fields reduced soil drifting and thus reduced oviposition sites. When weeds were sprayed with herbicides there was less food available to nymphal grasshoppers. As in the Red River Valley, reduction in the use of horses for farm work caused a reduction in pasture acreage.

FUTURE CHANGES THAT MAY AFFECT GRASSHOPPER POPULATIONS

Since changes in grasshopper habitat caused by agricultural practices have altered grasshopper populations in the past, it is of interest to speculate on (1) the changes that may occur in agriculture in the future and (2) how these changes may affect grasshopper populations. Possibilities for reducing populations may be discovered by further studies on the ecology and behaviour of grasshoppers.

Some agronomists are advocating a change to continuous cropping on the Prairie Provinces; in other words, very few fields would be left in summer fallow. At present practically no grasshopper eggs are laid in fallow fields. Consequently, an increase in the acreage sown to cereals would mean that more oviposition sites would be available for *M. sanguinipes*, particularly in cropped loamy soils. Fall cultivation of stubble might cause limited destruction of egg pods (Putnam and Handford 1956) and thus diminish the rate of population increase. However, this mortality may be more than offset by the increase in population caused by the increased acreage sown to cereals. In warm, dry, sunny summers that favour an outbreak, crop damage might be more widespread than it has been in recent outbreaks.

The trend toward increased use of mineral fertilizer during the past few years may or may not favor an increase in grasshopper population. Smith and Northcott (1951) found that *M. sanguinipes* (cited as *M. mexicanus mexicanus)* survived longer and produced more eggs on wheat grown on a high level of nitrogen than on a low level of nitrogen. On the other hand, the vigorous and lush plants that result from fertilization may be more resistant to attack. But, as McGinnis and Kasting (1966) have indicated not only food quality needs to be considered in grasshopper nutrition but also food quantity. This question involves consideration of food utilization. If grasshoppers do not utilize a high percentage of the food they ingest, they require a greater quantity of food to obtain the nutrients they need. Therefore, even though the population of grasshoppers does not increase greatly on food of low nutrient content, much damage would be inflicted on a crop. It is clear that in our present state of knowledge no certain prediction can be made about the effects of levels of fertility on the damage caused by grasshoppers. This problem requires much more study.

In some parts of Manitoba, a new system of constructing roadside ditches is being introduced. Presently, the roads are built entirely on the 99 foot road allowance. The soil dug up to make the ditches is piled on the road resulting in a high crown. The ditches are as deep as required to carry off excess surface water and the road is built with the surface at least 18 in. above prairie or ground level to prevent snow accumulation in winter. The slope of the roadside and the top of the bank on the field side of the ditch provide ideal oviposition sites for grasshoppers. These slopes have the advantage of being well-drained, and dry more quickly than the surrounding soil. In autumn, the south-facing slopes are most frequently used for oviposition as these are protected from the prevailing west wind and have the greatest exposure to sunlight. Few eggs are laid in slopes thickly covered with sod but those that are weedy or bare in patches are attractive as oviposition sites for *M. bivittatus* and *M. sanguinipes.*

The new method of road construction makes the ditch shallower and wider by extending the ditch further into the field. Thus, the slope to the crown of the road is less steep and the vertical bank on the side of the ditch farthest from the road is eliminated. This system, first proposed for weed control, seems to offer hope for grasshopper control as well. The ditch should dry more quickly and may even be sown to crop to the edge of the road itself. The crop will prevent establishment of *Poa* sod in which *C. pellucida* deposits its eggs and of weed patches that favor the growth of *M. bivittatus.*

Another method of altering the roadside habitat would be to sow the slopes of newly-graded roads to a grass that is less suitable as grasshopper food such as brome grass (Pickford 1958, 1962) or crested wheatgrass (Davis 1949). Perhaps a mixture of such grasses would have a greater effect than a single species.

The stated objective of the Manitoba government to increase cattle production will lead to greater acreages being devoted to hay and pasture. If the vegetation is not dense in these fields, an increase in grasshopper population could result. As Dempster (1963) pointed out, grasshoppers prefer a habitat that has a mixture of short and long vegetation in patches. Development and oviposition increase in this type of habitat. Patchiness can be caused by poor soil or by overgrazing.

Little is known of the role natural predators and parasites play in the dynamics of grasshopper populations. Generally, the common predators and parasites are more sensitive to environmental changes than are their hosts. One important predator of adult grasshoppers is Franklin's Gull. Flocks of these may be seen on pastures or mowed hayfields in August where they probably feed on large numbers of grasshoppers. W. Romanow of the Winnipeg Research Station (personal communication) has stated these gulls have interfered with insecticide tests in the field by eating grasshoppers in his experimental plots between the time the pre-spray counts were made and the time the test insecticides were to have been applied. If the population of Franklin's Gulls were reduced through destruction of their nesting habitat in marshes and sloughs, an increase in grasshopper population could result.

In summary, any changes in the environment that cause a mosaic type of vegetation to develop, will lead to an increase in population. The grasshoppers then have areas of sparse vegetation in which to bask during the cooler parts of the day and areas of tall green vegetation in which to escape from the heat in the hotter parts of the day. In uniform or dense vegetation populations will be greatly reduced.

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RESOURCE MANAGEMENT IN RETROSPECT: AN EPILOGUE

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I have been asked by your Editor for a few concluding comments on the foregoing symposium. It is with a sense of serious inadequacy, however, that I attempt to meet this request. My comments in no way attempt to summarize what has been said but rather constitute a brief look at some of the implications of mans creative actions relative to his stewardship of the planet that he inhabits.

It is evident that man is an integral part of nature but is different from other organisms. Because he is a rational being he has consciously endeavored throughout history to improve his own well being. When he first nursed and tended a fire for protection and warmth, domesticated animals to assist in meeting his needs, or converted large acreages of virgin prairie to grain fields he was consciously modifying his environment to serve his own ends. He has never been able to predict with certainty, however, the long term results of his actions. To date he has been generally successful in his endeavors but now faces a dilemma resulting from his creative activities. On the one hand in the developed countries technological advances have permitted man to live better and with less physical effort than ever before. Food is more plentiful and less expensive than in earlier periods, health and longevity are much improved, and communication and transportation have reached a level far beyond anything known to history. On the other hand, we have reached a point where there is serious concern about side effects and by-products from these advances. The advances in medical science, which have drastically reduced the death rate and increased longevity, have contributed greatly to the world's exploding human population. Use of pesticides to protect crops from weeds, diseases, and insects has given rise to residue problems whether they be organochlorine insecticides or mercury fungicides. For the convenience of the automobile we are now paying the price of smog, air pollution, tragic accidents, and unsightly "bone yards". Increased agricultural efficiency and the ever increasing demand for more processed goods have caused a major proportion of the population to migrate to, and live in, large urban centres. In all large cities the ill-effects of overcrowding and population density are apparent.

The present symposium, therefore, has been timely. Each speaker has viewed circumstances from his own vantage point and has projected into the future. The contributions are about equally divided among three broad general areas: Political (Resources and Resource Management), Philosophical (Research Management), and Scientific (Interactions between organisms and the environment). Despite the diversity in approach, the underlying goal has been to identify some of the problems resulting from our present form of society and to suggest means of solving or eliminating them.

The necessity for close interaction among the three areas is clear. The political sector is charged with preserving and protecting the natural resources of the country for the benefit of its citizens now and in the future. One of its responsibilities, therefore, is to provide support and encouragement for scientific investigations toward this end. The research manager is the next link in the chain; he must employ the resources provided, both men and materiel, so that the return from the investment will be maximized. Because scientific investigation is now a costly pursuit, accountability and effective management is demanded. Ultimately there is the scientist, in the present instance the biologist, who has the training, experience, curiosity, and desire to obtain answers to specific problems. Communication and co-operation among the specialists, each with details on a particular aspect, can permit solution of the overall problem by organizing and integrating the available pertinent information. Only when politician, manager, and scientist work together toward the common goal can success be maximized.

Today human success is measured largely in economic terms and year by year we strive to increase the Gross National Product; if the future is disregarded there is no need to do otherwise. If man is to accept his stewardship of this planet with a true sense of responsibility, however, he cannot allow current monetary reward to be the sole objective. At present a large proportion of the population in the developed countries lives more comfortably and better than did royalty less than two centuries ago. This would not be possible, however, had earlier generations depleted or destroyed those natural resources that have made our present standard of living possible. Is it not our responsibility also to bequeath to future generations a productive and viable planet? No doubt this could be done if we were to revert to those earlier ways of life with all the attendant disadvantages of famine, diseases, early death, and so forth. Such action, of course is unthinkable, nonsensical, and unacceptable. Realistically then, we must strive to maintain and improve the welfare of mankind but at the same time we are obliged to devise solutions to the detrimental by-products of modern society. To do this we will have to use our science and technology with vision and wisdom. Such is the challenge we face today!

THE ARTHROPOD FAUNA OF *DIBOTRYON MORBOSUM* (SCHW.) THEISS. AND SYD. (ASCOMYCETES: DOTHIDEACEA) IN MANITOBA AND SASKATCHEWAN

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ABSTRACT

Over 2,700 specimens of arthropods representing 10 orders, 50 families, 82 genera and 97 species were collected from 8,000 knots of *Dibotryon morbosum* (Schw.) Theiss. & Syd. in Manitoba and Saskatchewan. The various species present in the knots are separated into fungivorous inhabitants, common visitors and chance visitors. The parasites recovered from this fauna are listed. The two major differences between the fauna of black knot of cherry and the known fauna of shelf and bracket fungi in North America were more lepidopterous species occurred in black knot of cherry while dipterous and coleopterous species occurred mainly in shelf and bracket fungi.

INTRODUCTION

Several recent studies have been made in North America on the fauna of basidiomycetous fungi. The species of animals taken from the birch bracket fungus, *Polyporus betulinus* Bull. ex Fr. in the Gatineau Park, Quebec, were recorded by Pielou (1966), and in the four eastern provinces of Canada by Pielou and Verma (1968). The arthropod fauna of *Fomes fomentarious* (L. ex Fr.) Kichx. growing on dead birch in the Gatineau Park, Quebec, was listed by Pielou and Mathewan (1966). The insects and other inhabitants of shelf fungi were studied by Graves (1960) in the Chicago area, and in the southern Blue Ridge region of western North Carolina by Graves and Graves (1966b and 1968).

Wong and Melvin (1965), in a study of the arthropod fauna of the ascomycetous fungus *Dibotryon morbosum* (Schw.) Theiss. & Syd., noted that certain insects feed on the black knots of cherry, and others utilize them for hibernation. Additional species have since been recorded and the arthropod fauna of this habitat is divided into the three categories defined by Graves and Graves (1966a). These categories are: (1) species entirely dependent on the host fungus for food and usually shelter (Mycetobionts), (2) species often present in but not entirely dependent on the host fungus and may be found elsewhere (Mycetophiles), and (3) chance visitors that are not closely associated with the fungi (Mycetoxenes).

METHODS

Old and new black knots of cherry were collected at three different periods of the year in Manitoba and Saskatchewan. Collections were made in very early May for Mycetoxenes and Mycetobionts; in July for Mycetobionts; and in October for Mycetobionts, Mycetophiles and Mycetoxenes. The old and new knots were placed in large glass or polyethylene containers and were examined daily for adult emergence.

RESULTS

Over 8,000 black knots of cherry were obtained from 290 collections throughout the range of choke cherry, *Prunus virginiana* L., and pin cherry, *Prunus pensylvanica* L.f., in Manitoba and Saskatchewan. Over 2,700 specimens of arthropods representing 10 orders, 50 families, 82 genera and 97 species were collected and their type of association with *D. morbosum* are indicated in Table 1. The parasites recovered from the insects feeding in black knot are indicated in Table 2.

There was no apparent difference in the insect fauna of black knot on choke cherry and pin cherry. Four major differences were noted when the arthropod fauna of black knot of cherry was compared with the known arthropod fauna of shelf and bracket fungi in North America. These are: (1) lepidopterous species occurred mainly in black knot of cherry, (2) dipterous and coleopterous species occurred mainly in shelf and bracket fungi, (3) wood-boring species of Coleoptera and Lepidoptera occurred only in black knot of cherry, and (4) collembola occurred only in shelf and bracket fungi. These faunal differences appear to reflect the difference between the two habitats. The habitat of the shelf and bracket fungi consist of mycelium, and that of the black knot of cherry consist of hypertrophied plant tissue and mycelium.

Table 1. Species associated with *Dibotryon morbosum* segregated into Mycetobionts (1) Mycetophiles (2) and Mycetoxenes (3).

Species	Type of association	No. of adults
INSECTA		
PSOCOPTERA		
Unidentified sp.	3	4
THYSANOPTERA		
Phaeothripidae		
Cryptothrips rectangularis Hood	3	30
HOMOPTERA		
Aphididae		
Rhopalosiphum cerasifoliae (Fitch)	3	7
NEUROPTERA		
Chrysopidae		
Chrysopa sp. prob. *carnea* Stephens	3	1
Chrysopa sp.	3	7
COLEOPTERA		
Buprestidae		
Buprestis sp.	3	6
Carabidae		
Bembidion sp.	3	1
Cerambycidae		
Elaphidionides villosus (Fab.)	3	2
Psenocerus supernotatus (Say)	3	4
Chrysomelidae		
Phratora purpurea purpurea Brown	3	2
Xanthonia decemnotata (Say)	3	2
Corynetidae		
Phyllobaenus humeralis (Say)	3	4
Phyllobaenus subfasciatus (Lec)	3	1

Species	Type of association	No. of adults
COLEOPTERA (Continued)		
Curculionidae		
Conotrachelus nenuphar (Hbst.)	2	97
Pseudanthonomus sp.	3	10
Lathridiidae		
Melanophthalma sp.	3	2
Melandryidae		
Canifa sp.	1	4
Canifa pallipes (Melsh.)	1	83
Scolytidae		
Phloeotribus liminaris (Harr.)	2	226
Staphylinidae		
Staphylinid sp.	3	3
LEPIDOPTERA		
Aegeriidae		
Synanthedon pictipes G. & R.	1	59
Thamnosphecia scitula (Harr.)	1	1
Arctiidae		
Haploa lecontei Guer.	3	3
Carposinidae		
Carposina	1	6
Carposina comonana	1	172
Gelechiidae		
Chionodes sp.	1	29
Filatima sp.	1	14
Telphusa sp.	1	606
Xenolechia velatella Busck	1	39
Geometridae		
Hypagyrtis sp.	3	2
Noctuidae		
Polia imbrifera Gn.	3	2
Olethreutidae		
Grapholitha prunivora Walsh.	2	145
Pyralidae		
Acrobasis tricolorella (Grt.)	3	3
Phlyctaenia sambucalis Schiff.	3	2
Tineidae		
Tinea sp.	3	1
Tortricidae		
Pandemis canadana Kft.	3	1
Yponomeutidae		
Argyrestia oreasella Clem.	1	1

Species	Type of association	No. of adults
DIPTERA		
Cecidomyiidae		
Asynapta sp.	1	1
Winnertzia sp.	1	5
Chloropidae		
Gaurax apicalis Mallock	1	7
Gaurax festivus Loew.	1	6
Gaurax poss. *montanus* Coq.	1	65
Oscinella catalpae (Mallock)	1	339
Oscinella sp. nr. *catalpae* (Mallock)	1	12
Oscinella sp.	1	6
Lonchaeidae		
Lonchaea polita Say	3	1
Muscidae		
Phaonia sp.	3	1
Sciaridae		
Bradysia sp.	1	152
HYMENOPTERA		
Formicidae		
Leptothorax muscorum (Nyl.)	3	10
Tenthredinidae		
Amauronematus sp.	3	1
ARACHNIDA		
ARANEIDA		
Araneidae		
Araneus nordmanni (Thorell)	3	1
Clubionidae		
Clubiona sp.	3	2
Dictynidae		
Dictyna sp.	3	3
Linyphiidae		
Immature - unidentified species	3	2
Salticidae		
Metaphidippus sp.	3	1
Theridiidae		
Theridion poss. *frondeum* Hentz.	3	22
Thomisidae		
Philodromus sp.	3	5

Species	Type of association	No. of adults
ACARINA		
Acaridae		
Histogaster carpio (Kramer)	1	7*
Histogaster n. sp.	1	3*
Tyrophagus putrescentiae (Schrank)	1	46*
Thyreophagus sp. nr. *corticalis* (Michael)	1	9*
Cepheidae		
Cepheus sp.	1	1*
Glycyphagidae		
Glycyphagus domesticus (DeGeer)	1	3*
Laelaptidae		
Hypoaspis sp. nr. *giffordi* Evans & Till.	1	2*
Oribatulidae		
Pelops sp.	1	1*
Peloribates sp.	1	1*
Phauloppia sp.	1	1*
Scheloribates latipes (Koch.)	1	3*
Saproglyphidae		
Calvolia sp.	1	3*
Saproglyphus neglectus Berlese	1	9*

* Due to the great number of mites obtained, only number of collections are indicated.

Table 2. Species of parasites recovered from insects inhabiting *D. morbosum*

Parasites	Hosts	No. of adults
HYMENOPTERA		
Braconidae		
Apanteles sp.	unknown	2
Brachistes sp.	*Synanthedon pictipes* G. & R.	1
Bracon sp.	*Telphusa* sp.	3
Bracon sanninoideae (Gahan)	*Synanthedon pictipes* G. & R.	21
Bracon variabilis (Prov.)	*Telphusa* sp.	20
	Carposina commonana Kft.	56
	Grapholitha prunivora Walsh	26
	Synanthedon pictipes G. & R.	45
	Conotrachelus nenuphar (Hbst.)	8
Helconidea ligator (Say)	unknown	36
Iphiaulax americanaus Prov.	*Synanthedon pictipes* G. & R.	1
Macrocentrus marginator (Nees.)	*Synanthedon pictipes* G. & R.	5
Meteorus n. sp. nr. *pinifolii* Mason	*Synanthedon pictipes* G. & R.	1
Microctonus sp.	*Phloeotribus liminaris* (Harr.)	1
Cynipidae		
Ganaspis sp.	*Theridion* poss. *frondeum* Hentz	1
Pseudeucoila sp.	unknown	1
Eulophidae		
Elachertus proteoteratis (How.)	*Telphusa* sp.	1
Euderus sp.	*Telphusa* sp.	4
Eulophus sp.	*Telphusa* sp.	7
Hyssopus sanninoideae (Grlt.)	*Telphusa* sp.	1
Tetrastichus sp.	*Carposina comonana* Kft.	1
Tetrastichus poss. *fumipennis* (Grlt.)	*Carposina comonana* Kft.	5
	Telphusa sp.	6
Tetrastichus nr. *cormus* Burks.	unknown	3
Ichneumonidae		
Devorgilla sp.	*Carposina comonana* Kft.	3
Dolichomitus messor perlongus (Cr.)	*Synanthedon pictipes* G. & R.	1
Itoplectis conquisitor (Say)	*Telphusa* sp.	1
Scambus decorus Wly.	*Synanthedon pictipes* G. & R.	1
Scambus sp. poss. *tecumseh* (Vier)	*Synanthedon pictipes* G. & R.	1
Pteromalidae		
Habroctus poss. *phycidis* Ashm.	*Telphusa* sp.	7
	Carposina comonana G. & R.	5
Pachyneuron sp.	unknown	2
Pteromalus sp.	unknown	1

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ADDITIONAL RANGE AND HOST RECORDS OF THE FLEAS (SIPHONAPTERA) OF MANITOBA

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ABSTRACT

Seven species of fleas representing six genera were added to the flea faunal list of Manitoba. Two species of *Ceratophyllus* infested birds of the swallow family. Range extensions were recorded for species of *Catallagia, Doratopsylla, Foxella, Peromyscopsylla,* and *Saphiopsylla.* New host records for 13 species of fleas were found on 17 species of mammals and birds. Records on infestations on shrews were emphasized.

INTRODUCTION

Buckner (1964) has published a list of the fleas of Manitoba infesting mammals: prior to that publication only 15 species of fleas had been recorded in the province, but that work added an additional 17 species or varieties of fleas to the existing list. Continuing studies have added a number of records to the list, and additions to the 1964 list are published herein.

METHODS

Small mammals were trapped using principally live trapping techniques. Mammals were examined carefully for fleas, which were captured by hand and preserved in 70% alcohol. They were later cleared and identified according to the techniques and keys provided by Holland (1949). Particular attention was paid to the examination of the insectivores because existing records of this group were very scant. Specimens taken from abandoned bird nests were submitted by independent cooperators.

RESULTS

During the period of investigation, 14 species of small mammals and the nests of two species of birds were examined for the presence of fleas (Table 1). Only the water shrew, *Sorex palustris palustris* Richardson (three specimens examined) and the flying squirrel, *Glaucomys sabrinus sabrinus* (Shaw) (four specimens examined) were not parasitized by fleas: the others were parasitized in varying degrees. The highest incidence of parasitism was for the deer mouse, *Peromyscus maniculatus bairdii* (Hoy & Kennicott), with over 29% of the specimens yielding fleas. The lowest incidence of parasitism was recorded for the cinereous shrew, *Sorex cinereus cinereus* Kerr, with less than 2% of the individuals yielding fleas.

Seven additional species were added to the list of fleas of Manitoba; *Catallagia borealis* Ewing, *Ceratophyllus idius* Jordan & Rothschild, *C. riparius* Jordan & Rothschild, *Doratopsylla blarinae* C. Fox, *Foxella ignota albertensis* (Jordan & Rothschild), *Peromyscopsylla hamifer hamifer* (Rothschild), and *Saphiopsylla bishopi* (Jordan). This brings the faunal list of fleas for Manitoba to 37, which is similar to the lists from other

Table 1. Parasitism of Small Mammals
Period from 1964 to 1968

Mammal	Total number trapped	Number of mammals parasitized by fleas	% parasitized by fleas
Sorex cinereus cinereus Kerr	615	10	1.6
Sorex arcticus laricorum Jackson	83	2	2.4
Microsorex hoyi hoyi (Baird)	39	1	2.6
Sorex palustris palustris Richardson	3	0	0
Blarina brevicauda manitobensis Anderson	92	8	8.7
Peromyscus maniculatus bairdii (Hoy & Kennicott)	350	103	29.3
Zapus hudsonius hudsonius (Zimmerman)	15	2	13.3
Synaptomys cooperi cooperi Baird	10	1	10.0
Clethrionomys gapperi loringi (Bailey)	1,199	313	26.1
Microtus pennsylvanicus drummondii (Audubon & Bachman)	224	43	19.2
Tamiasciurus hudsonicus hudsonicus (Erxleben)	39	5	12.8
Glaucomys sabrinus sabrinus (Shaw)	4	0	0
Eutamias minimus borealis (Allen)	20	2	10.0
Mustela erminea richardsonii Bonaparte	60	8	13.3

provinces, exclusive of British Columbia and Alberta where considerable emphasis has been placed upon the Siphonaptera. The following annotated notes indicate the salient and pertinent features of the results of the study.

1. *Catallagia borealis* Ewing. 1 ♂, 1 ♀

Buckner (1964) noted an unidentified female *Catallagia* taken from *P. maniculatus* in the Whiteshell Park. The two additional specimens now confirm the identity of this form as *C. borealis*. Both additional records are from the red-backed vole, *Clethrionomys gapperi loringi* (Bailey), the female from Seddon's Corner, Manitoba, 7 October 1964 and the male from Riverton, Manitoba, 17 October 1964. According to G. P. Holland (pers. comm. 13 June 1969) this is by far the most westerly record of this species.

2. *Ceratophyllus idius* Jordan & Rothschild. 1 ♂, 1 ♀

These two specimens were recovered from a recently vacated nest of a tree swallow, *Iridoprocne bicolor*, near Winnipeg, Manitoba, 1 August 1964. They represent a new Canadian record for this species, although it has been recorded in the Northern Lake States.

3. *Ceratophyllus riparius* Jordan & Rothschild. 33 ♂♂, 51 ♀♀

Buckner (1964) on the grounds of previous widespread records and because the host is common, included this species on the hypothetical list for Manitoba. All the present records were recovered from vacated houses of the purple martin, *Progne subis*, in the Winnipeg area, 20 June 1964. Previous Canadian records are from British Columbia, Carlyle Lake, Saskatchewan, and Lower Wedgeport, Nova Scotia.

4. *Doratopsylla blarinae* C. Fox. 1 ♂

This single specimen was taken from the short-tailed shrew, *Blarina brevicauda manitobensis* Anderson, at Pine Falls, Manitoba, 19 August 1963. Although the short-tailed shrew is evidently the normal host of this flea, we have never before recorded the species from our area. Previous Canadian records of the species places its range from Algoma and Algonquin Park eastwards. This record therefore represents about a 500 mile westward extension of the known range.

5. *Epitedia wenmanni* (Rothschild). 8 ♂♂, 15 ♀♀

Two specimens of this species, both males, were recovered from the cinereous shrew, *Sorex cinereus cinereus* Kerr, one from Pine Falls, Manitoba, 6 October 1965, the other from Telford, Manitoba, 13 October 1968. This is a new host record for this flea. Previous records are mostly from mice of the genus *Peromyscus*.

6. *Foxella ignota albertensis* (Jordan & Rothschild). 1 ♂, 2 ♀♀

This is an additional species added to the Siphonapterous faunal list of Manitoba, although Buckner (1964) predicted in his hypothetical list that it would likely be found in this province. Two of the specimens were taken from the field vole, *Microtus pennsylvanicus drummondii* (Audubon & Bachman), one male from Telford, Manitoba, 28 August 1968, and one female from the same locality, 12 October 1968. The third, a female, was taken from the deer mouse *Peromyscus maniculatus bairdii* (Hoy & Kennicott), in the Whiteshell Park, 24 May 1968.

These records are puzzling. Previous records of this species are from pocket gophers of the genus *Thomomys*, and we are informed by Holland (pers. comm. 13 June 1969) that the species is very host specific and that our records are surely accidental. From our extensive small mammal surveys we have never recorded *Thomomys*, in the Telford area. Pocket gophers do occur in the western sections of the province and this is where one might have expected to recover *Foxella*, but to record this flea some 200 miles eastward of the known range of its specific host is difficult to explain.

7. *Megabothris quirini* (Rothschild). 28 ♂♂, 56 ♀♀
This is a common flea, occurring mostly on rodents. One male specimen however taken at Red Rock Lake, Manitoba, 2 August 1957, was recovered from a short-tailed shrew, *Blarina brevicauda manitobensis* Anderson, and this represents a new host record for this flea.

8. *Monopsyllus wagneri systaltus* (Jordan). 7 ♂♂, 9 ♀♀
This has been a common flea in our study area, although of recent years it has declined somewhat in abundance. Previous records were mostly from rodents, but one of our recent specimens, a male, was taken from the short-tailed shrew, *Blarina brevicauda manitobensis* Anderson.

9. *Nearctopsylla genalis hygini* (Rothschild). 3 ♂♂, 6 ♀♀
Holland (1949) has recorded this flea from Aweme, Manitoba, but these are the first records in our collections. Holland (1949) describes this genus as winter fleas of the Mustclidae, and most of the specimens he examined were from the genus *Mustella.* A few of his records were from *Sorex.* All nine of our specimens were taken from the short-tailed shrew, *Blarina brevicauda manitobensis* Anderson, two males and six females from a single host at Pine Falls, Manitoba, 16 October 1966, and the remaining male from the Whiteshell Park, 12 October 1968.

10. *Orchopeas leucopus* (Baker). 72 ♂♂, 139 ♀♀
This is the most common flea in our collection. It is widespread and occurs on a number of hosts, although most of our specimens have been taken from the deer mouse, *Peromyscus* sp. However one male and five females of this species from Churchill, Manitoba, 26 June 1965, were recovered from the red squirrel, *Tamiasciurus hudsonicus hudsonicus* (Erxleben).

11. *Peromyscopsylla catatina* (Jordan). 23 ♂♂, 23 ♀♀
We have recorded increasing numbers of this flea in our collections over the past few years, mostly form the Microtine rodents *Microtus* sp. and *Clethrionomys* sp. The following however represent new host records:

1♂ *ex Sorex cinereus cinereus* Kerr, Agassiz Forest, Manitoba, 22/IX/65

1♂ *ex Blarina brevicauda manitobensis* Anderson, Whiteshell Park, Manitoba, 24/VIII/68

1♂ *ex Peromyscus maniculatus bairdii* (Hoy & Kennicott), Whiteshell Park, Manitoba, 24/IX/64

1♀ *ex Peromyscus maniculatus bairdii* (Hoy & Kennicott), Pine Falls, Manitoba, 18/VIII/68

12. *Peromyscopsylla hamifer hamifer* (Rothschild). 6 ♂♂, 6 ♀♀
Previous records of this species are from northern Ontario, north of the city of North Bay. These specimens therefore represent a westward extension of the known range of over 500 miles. Two males and four females taken from the red-backed vole, *Clethrionomys gapperi loringi* (Bailey), all from the Whiteshell Park, October 1968 represent new host records for this species. The normal host of this flea is apparently *Microtus* sp.

13. *Saphiopsylla bishopi* (Jordan). 1 ♀
This specimen was collected from the red-backed vole, *Clethrionomys gapperi loringi* (Bailey), 13 October 1968, in the Whiteshell Park, Manitoba. Previous Canadian records of this species are from eastern Ontario and were taken from the short-tailed shrew, *Blarina brevicauda,* and the field vole, *Microtus pennsylvanicus.* This record therefore extends the known range of the flea some 700 miles westward, and represents a new host record as well.

14. *Stenoponia americana* (Baker). 10 ♂♂, 25 ♀♀
This is likely a common flea in the study area although it may go through periods of

population depression, because it has only recently appeared in significant numbers in our collections. The majority of our specimens were taken from the red-backed vole, *Clethrionomys gapperi loringi* (Bailey). Two specimens however are from unusual hosts:

1♂ *ex Microsorex hoyi hoyi* (Baird), Pine Falls, Manitoba, 7/X/65

1♀ *ex Blarina brevicauda manitobensis* Anderson, Whiteshell Park, 14/X/68

DISCUSSION

In an earlier paper, Buckner (1964) published a hypothetical list of fleas that might be expected to occur in Manitoba. This list was compiled by noting the fleas that have been recorded both east and west of Manitoba, and by noting fleas whose ranges border closely on the boundaries of this province. Of the 16 fleas recorded in the hypothetical list, only two are confirmed in the new range listings in this paper. The remaining five species new to the Manitoba list represent vast range extensions. One might logically therefore look for at least 14 more species of fleas in Manitoba. Of these, some are parasitic on bats, and some on birds, two groups that were not surveyed intensively. Records from lagomorphs and ground squirrels are also rather sparse. Future emphasis on these groups might therefore produce a more complete and realistic list of the province's siphonapterous fauna.

Many of the new host records recorded herein are from the Soricidae. Previous records of fleas from soricids exclusive of *Blarina* have been rather sparse, because fleas quickly abandon small shrews once the host dies, and the efforts in catching and examining living shrews are considerable. It is therefore gratifying to note that seven of the 13 new host records listed in this paper are from shrews. We do not intend to relax our efforts in cataloguing fleas parasitic on shrews however, because there are quite likely large gaps in our knowledge in this area.

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EFFECT OF INSECTICIDES AND APPLICATION PROCEDURES ON PHYTOTOXICITY TO SUGAR BEET SEEDLINGS AND CONTROL OF THE SUGAR-BEET ROOT MAGGOT[1]

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ABSTRACT

The sugar-beet root maggot, *Tetanops myopaeformis* (Roeder), was effectively controlled in Manitoba by in-furrow treatments of Furadan, while ethion and carbophenothion also protected sugar beet stands. Phytotoxicity was not excessive at the application rates tested. Dyfonate performed well but placement above, rather than in the seed furrow, was necessary to eliminate phytotoxicity to the seedlings. Post-emergence treatments of either diazinon or fensulfothion (Dasanit) alone, may reduce maggot infestations effectively but damage to the crop may not be prevented.

Our results with above-furrow treatments of Bay 37289 and Dyfonate agree with those reported from Idaho.

Phytotoxicity to seedling stands remains a problem in the utilization of organophosphorus and organocarbamate insecticides for control of the sugar-beet root maggot. Symptoms of chemical damage to seedlings were observed with Furadan, diazinon, fensulfothion (Dasanit), disulfoton, Dyfonate, phorate and Ekatox (parathion), even though soil moisture was ideal for seedling emergence. The sugar beets appear to outgrow this damage, without detriment to the crop.

INTRODUCTION

Allen and Askew (1966) showed that several organophosphorous insecticides effectively controlled the sugar-beet root maggot, *Tetanops myopaeformis* (Roeder), but were very phytotoxic when applied directly into the seed furrow. Peay *et al.* (1968) used special machinery to apply insecticide granules in bands below the soil surface and although phytotoxicity was eliminated, high rates of application were required for sugar-beet root maggot control.

This paper reports results of investigations from 1965 to 1967 on various methods and schedules of treatment intended to minimize the phytotoxicity to seedlings caused by insecticides, without unduly affecting root maggot control. In-furrow and above-furrow applications were compared and the use of additional post-emergence applications of sprays or granules was evaluated.

MATERIALS AND METHODS

The insecticides tested for sugar-beet root maggot control are listed in Table 1. Except for compounds listed under registered names or experimental numbers, approved common names (Canadian Standards Association 1969) are used in the text. The insecticde granules used contained from 5 to 20% active ingredients and sprays were prepared from emulsion

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concentrates formulated by the suppliers. Application rates shown in the Tables 2, 3 and 4 are in terms of active ingredients per beet acre.

Test plots were arranged in randomized blocks; each plot consisted of four 60-ft. rows. Four outside guard rows were provided for each block. A 4-row beet drill, equipped with a V-belt metering device, was used to apply seed, insecticide granules, and fertilizer into the furrow. Monogerm seed was sown at 10.0, 5.0 and 3.0 lb/acre in 1965, 1966 and 1967. In 1965 and 1966 Ammonium phosphate (11-48-0) was applied at 80 lb/acre to the furrow with the seed. In 1967 only 45 lb/acre of this fertilizer was applied to the furrow.

Table 1. Common names, registered names with chemical definition and sources of insecticides.

Bay 37289 O—ethyl O—2,4,5—trichlorophenyl ethylphosphonothioate, Chemagro, Corp., Kansas City, Mo.

Baygon (Bay 39007) O—isopropoxyphenyl methylcarbamate, Chemagro Corp., Kansas City, Mo.

Carbophenothion, Stauffer Chemical Co., Portland, Oregon.

Diazinon, Fisons (Canada) Ltd., Toronto, Ont.

Disulfoton, Chemagro Corp., Kansas City, Mo.

Dyfonate (N-2790) O—ethyl-S—phenyl—ethylphosphonodithioate, Stauffer Chemical Co., Portland, Oregon.

Ekatox (5% parathion) Green Cross Chemicals, Montreal, Que.

Ethion, Niagara Chem. Div. F.M.C. Corp., Middleport, N.Y.

Fensulfothion (Dasanit) O,O—diethyl O—p—(methylsulfinyl)—phenyl phosphorothioate. Chemagro Corp., Kansas City, Mo.

Furadan (NIA 10242) 2,3—dihydro—2,2—dimethyl—7—benzofuranyl—N—methylcarbamate Chem. Div. F.M.C. Corp., Middleport, N.Y.

Heptachlor, Velsicol Chemical Co., Chicago, Ill.

Phorate, Cyanamid of Canada, Rexdale, Ont.

In 1965, **Experiment 1** compared the placement of insecticides either in or above the seed furrow with heptachlor applied to the furrow. **Experiment 2** evaluated in-furrow treatments and the effect of additional post-emergence sprays. **Experiment 3** tested application rates for in-furrow treatments with ethion.

In 1966, **Experiment 4** compared insecticides applied in-furrow at various rates with heptachlor applied similarly. In **Experiment 5** above-furrow applications at seeding were compared with additional post-emergence band applications of fensulfothion (Dasanit) and Bay 37289 granules or sprays.

In the foregoing trials the insecticides were applied as follows:

1) **In-furrow** — Insecticide granules and the fertilizer were discharged into the furrows at a depth of 1 to 1½-in. with the seed.

2) **Above-furrow** — After the seed and fertilizer were placed in the furrows at the usual depth with the drill-discs, they were partially covered with loose soil by drag-bars. Insecticide granules were dropped from suspended outlet tubes of a Noble applicator to give 4 to 5-in. bands of granules. Drag-bars followed to cover them with soil that was firmed by press-wheels.

3) **Post-emergence treatments** — In 1965 a four-row sprayer was operated at 30 psi to deliver 7.0 gal./acre. The sprayer, equipped with flat spray nozzles (8001E), was adjusted to

spray 8-in. bands that covered the seedling rows. In 1966 similar bands were applied at 135 psi from 6502 nozzles, to deliver 39.0 gal./acre. At this rate, however, the surface soil was merely wetted, not drenched as intended. Insecticide granules were dispensed in 4 to 5-in. bands over the rows of thinned beets and partially covered with soil by a 'Spyder Spring' attachment.

In 1967, **Experiments 6 and 7**, the effectiveness of several insecticides was compared with that of heptachlor. An International Flexi-planter was used to assure better separation of the seed and insecticide granules. The seed was released into the bottom of the furrow from seeder boxes. Insecticide granules and fertilizer were delivered from V-belts to the rear of the drill-discs and released as the furrows closed forming inverted wedges, which were lightly covered with soil and firmed by press-wheels.

Seedling stands on each plot were evaluated by counting the number of beet-containing inches in two 100-in. lengths of row. Stands after thinning were estimated by counting the beets on two 25-ft. lengths from the central rows of each plot. About eight beet-containing inches/100-in. of row before thinning or 100 beets/100-ft. of row after thinning, assure complete stands. In 1965 and 1967, we also observed chemical damage resulting in chlorosis or stunting of the seedlings; this was not always associated with a significant stand reduction.

The adult emergence period was determined by using water traps as described by Harper and Story (1962).

Root maggot infestations were estimated on each plot in early September by counting the maggots in 10 soil samples, each 8-in. square and 14-in. deep. Each sample was centered on a beet in the outside rows.

In 1965 and 1967 beets from two 50-ft. lengths of the central rows of each plot were harvested and weighed early in October to determine yield. In 1966, an infestation of the Red-backed cutworm reduced beet stands on some of the treated plots as well as on untreated plots. Accordingly yield data were of no value in assessing root maggot damage; and root damage, associated with early root maggot attack as described and illustrated by, Harper *et al.* (1961), was evaluated. Percentage root damage was converted to Sine angle before analysis.

All data were examined by analysis of variance and the multiple range test (Duncan 1955); significance was tested at the 1% level unless otherwise indicated.

RESULTS

Phytotoxicity

Experiment 1. Initial stands of sugar beets were significantly reduced by in-furrow treatments with diazinon at 0.75 lb/acre and disulfoton at 2.0 lb/acre. Also, diazinon and disulfoton caused symptoms of chemical damage. Seedlings on emergence were stunted, yellow, and the leaf margins were white, particularly towards the apex (Table 2). When applied above the furrow diazinon at 0.8 lb/acre, disulfoton, fensulfothion (Dasanit) and Bay 37289 at about 2.0 lb/acre were not phytotoxic. Baygon granules applied in the same way were poorly distributed by the equipment used; only 1.1 lb/acre was dispensed but where heavy deposits occurred along the rows, beets were killed leaving an irregular stand. When this chemical was applied in-furrow at 2.0 lb/acre nearly all the beets were killed and, therefore, the data are not included in the table.

Experiment 2. In-furrow treatments with Furadan and carbophenothion at 1.0 lb/acre were not phytotoxic and were comparable to heptachlor. But Furadan at this rate also showed symptoms of chemical damage. Diazinon even at 0.5 lb/acre was phytotoxic and the seedlings were stunted; additional post-emergence sprays did not increase phytotoxicity. Carbophenothion was non-phytotoxic (Table 2).

Table 2. Effect of insecticide placement and timing of sprays on phytotoxicity, maggot control, and yield at Winkler, Manitoba, 1965.

Insecticide	Toxicant (lb/acre) In Furrow	Toxicant (lb/acre) Above Furrow	Sprays Post Emergence June 18	Sprays Post Emergence June 24	Stand Beet[1] Inches	Stand Number[2] of Beets	Maggots per Beet	Control (%)	Yield (Tons/acre)
					Experiment 1 (5 replicates)				
Heptachlor	1.0				26.3 a	88 a	8.9 a	81	11.3 a
Diazinon	0.75				10.8 c	64 c	5.2 a	89	10.7 abc
		0.84			28.3 a	75 abc	11.4 a	75	11.0 ab
Disulfoton	2.0				15.7 bc	70 bc	9.2 a	80	10.1 abc
		2.0			20.5 ab	72 bc	21.6 b	53	9.8 bc
Fensulfothion		2.2			23.9 ab	74 abc	14.0 ab	70	10.8 abc
Bay 37289		2.2			30.1 a	68 c	8.8 a	81	10.1 abc
Baygon		1.1			26.2 a	76 abc	47.8 c	0	9.5 c
Untreated					29.5 a	86 ab	46.5 c		7.9 d
					Experiment 2 (6 replicates)				
Heptachlor	1.0				38.9 a	93 ab	3.4 ab	82	10.4 ab[3]
Furadan	1.0				33.2 abc	89 abc	2.9 a	85	9.6 abc
Diazinon	0.5				22.8 c	81 d	3.8 ab	80	9.7 abc
	0.5		1.0		27.0 bc	85 bcd	1.7 a	91	10.5 a
	0.5		1.0	1.0	26.7 bc	82 cd	0.8 a	96	10.4 ab
	Nil		1.0	1.0	39.0 a	91 abc	4.7 ab	75	9.5 bc
Carbophenothion	1.0				36.6 ab	92 ab	7.4 b	61	9.6 abc
	1.0		1.0		41.2 a	94 ab	4.2 ab	78	9.5 bc
	1.0		2.0		35.6 abc	97 a	4.9 ab	74	10.0 abc
	Nil		2.0		37.4 ab	92 ab	11.5 c	40	9.6 abc
Untreated					41.2 a	93 ab	19.1 d		9.2 c
					Experiment 3 (5 replicates)				
Ethion	1.0				25.3 a	79 a	7.8 a	69	7.7 a
	1.5				20.0 a	75 a	7.9 a	69	8.0 a
	2.0				18.0 a	76 a	7.3 a	71	7.6 a
Untreated					24.1 a	83 a	25.3 b		6.1 b

1 Beet-containing inches in per 100 in. of row before thinning.

2 Number of beets per 100 ft. of row after thinning.

3 Range test at P=0.05

Experiment 3. Ethion applied at rates from 1.0 to 2.0 lb/acre did not cause significant phytotoxicity (Table 2).

In 1966 the phytotoxic effects cannot be ascribed with confidence because an infestation of the Red-backed cutworm caused extensive damage to seedling stands not protected by in-furrow or above-furrow treatments.

Experiment 4. Again diazinon, Furadan, and disulfoton appear to show phytotoxicity at 0.5, 1.0 and 1.5 lb/acre, because cutworm control was evident at lower application rates of diazinon and Furadan. However, symptoms of chemical damage were not observed.

Experiment 5. With above-furrow treatments phytotoxicity was not apparent on seedlings. The poor stands after thinning reflect lack of cutworm control, because the post-emergence treatment applied near the end of June did not effect stand protection (Table 3).

Table 3. Effect of insecticide placement, timing and type of application on phytotoxicity, maggot control, and root damage at Winkler, Manitoba, 1966.

	Toxicant (lb/acre)						Maggots		Damaged[3]
	In	Above	Grans.	Spray	Beet[1]	Number[2]	per	Control	Beets
Insecticide	Furrow	Furrow	June 30	June 28	Inches	of Beets	Beet	(%)	(%)
					Experiment 4 (6 replicates)				
Heptachlor	1.0				15.4 ab	86 a	1.7 a	77	17.2 a
Furadan	1.0				12.1 ab	81 a	1.9 a	75	17.9 a
	0.75				13.6 ab	75 ab	2.0 a	73	17.3 a
	0.50				16.5 a	90 a	4.4 ab	41	15.2 a
Diazinon	0.50				5.3 cd	45 c	2.9 a	61	22.2 a
	0.25				10.4 bc	68 ab	4.4 ab	41	19.1 a
	0.12				9.5 cd	60 bc	4.9 ab	35	26.3 a
Disulfoton	1.5				4.9 d	42 c	2.7 a	64	22.4 a
Untreated					7.4 cd	46 c	7.5 b		43.2 b
					Experiment 5 (6 replicates)				
Fensulfothion		1.5			18.6 ab	85 ab	3.0 ab	72	16.7 a
		1.0	1.0		17.9 ab	78 ab	1.7 ab	85	22.5 a
		1.0		1.0	17.7 ab	66 b	1.4 a	87	22.3 a
		Nil	1.5		—	65 b	3.2 ab	71	41.5 b
		Nil		1.0	—	—	2.9 ab	73	49.4 bc
Bayer 37289		1.5			20.5 ab	82 ab	4.5 ab	59	24.6 a
		1.0	1.0		24.1 a	84 ab	3.4 ab	69	21.9 a
		1.0		1.0	23.4 a	69 b	3.6 ab	67	21.1 a
		Nil	1.5		—	57 b	10.2 cde	6	54.2 c
		Nil		1.0	—	—	12.6 de	0	50.7 bc
Dyfonate		1.0			17.5 ab	102 a	4.4 ab	60	21.8 a
Disulfoton		1.5			14.6 b	70 b	6.3 abc	42	20.9 a
Diazinon[4]		1.0			24.9 a	98 a	6.5 bcd	40	18.2 a
Untreated					13.8 b	58 b	11.0 de		46.9 bc

1 Beet-containing inches per 100 in. of row before thinning.

2 Number of beets per 100 ft. of row after thinning.

3 Angular transformation used in analysis.

4 Granules 14.3% active ingredients.

Experiment 6. Results in 1967 with the modified furrow treatment showed that Dyfonate,· phorate, and fensulfothion (Dasanit) caused significant phytotoxicity at 1.0 lb/acre. The first three, showed chemical damage by June 13th. Furadan was not phytotoxic and appeared to have stimulated growth.

Experiment 7. Fensulfothion showed increased phytotoxicity with increasing rates of application and beets were stunted at all rates. This was not true for Bay 37289. Ekatox (parathion) was phytotoxic and caused chemical damage to seedlings (Table 4).

Maggot Control and Damage

Experiment 1. In-furrow treatments with diazinon and disulfoton at 0.75 and 2.0 lb/acre, respectively, gave as effective maggot control as heptachlor. Applied above-furrow at seeding, diazinon at 0.84 lb/acre and Bay 37289 at 2.2 lb/acre were equally effective in controlling maggots; fensulfothion (Dasanit) at 2.2 lb/acre was slightly less effective.

Disulfoton and Baygon at the rates used were not effective (Table 2). Yield increases associated with effective maggot control ranged from 2.0 to 3.4 tons/acre. The stand of untreated beets was reduced 15% by root maggots between July 7th and harvest.

Table 4. Effect of furrow applications of established or prospective toxicants on phytotoxicity, root maggot control, and yield at Winkler, Manitoba, 1967.

	Toxicant (lb/acre)	Stand		Maggots		
Insecticide	Furrow	Beet[1] Inches	Number[2] of Beets	per Beet	Control (%)	Yield (Tons/acre)
			Experiment 6 (8 replicates)			
Dyfonate	1.0	16.4 cd	76 dc	.17 a	93	12.6 bc
Heptachlor	1.0	28.6 a	96 a	.34 a	86	13.7 a
Furadan	0.75	27.0 a	96 a	.41 a	83	13.1 ab
Phorate	1.0	20.2 bc	83 bc	.40 a	84	12.3 bc
Carbophenothion	1.0	28.7 a	100 a	.74 a	69	13.2 ab
Fensulfothion	1.0	14.9 d	71 d	.84 a	65	12.0 c
Disulfoton	1.0	21.7 b	89 ab	.51 a	79	12.3 bc
Untreated		30.1 a	100 a	2.42 b		12.9 abc
			Experiment 7 (6 replicates)			
Heptachlor	1.0	29.0 a	97 a	.06 a	94	13.1 a
Fensulfothion	0.5	23.9 a	85 a	.17 a	83	13.3 a
	1.0	15.2 b	80 ab	.11 a	89	13.7 a
	1.5	13.4 b	73 ab	.23 a	78	12.5 a
	2.0	12.7 b	61 c	.25 a	76	11.7 a
Bay 37289	1.0	27.5 a	93 a	.22 a	79	13.5 a
	1.5	25.5 a	78 ab	.09 a	91	12.1 a
	2.0	26.5 a	77 ab	.17 a	83	12.0 a
Ekatox	1.5	16.0 b	75 ab	.09 a	91	11.8 a
Untreated		28.9 a	97 a	1.03 a		12.5 a

[1] Beet-containing inches per 100 in. of row before thinning

[2] Number of beets per 100 ft. of row after thinning

Experiment 2. In-furrow treatment with Furadan at 1.0 lb/acre was as effective for maggot control as heptachlor at the same rate, or diazinon at 0.5 lb/acre. Carbophenothion at 1.0 lb gave only 61.0% control. With diazinon one or two post-emergence sprays (Figure 1) after in-furrow treatments improved maggot control. An additional spray application with carbophenothion at either 1.0 or 2.0 lb/acre increased control only slightly. Sprays of diazinon alone applied three days before and three days after thinning gave 75% control, while carbophenothion at 2.0 lb/acre three days before thinning gave only 40% control (Table 2). In contrast with Experiment 1 the over all population, as indicated by the untreated plots, was reduced; possibly, because half the plots in this experiment were sprayed within three days of peak adult emergence. The maximum increase in sugar beet yield was only about one ton/acre.

Experiment 3. In-furrow applications of ethion were equally effective (75 to 79% control) when applied at rates of 1.0, 1.5 and 2.0 lb/acre. Yields were increased by 1.5 to 1.9 tons/acre (Table 2).

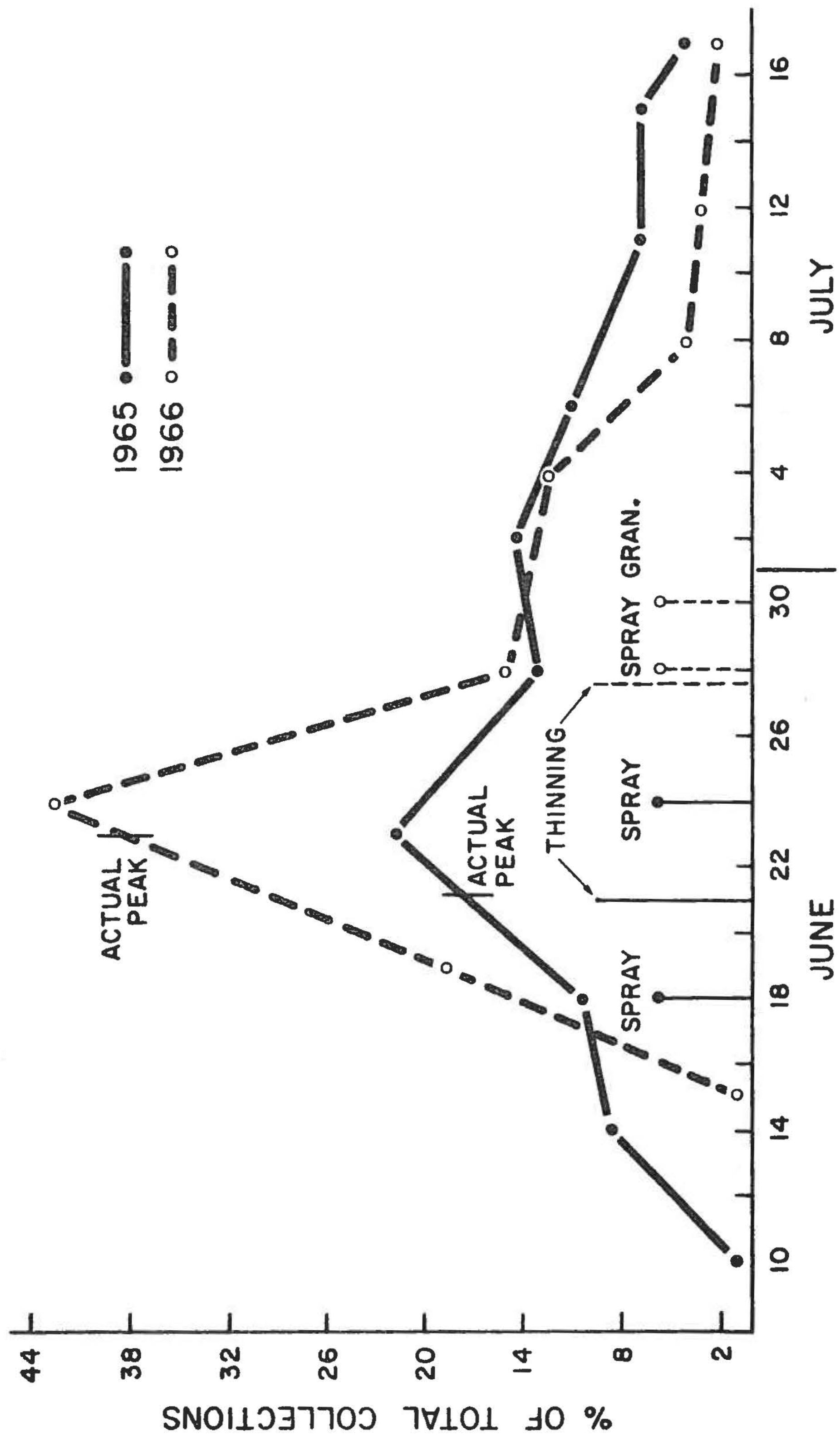

FIGURE 1. Flight patterns of adults of the sugar-beet root maggot, indicated by water traps, showing dates of thinning, and dates of applying sprays or granules (gran). in 1965 and 1966.

Experiment 4. In-furrow treatments with Furadan at either 0.75 or 1.0 lb were as effective as heptachlor at 1.0 lb, while diazinon at 0.5 and disulfoton at 1.5 lb/acre gave similar results. Lower rates of Furadan and diazinon were not effective. All treatments decreased root damage to beets by more than 50%.

Experiment 5. Above-furrow treatments of fensulfothion (Dasanit) and Bay 37289 gave similar control when applied at 1.5 lb/acre at seeding. Post-emergence spray and granular treatments at 1.0 and 1.5 lb/acre, one or three days after thinning did not improve the response to either insecticide. When only the post-emergence treatments were applied fensulfothion gave effective maggot control, while Bay 37289 did not; and neither protected against root damage. Clearly, treatment was required at seeding time, particularly since the post-emergence treatments were applied 5 to 7 days after the peak of adult flight (Figure 1). Dyfonate at 1.0 lb was effective and although disulfoton 1.5 lb and diazinon at 1.0 lb/acre were not, all provided protection to the roots. Diazinon did not equal its previous performance, because we could not properly apply the 14.3% granules provided (Table 3).

Experiments 6 and 7. The sugar-beet root maggot population was exceptionally low in 1967, and all furrow treatments gave levels of control that were not significantly different from those given by heptachlor. At this population level, yields varied only slightly.

DISCUSSION

In Manitoba it was shown (Allen and Askew 1966) that Bay 37289 and fensulfothion (Dasanit), each at 2.0 lb/acre and Dyfonate and diazinon, each at 1.0 lb/acre, were effective against the sugar-beet root maggot when applied to the seed furrow. However, they were so phytotoxic that sugar beet stands and yields were significantly reduced.

In the present study we determined that above-furrow applications at seeding were not phytotoxic and were reasonably effective for root maggot control when Bay 37289 and fensulfothion (Dasanit) were used at 1.5 to 2.0 lb/acre, Dyfonate at 1.0 lb/acre, and diazinon at 0.84 lb/acre. In Idaho, Peay *et al.* (1968 and 1969) devised a system for applying insecticide granules in a six in. band, one in. beneath the soil surface to minimize phytotoxicity. They found that Bay 37289 and Dyfonate, each at 2.0 lb/acre, were the most effective materials; among the group they ranked second, were fensulfothion (Dasanit) and Furadan, each at 2.0 lb/acre, and diazinon at 1.0 to 2.0 lb/acre. The amounts of insecticide required for both methods of application, appear too high to be economically useful in Manitoba where sugar beets are grown without the benefit of irrigation. Furthermore, the method of application tested in Idaho, does not appear suitable for use in Manitoba, because in many years the seed bed would dry out and reduce germination.

The effectiveness of post-emergence treatments alone was not entirely dependent on timing of the applications, relative to the peak of adult emergence (Figure 1). The properties of the insecticides used may also be important. In 1965, diazinon sprays applied close to the peak of adult emergence gave root maggot control, whereas a carbophenothion spray did not (Table 2). In 1967, when fensulfothion (Dasanit) and Bay 37289 were applied, either as sprays or granules 5 and 7 days after peak emergence, only the former gave control (Table 3). But neither prevented early damage to the roots, suggesting that fensulfothion (Dasanit), which is more soluble in water, penetrated the soil more readily to eliminate established root maggots.

Peay *et al.* (1969) reported that foliar sprays directed at the adults, at peak emergence, may provide economical control when applied to large acreages. Malathion was considered a suitable insecticide, but due to the mobility of the adults, further information on the proper timing and the number of spray applications is required; meanwhile the use of insecticide granules was advised.

Our results in Manitoba suggest that in-furrow applications of Furadan at 0.75 lb/acre are not phytotoxic and can provide effective control of the sugar-beet root maggot at minimal cost.

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GENERAL NOTES

TOXICITY OF LINDANE-TREATED SURFACES TO *TYROPHAGUS PUTRESCENTIAE* (SCHRANK) (ACARINA: ACARIDAE)[1]

P. S. Barker

Sanitation procedures to protect stored foods from pests must often be supplemented by the use of residual insecticides. Thus, Watters (1961) found methoxychlor, lindane, and pyrethrins applied to the walls and floors of prairie warehouses offered some protection against infestation by the hairy spider beetle, *Ptinus villiger* (Reit.).

The effect of methyl bromide as a fumigant for grain mites has been examined by Burkholder (1966) and Barker (1967). Barker (1969) also determined the susceptibility of the mushroom mite, *Tyrophagus putrescentiae* (Schrank), to ethylene dibromide and hydrogen phosphide. Moreover, susceptibility of some species of mites to malathion deposits has been examined by Krantz (1956), Marzke and Dicke (1959), Axtell (1966) and Barker(1968). Marzke and Dicke (1959) showed that masonite panels treated with lindane at rates of 50 and 200 mg/ft^2 effectively controlled *Acarus siro* L., and Krantz (1956) found that lindane mixed with wheat dust was effective against this species.

The present study was undertaken to determine the susceptibility of the mushroom mite, *T. putrescentiae,* to lindane treated filter paper and fir plywood.

MATERIALS AND METHODS

Cultures of *T. putrescentiae* were maintained on pulverized brewer's yeast in 250 ml Erlenmeyer flasks stoppered with cotton and kept at temperatures of 24 to 30^{o}C and at relative humidities that ranged from 90 to 95%. The cotton stoppers in the culture flasks were changed 24 hours prior to use of the culture. Since the mites climbed onto the new cotton stoppers, living mites free from debris could be obtained when the stopper was shaken over treated surfaces.

Acetone solutions of pure lindane were pipetted onto 9 cm diam disks of Whatman No. 2 filter paper, and 10 cm squares of fir plywood. Each paper disk received 1 ml of lindane solution whereas 2 ml of solution were pipetted onto each plywood panel. The paper disks received 19.38, 29.66 and 40.64 mg/ft^2 of lindane and the plywood panels received 29.29 and 41.52 mg/ft^2 of toxicant.

Plastic rings, 8 cm (i.d.) and 1 cm deep, coated with silicone stopcock grease around the lower inner surfaces were placed on the treated surfaces at the start of the trials. Stoppers withdrawn from the culture flasks were then shaken over the treated surfaces inside the plastic rings. The disks and squares were examined and dead mites removed. The intact assay units were placed in desiccators at 90 to 95% relative humidity (r.h.) and held at temperatures of either 15.6$\pm$1^o C or 20.6$\pm$1^{o}C. Mortality was assessed 2 or 3 times a day.

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RESULTS AND DISCUSSION

The LT_{50} was inversely related to residue concentrations and to temperature (Table 1). The temperature effects are in agreement with those obtained with malathion (Barker, 1968), ethylene dibromide and hydrogen phosphide (Barker, 1969).

Table 1. LT_{50} (hours) of *Tyrophagus putrescentiae* (Schrank) on two surfaces treated with lindane.

Substrate	Dose mg/ft^2	Temperature (°C) 15.6	20.6
Paper	19.38	105.0	67.4
	29.66	96.6	54.3
	40.64	67.3	46.3
Wood	29.29	66.0	44.0
	41.52	47.5	20.0

A given deposit of lindane was more effective against *T. putrescentiae* when applied to wood than to filter paper. Although similar amounts of lindane were applied to the two surfaces, this bioassay indicates that more toxicant was actually present per unit of surface area on wood than on filter paper.

Since lindane was effective when applied to fir plywood at the lowest dosage used, it is possible that applications of this insecticide to the floors and walls of warehouses as suggested by Watters (1961) for the control of *Ptinus villiger*, may also control infestations of *T. putrescentiae.*

ACKNOWLEDGEMENT

I thank Mr. D. Kurtz for his assistance.

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Received 10 October, 1969

FEEDING AND MATING OF THE LONGHORN BEETLE, *SAPERDA CALCARATA* SAY. (COLEOPTERA: CERAMBYCIDAE)

J. A. Garland[1] and H.A. Worden[2]

ABSTRACT

Adults of *Saperda calcarata* feed and mate on poplar foliage in the evening. These beetles display preferences for particular poplar cultivars in their food selection. Evidence that preferences exist is presented.

INTRODUCTION

The poplar borer, *Saperda calcarata* Say, occurs at the Indian Head Tree Nursery, located within the aspen parkland of south central Saskatchewan. The biology and ecology of this species have received considerable attention (Bird 1930, Peterson 1948, Wong *et al.* 1963). In this study, adult behaviour was observed in a field of the Nursery where poplar cultivars were being grown in the form of poplar stools for production of cuttings.

MATERIALS AND METHODS

The study area consisted of a field on the Nursery, designated field R1 in the SE¼. Several poplar cultivars had been planted as cuttings in 1957, and stools had been created by harvesting the annually produced stems. At the time of this study, 1968, five cultivars remained: Saskatchewan, Volunteer, Northwest, 44-52, Dunlop (see Roller and Thibault 1969 for botanical names and parentages of these cultivars). The stools were arranged in blocks consisting of several rows of a single cultivar, the blocks being adjacent to each other.

The stools in the study area had short, stout butts which branched six inches above the ground to form antler-shaped boles. From the short branches of the boles, stems had grown and attained a length of three to six feet with basal diameters of nearly an inch. Some of the stools were dead in the butt and bole, and some supported current year's stems that had died.

To determine if food-host selection involved preferences for certain cultivars, leaves on all of the stools in the field were examined for signs diagnostic of adult feeding. Presence of a diagnostic feeding indication on a leaf of a stool meant that at least one adult *Saperda calcarata* had fed on that stool.

The rows of the five remaining poplar cultivars were arranged in a design that caused each cultivar to have one row adjacent to a row of another cultivar. This situation provided the beetles with a choice along the length of these paired rows, if the majority of stools in one row had a counterpart in the adjacent row of the other cultivar. There were two paired-row situations which satisfied this condition. The leaf-feeding data for the stools of these paired rows were compared in order to determine if a gradation of preferences existed.

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RESULTS AND DISCUSSION

Adult *Saperda calcarata* were found on the poplar stool foliage during the early part of July. Feeding beetles were solitary, and could be found before sunset and for several hours afterwards near the centre of the stools on the upper surfaces of older leaves. Rounded holes with distinctive scalloped edges were chewed (Figure 1). Similar feeding holes are made by adults of the European *Saperda carcharias* (Hepp 1928). The beetles often defecated on the leaves or chewed the leaf petioles.

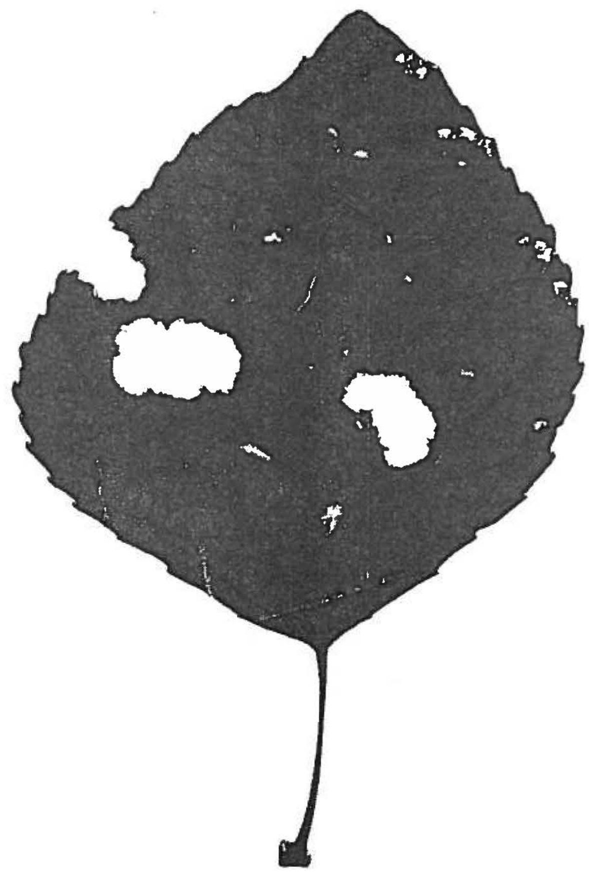

Figure 1. Leaf damage by adult *Saperda calcarata*

These feeding holes persisted for many weeks without losing their distinctive shape or edging, and could easily be distinguished from leaf damage caused by other poplar pests, hail, or wind-blown soil. Examination of all the stools in the field during the second week of August revealed that the beetles had fed on all five poplar cultivars, and that Dunlop cultivar had the greatest proportion of its stools fed upon (Table 1). In each of the two paired-row situations, preferences were obvious: 44-52 was preferred to Northwest, and Dunlop was preferred to 44-52 (Table 2).

A single mating was observed on a Dunlop cultivar after sunset on July 5, 1968. Mounting occurred on a horizontal leaf near the centre of the stool. The female, after being mounted, walked around on the leaf surface until the male touched his antennae to her prothoracic legs. Copulation commenced when the female was still. The copulating pair remained motionless for several minutes. Subsequent movement by the female interrupted copulation, but the male remained mounted on the female for a long while afterwards.

Table 1. Feeding by adult *Saperda calcarata*

	STOOLS	
POPLAR CULTIVAR	Examined	Fed on (%)
Saskatchewan	75	9
Volunteer	31	10
Northwest	341	4
44-52	220	15
Dunlop	379	58

Table 2. Preferences in food selection

		STOOLS	
POPLAR CULTIVAR		Examined	Fed on (%)
PAIR I	Northwest	53	2
	44-52	45	9
PAIR II	44-52	60	17
	Dunlop	44	57

These observations have indicated that *Saperda calcarata* is active in the early and late evening, and that poplar cultivars are preferentially differentiated in at least one facet of the beetle's host-selecting behaviour. The reasons underlying the preferences remain unknown. A number of other insects display demonstrable preferences for particular poplar cultivars (Arru 1967), but only in a few instances have the susceptibility factors been recognised (Cadahia 1965, Chiba 1966) or characterised as genetic in origin (Panetsos and Kailidis 1969).

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BOOK REVIEW

CONCEPTS OF ECOLOGY by Edward J. Kormondy; 209 pages; $2.95 (paper) — $4.95 (cloth) (U.S. price); Prentice-Hall, Inc. Publishers, Englewood Cliffs, New Jersey; 1969.

At a time when there is a growing awareness among scientists and the public in general about world-wide environmental pollution, Dr. Kormondy's readable and balanced treatment of significant concepts of modern ecology is welcome to the specialist and non-specialist alike. Unlike several other recent volumes written on this subject, the book does not unduly emphasize certain controversial subjects, nor does it bring forward masses of data to refute or prove these theories.

Although the author's main emphasis seems to center around the ecosystem concept, he has taken great care to include other specialized areas of ecology, such as population and biochemical ecology. Dr. Kormondy has the knack of synthesizing diverse topics into an integrated whole, and of writing in an easily understandable style. Although a vast subject is dealt with in concise form, the book contains all the essential subject matter for providing the reader with a clear view of the present state of our knowledge of the science of ecology.

An introductory chapter reviews current concepts of the nature of ecosystems on earth. Two of these concepts are: that the energy flow originating from the sun is noncyclic, whereas mineral nutrient flow is cyclic; that ecosystems are almost continuous, rarely discrete entities delimited sharply from other ecosystems. Titles of the numbered chapters suggest the comprehensiveness of this book: 1. The nature of ecosystems; 2. Energy flow in ecosystems; 3. Biogeochemical cycles and ecosystems; 4. Ecology of populations; 5. The organization and dynamics of ecological communities; 6. The ecology of man.

A particularly welcome feature is the inclusion of the chapter on the ecology of man. This chapter is a bold attempt to relate two of the world's main woes - pollution and population explosion - within the framework of the total ecosystem of which we are part.

In writing each chapter the author has not only used the most recent research findings from plant, animal and geochemical sciences, but also simplified the complex ideas of eminent ecologists of the past and present by means of well drawn diagrams. There is a minimum use of ecological jargon. Some of the bibliographies at the end of chapters could have been more detailed and representative.

To the economic entomologists who are very enthusiastic and see unlimited possibilities of biological control through the application of non-chemical methods, such as sterile-male technique, which was originally devised to reduce the population of the screw-worm fly in the Southern United States, the author has a word of caution, " . . . such measures are not equilibrium - oriented and some of their consequences, as well as the control techniques, may be less desirable than the original problem." Man's tinkering with these intra-ecosystem balances has already caused incalcuable damage to some of his greatest natural water resources, such as the St. Lawrence River and the Great Lakes. The author skillfully explains how in these aquatic ecosystems, man accelerated the slow natural process of eutrophication (the aging process from low production to high production) by pollution and drastically reduced their usability to himself.

With respect to pollution by pesticides, the author has clearly distinguished between the widely used biodegradable types, such as the weed-killer 2,4-D which is quickly destroyed by soil and water bacteria and the undegradable types, such as dieldrin and DDT, which are likely to be fixed to clay-rich soil and later passed along a food chain through plants. He cited the following example and points out that due to the differential metabolic and retention capacities of organisms, residue levels tend to increase with higher trophic levels from producer plants to herbivores and then to carnivores, "....... in a study of DDT concentrations in organisms along the south shore of Long Island, where the insecticide has been used to control mosquitoes for some twenty years, some carnivores had concentrated it by a factor of more than 1000 over the organisms at the base of the food chain." DDT has been widely used for many years to control mosquitoes in the urban areas. Although its use has recently been prohibited by a few Governments, we may not yet have seen the full consequences of the past prolonged use of DDT.

The book is highly recommended both to the specialist and layman interested in the study of the environment.

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PROGRAM OF THE 25th ANNUAL MEETING of the ENTOMOLOGICAL SOCIETY OF MANITOBA

November 13 and 14, 1969

Agriculture Auditorium, Dafoe Road
The University of Manitoba

THEME: "ECOLOGICAL INTERPRETATION OF PHYSIOLOGICAL AND GENETIC MECHANISMS IN INSECTS"

Thursday, November 13

8:00 - 9:00 a.m.	- Registration
9:00 - 9:30	- Address of Welcome, Announcements
9:30 - 10:00	- **Invitational Papers** (Chairman - R. A. Brust) - Chironomids and Lake Typology O. A. Saether, Freshwater Institute, Campus
10:30 - 11:00	- COFFEE
11:00 - 12:00	- Field biology of the Soviet Union W. O. Pruitt, Dept. of Zoology, Campus
12:00 - 1:30 p.m.	- LUNCH (available on Campus)
1:30 - 2:00	- **Invitational Papers** (Chairman - W. J. Turnock) - Photoperiodism and diapause in the tobacco hornworm. R. A. Bell, Metabolism and Radiation Research Laboratory, Fargo, N.D.
2:00 - 3:00	- **Submitted Papers** 1. Photoperiodic control of diapause in *Aedes atropalpus* K. S. Kalpage, Dept. of Entomology, Campus 2. Ecology of the pitcher plant mosquito, *Wyeomyia smithii* K. W. Evans, Dept. of Entomology, Campus 3. Autogenous ovarian development and photoperiodic effects in *Wyeomyia smithii* S. M. Smith, Dept. of Entomology, Campus
3:00 - 3:30	- COFFEE
3:30 - 4:30	- 4. Ecology of the corn borer in Manitoba. W. Hanec and J. Tsuang, Dept. of Entomology, Campus 5. Cabbage maggot control in rape. W. Allen, Canada Dept. of Agriculture, Campus 6. Influence of host plant or insemination on programming of oviposition in the diamondback moth, *Plutella maculipennis* (Lepidoptera) R. J. Hillyer and A. J. Thorsteinson, Dept. of Entomology, Campus

Friday, November 14

9:00 - 9:30 a.m.	- **Invitational Paper** (Chairman - G. Fraser) - The potential for genetic suppression of insect populations by their adaptations to seasons and climates. W. Klassen, Metabolism and Radiation Research Laboratory, Fargo, N.D.
9:30 - 10:30	- **Submitted Papers** 1. The potential use of inundative releases against a forest defoliator. W. J. Turnock, Canada Dept. of Forestry, Campus 2. Observations of adult feeding and mating of the long-horn beetle, *Saperda calcorata* J. A. Garland and H. A. Worden, Canada Dept. of Forestry, Campus 3. The effect of available space on the functional response in several predator-prey systems C. H. Buckner, Canada Dept. of Forestry, Campus
10:30 - 11:00	- COFFEE
11:00 - 12:00	4. Feeding behavior of *Epilachna vigintioctopunctata* on *Luffa aegyptiaea* S. S. Krishna, Dept. of Entomology, Campus 5. Notes on the life history of *Caloglyphus anomalous* P. Barker, Canada Dept. of Agriculture, Campus
12:00 - 1:30 p.m.	- LUNCH
1:30 - 2:30	- **Submitted Papers** (Chairman - P. Barker) 6. Bionomics of intermediate hosts of *Echinuria uncinata* (Nematoda) F. Austin, Dept. of Zoology, Campus 7. Helminth parasites of Amphibians in the Delta Marsh L. Hlynka, Dept. of Zoology, Campus 8. *Echinococcus multilocularis* in Manitoba G. Lubinsky, Dept. of Zoology, Campus

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SOCIAL EVENING — NOVEMBER 14

8:30 p.m.	- "WINE AND CHEESE"
Place:	- Faculty Club, Pembina Hall, University of Manitoba

ADDITIONS TO THE LIBRARY OF THE ENTOMOLOGICAL SOCIETY OF MANITOBA[1]

Acridological abstracts, no. 9-10, 1968. (Anti-Locust Research Centre, London.)
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Annales de zoologie; écologie animale, v. 1, no. 2, 1969. (France. Institut national de la recherche agronomique.)
Annales des épiphyties, v. 19, no. 3-4, 1968. (France. Institut national de la recherche agronomique.)
Annals of the Agricultural College of Sweden, v. 34, no. 6, 1968; v. 35, no. 1-4, 1969.
Annals of the Entomological Society of Quebec, v. 13, no. 3, 1968; v. 14, no. 1, 1969.
Anti-locust bulletin, 44-46, 1969. (Anti-Locust Research Centre, London.)
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Pest infestation research, 1968. (Pest Infestation Laboratory, Slough, Eng.)
Polska akademia nauk. Instytut zoologiczny, Warsaw. Annales zoologici, v. 25, no. 13, 1968; v. 26, no. 1-19, 1968-69; v. 27, no. 1-7, 1969.
Polska akademia nauk. Instytut zoologiczny, Warsaw. Fragmenta faunistica, v. 14, no. 11-13, 1968; v. 15, no. 1-10, 1968-69.
Studi sassaresi, sezione III, v. 16, fasc. 1-2, 1968. (Sassari, Sardinia. Università. Facoltà di agraria.)
Zastita bilja; Plant protection, no. 99-101, 1968. (Savenzni institut za zastitu bilja, Belgrade.)

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1. The Manitoba Entomologist is printed annually and publishes articles on all phases of entomology. Each paper should contain the results of original research, or review in depth some aspect of entomology. While the primary aims are to publish material of regional interest, papers of interest to other geographic areas or of general interest will be accepted.

2. Manuscripts should be prepared according to instructions described in the **Style Manual for Biological Journals**, published by the American Institute of Biological Sciences, 2000 P. St. N.W., Washington, D.C. 20036.

3. Manuscripts should be submitted in duplicate, including the original and one carbon copy on 8½ x 11 paper, double spacing the entire manuscript. For the correct format, please consult past issues of this journal. Each manuscript over two typescript pages should include an Abstract not exceeding 200 words.

4. Tables and illustrations should be clear and concise, kept within reasonable limits, and should not repeat material presented in the text. Notations identifying the author and title should be made lightly in pencil on the back of each illustration. Tables should be typed separately, one to a page at the end of the manuscript.

5. Each manuscript is reviewed by at least one external referee, who will check for scientific content, originality, and clarity of presentation.