THE COST AND FEASIBILITY OF WILDLIFE HABITAT MAINTENANCE ON PRIVATE LANDS IN THE MINNEDOSA POTHOLE COUNTRY

by

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INTRODUCTION

A PERSPECTIVE ON VALUATION MODELS FOR CANADIAN WILDLIFE

1965-1974

It is a particular pleasure to present research in this report to Manitoba's and Canada's resource community. Some background would be useful. In 1966 the Canadian Wildlife Service began a $50 million habitat acquisition program. At that time the only objective approach that could be made to the issue of the economic value of waterfowl was to infer value by estimates of spending by waterfowl hunters or by administrative prices. This raised complex issues and caused great pain to both economists and biologists. Unless a value could be established for a duck, then the amount of habitat needed could not be estimated. If, however, a duck could be said to be worth something - anything - then, so it was reasoned, the money could come from somewhere. The land could then be purchased for ducks; from hunters or from governments or, if necessary, from agriculture.

There were a number of marvelous problems involved in trying to place a value on a duck. Many had to do with the conception of waterfowl as individual organisms to be managed individually and harvested in seperate places rather than managed in large numbers. Another major problem involved organizing the questions and conjectures in a kind of vast systems framework for North America in order to determine their implications for valuation. Indian rights, international treaties, whole government agencies had to be considered.

There was a touching faith by all of us in the justification of duck values found in the theoretical constructs of economic rent and consumer surplus. We soon found this a very weak reed. No one was cashing any of our cheques on those notions. That was the day of tough economic models, stringent objective evaluation before environmental values. Experts found it difficult to define the waterfowl habitat that was actually required; the location, the amount needed, the sequence in which it would be used and that point at which it would be used up. Duck habitat in some years was not duck habitat in other years. Often perverse waterfowl failed to use habitat defined by experts as prime, the year before. In some years habitat was beneficial and benign but in other years it was deadly to waterfowl. Few knew why.

In order to justify the program we tried to relate duck habitat purchases to curing rural poverty in Manitoba and Saskatchewan. But we soon found that the two goals could not be accomplished by the same program for it was not necessarily low income farmers who held desirable areas for waterfowl habitat. Most experts became very edgy when numbers were injected into the conversation; how many waterfowl were required? Was it 50, 100, 200 million? Some became quite expansive about it, suggesting that they could see large portions of North America's land being used for bumper crops of ducks instead of grain. At the value of a duck-hunter-day, estimated then at $25, perhaps they were right. At least no one had proved them wrong.

As the study proceeded a number of untested assumptions came to light. The general proposition was accepted that much slough and other desirable habitat was being removed by foul play as agriculture plowed up land for crops. However, there was also some unevaluated evidence which indicated considerable resilience to such habitat reduction among the waterfowl population itself. In many cases, waterfowl were utilizing new habitats as the old disappeared. Thus reservoirs, ponds, ditches, sewage ponds, swimming pools, lake edge, the Red River Floodway and other places, not normally thought suitable, were being appropriated by the ducks themselves. Could it be that the new, accidently created, habitat was compensating for the disappearance of the more stodgy, victorian but scientifically certified habitat? As far as habitat was concerned ducks seemed to be highly resilient creatures, thriving in any habitat available. Mallards lived, bred, nested, divorced and died of old age in wooden boxes and tin cans in London zoos and ponds. A brace of wild waterfowl have lived year round in a ten foot diameter fountain in the middle of an 800 year old cobbled square in Vienna. They appear to thrive on an unnatural diet of Secher Torte and liver pate.

The number of untested propositions, assertions and assumptions was disconcerting. Hunters, were said only to shoot the lame, halt, the blind and the unmusical - and those cleanly through the heart. This culled the flocks in a useful way. If a species was overhunted why try to artificially increase their numbers through habitat retention; why not switch instead to another species in plentiful supply. The English Sparrow comes to mind. Most hunters were sportsmen who enjoyed hunting difficult, challenging fowl far more than sitting ducks. The sharp-eyed highly skilled and sporting hunter enjoyed a challenging adversary. If this was so, then the question of hunting alternative, really sporting fowl arose. Why not a season with the swift challenging humming bird as target, or even the 100 m.p.h. Deer Fly? Swift adversaries, both would undoubtably be a great challenge to true sportsmen.

Perhaps then there are alternatives to be examined to merely increasing numbers. There is a tendency among us in the wildlife management profession to implicitly depend on and defend hunters as our clientele and to justify hunting pressure while ignoring the overall management consequences.

We should begin to question whether the conventional wisdom about our objectives in migratory waterfowl management are appropriate. Is protected habitat the way to produce more waterfowl? During World War II a great natural experiment took place. Investments in agricultural production resulted in filling sloughs, breaking new land and destroying huge amounts of prime habitat. Expert hunters had taken to the battlefields of Africa and Europe, sparing the fields or lakes of North America. What happened? There was apparently an increase in the migratory waterfowl population despite the habitat loss. I suggest the increase resulted from less hunting pressure. This proposition has not been thoroughly examined.

If increased number of waterfowl is what we want we need to examine alternative management strategies. Then we should test the effect on flocks of a reduced season length or lower bag limits or tests, as in Europe, to raise the skills of hunters on the price for shells. Shells at $5 each would likely improve skills enormously and might effect populations favourably. To the best of my knowledge none of these propositions, alternative strategies or assumptions have been tested. The price of licenses might even be raised to a level to pay for the management of waterfowl - thus confronting the consumer with the real cost of the sport.

A systems framework might use the criterion of managing waterfowl numbers within the context of existing habitat for consumptive and non-consumptive goals. An integrative solution would meld agricultural production needs with consumption objectives. It would be necessary for both advocates to treat together and acquire public funds to disolve constraints.

Mr. Colpitts' work proposes a framework for the accommodation of both advocates. His approach to the problem of value is a true quantum jump in wildlife management. For here, we begin to know what we are talking about, in terms of needs and costs. He by-passes the value of waterfowl as judged by hunters' spending for equipment or an administrative value per duck-hunter-day, and establishes the opportunity cost of waterfowl in terms of the foregone agricultural production. That amount, plus an incentive is what the public - or someone - must pay the farmer for the use of habitat. This is a real breakthrough. It is unnecessary to use hunter days, hunter spending, administered prices and all the other circumlocutory devices to find the value of a duck. Mr. Colpitts' work presents the costs quite accurately with the proposition "if more ducks, then less grain." Mr.Colpitts is to be congratulated, as are the members of his committee. It is an excellent, thorough and compelling piece of work. I would propose that perhaps now we should proceed to examine some of the assumptions and management alternatives that have not been examined in our management of waterfowl. The price the public is willing to pay is one excellent approach. It leads directly to the issue of the allocation of the harvest, between consumptive and non consumptive uses.

There are many other interesting problems in wildlife management involving tendency to distrust the "unnatural", the influence of unknowns. New conditions or altered circumstances are always assumed to be deleterious. There is less belief in the adaptability and resilience of natural phenomena and organisms than ecological principles suggest there might be. It is amusing to note that natural organisms do contribute to our environmental deterioration or require adjustment in parameters of resource management. For example, waterfowl may be heavy polluters of water sources. A small

Wisconsin town has its water supply pond thoroughly contaminated annually by the numbers of migratory ducks and geese settling there. The waste of two geese is equivalent to one human in polluting the town's water supply.

The adaptability and labour saving efforts of waterfowl are also satisfactorily rational. Wisconsin wildlife managers who fed waterfowl travelling the flyways south have been embarrassed in the past. The available food at stations caused many waterfowl to abort their journey south. They settled permanently there instead of migrating properly as "wisdom of the wild" requires. The managers were affronted by these unnatural practices. Shortly afterward the waterfowl were captured, crated and bound south to their proper Lousiana winter habitat on the Illinois Central Railroad. This behaviour by wild creatures and their managers adds a thoroughly satisfying dimension to the study of wildlife management.

It would be useful to see further breakthroughs made in wildlife management. It would also be extremely useful to test some of the assumptions and propositions that have been noted here. The next step the Natural Resource Institute hopes to take is to sponsor tests of societal values in placing and valuing wildlife populations within a systems framework. Later, perhaps, the submerged issue of who pays the costs and reaps the harvest along the flyways, can be broached by some brave soul.

The following pages are presented to give a cross section of the thought on values that existed in 1966. It is edited and reprinted here to provide perspective on the progress made by Mr. Colpitts and his committee.[1]

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1 Source: "A Proposed Economic Evaluation Procedure for Waterfowl Habitat in Canada - April 1967, Hedlin-Menzies Associates Limited, 1967 pg.1974

This paper is then a period piece that covers the development of a general approach to the problems of evaluation of wildlife resources in Canada, in 1965 and the general terms of reference for the 1965 study by Hedlin-Menzies and a decision to concentrate on particular problems associated with migratory waterfowl. Several approaches to economic evaluation were proposed, set and it was suggested that the most acceptable was a practical set of evaluation procedure in Canada. The following is an edited version of the first stage report produced in 1966.

"There is widespread recognition within the agricultural community today, particularly on the Canadian prairies, the land is no longer a plentiful resource with vast acreages unbroken and simply awaiting the plow. In fact, it is true to say that the public at large now recognizes that expansion of acreages under cultivation for food and expansion of acreages for raising of cattle and sheep to meet the ever-growing demands of the populace may soon be faced with critical problems of competing demands for that land. The steady growth of our sprawling cities and particularly their appetite for more and more rural land for residential development, for highways, and for the miscellany of associated services is a well known source of concern to the agricultural land agencies of many governments.

The concern of the Canadian Wildlife Service with the maintenance, growth and development of wildlife resources across Canada quickly brings them face-to-face with this land conflict problem, since wildlife already must compete at least in the more settled and less remote areas of Canada, not only with agricultural community breaking up the wilderness habitat but also with the vacationing public seeking more and more parks, beaches, swimming areas and the like, to follow a wide range of outdoor recreation pursuits.

It is true that in many areas, with sound planning of the facilities involved, the human inhabitants and the wildlife population can exist in reasonable harmony, particularly in major parkland areas across Canada where sufficient open land area minimizes the physical conflict and physical contact.

It is of particular concern in undertaking the study that recognition be given to the problem of diminishing wilderness and diminishing natural waterfowl habitat in a number of areas of Canada. In this country, even though there are only 270,000 quare miles of land under cultivation out of a total of some 3.5 million square miles of land area, it is obvious that in the major waterfowl habitat areas, especially in the southern prairies, a super-abundance of waterfowl habitat simply does not exist in the late 1960's.

An examination is necessary in broad terms of the current and future problems of ensuring that waterfowl habitat will be preserved in Canada at acreage and quality levels sufficient to maintain the waterfowl population.

Habitat preservation programs of biological research in common with similar programs in other fields require considerable capital, and the largest portion normally has to be obtained from government funds. Since the government agencies involved must always endeavor to maximize the effectiveness of their capital expenditures, their decision-making processes and procedures for the disposition of capital must always examine the economic and social benefits resulting from the various alternatives open to a particular capital investment. In many cases the sector of the economy where the greatest economic benefits are indicated will naturally capture the bulk of the available capital.

The assumption is made in undertaking this study, however, that governments at both the Federal and Provincial level in Canada already recognize that provision of human recreation facilities does carry with it the potential for substantial long-term benefits and therefore is desirable from both an economic and a social viewpoint.

It is clear from our research that until very recently in Canada there was little attempt at assessment of the problem of how much capital should be allocated to recreation in total, or to the appropriate level of government expenditures in particular types of recreation activities. It is equally clear that even the establishment of acceptable standards for recreation facilities and assessment of over-all requirements for the future to meet rapidly growing demand are still being given only cursory examination.

The absence of established standards and the prevalence of seemingly ad hoc programs in the recreation field has been due largely, to the severe difficulties involved in evaluating in strict economic terms the impact of recreation on the nation's population and economy. It may be relatively easy for the individual to be convinced of the advantages to him of having an easily accessible beach or camping area, park, or boating area, or water-fowl marsh. It would be extremely difficult for that same individual, however, to calcualte or estimate the portion of the gross national expenditure that should be devoted to provision, maintenance and improvement of such facilities across the country on the basis of their contribution to the gross national product of Canada.

Regardless of the apparent difficulties involved, it is our contention that an attempt must be made to assess the broad economic merits of any wildlife resource development program involving government capital, since in the final analysis the provision of funds to that program will be at the expense of another resource program elsewhere in the country or will have to be met out of higher taxes. This assessment cannot take a narrow viewpoint aimed at justifying each individual project on the basis of its primary benefits simply exceeding its total costs to the area in question. The broad assessment of evaluation of our wildlife resources, however, must recognize the importance of both financial and economic factors and also, most importantly, the potential social benefits to the community at large.

In determining the terms of reference for this specific study, therefore, a number of basic factors had to be borne in mind. The current and future situation in Canadian agriculture and the resultant impact on the need for reclamation and breaking up of marginal land such as waterfowl pot-holes and marshes, is of direct importance to any wildlife resource development program. Also, the relative rates of growth in Canada for the potential demand for land for agricultural purposes on the one hand, and for the rapidly growing demand for what may be broadly termed the "recreation industry" on the other. The cumulative effect of growing numbers of people with steadily improving levels of personal disposable income and with more and more leisure time for vacations and for short trips, leaves little doubt that recreation facilities and recreation habitat in general will not only have to be maintained but will have to be greatly expanded.

Attention in this study will be directed particularly to that part of the recreation industry which involves wildlife. Therefore we are concerned with both the ungulates and the waterfowl themselves as living beings and with their habitat. We are concerned too with all those who may be termed the wildlife resource users, whether they be big game hunters, duck hunters, animal and bird photographers, naturalists, bird watchers, or amateur ornithologists.

Our primary objective therefore must be to examine the specific problems which arise in providing for fully adequate habitat for the wildlife populations to be maintained at a level acceptable to the government agenices involved, and to the North American public as a whole. This in turn will necessitate close examination of the current and probable future population of duck hunters, photographers and others who in fact represent one essential part of the demand side of the wildlife resource equation. The effects of climate, predators and other natural enemies of wildlife, of course, also are significant in the equation.

As has been outlined already, the provision of adequate habitat however, is not simply a matter of deciding what areas and what acreages have to be set aside for wildlife in Canada. In many areas there is already fierce competition for the land involved from the agricultural community, from forestry and mining interests, and from other recreation uses. The problem therefore inevitably requires consideration of all the possible alternative uses of a particular resource area. Examination of all the real alternatives should involve both economic and social values for a considerable future period to be completely satisfactory. In practical terms, however, the readily identifiable economic benefits to the nation or to the specific area which result from a particular land maintenance or development program normally will prove much more compelling to anyone faced with a decision involving capital investment to acquire or lease or rent the land area than a general statement of its scenic beauty and abundant wildlife.

It is in this context that those most intimately concerned with the preservation and conservation of our nation's wildlife resources must closely examine their own programs. It has become clear already, for example, that in a number of the leading production areas for migratory waterfowl in North America major programs involving substantial expenditures are urgently required to even stabilize the steady loss of prime habitat areas to agriculture. This stabilization cannot take place however, with major inflows of capital, which in turn must follow some assessment process aimed at demonstrating two critical points. Firstly it must be demonstrated to the government agencies involved that the wildlife or waterfowl resources in question is in fact being severely impaired to the point where the pressure of national interests forces some action. Secondly, within the broad field of all the existing wildlife resources, there must be demonstrated some range of priorities for most urgent action. This latter selection and assessment of priority areas on the basis of greatest attractiveness as wildlife land to be conserved and/or on the basis of most critical local regional need, or both, is in fact the constant dilemma facing the government agenicies with broad national responsibility for the conservation of all the wildlife resources.

The following report concentrated in depth on the broad problems involved in economic evaluation of our wildlife resources. The primary objective will be to arrive at some practical, workable evaluation procedures for the migratory waterfowl resource areas, and this in turn will involve considerable study of programs actually being carried out in a number of areas in the United States.

The various areas of research which have been undertaken for this report had to start in many cases from a more detailed examination of the more critical areas of the evaluation problem. This research identified a number of approahces which seemed worth pursuing with the following terms of reference in mind: "To carry out the necessary research and investigatory work proposed in the said preliminary report (that is the Stage I report by Hedlin Menzies entitled 'Assessment of the Economic Value of Wildlife Resources'), with particular reference to ;

(1) determining a practical and administratively acceptable set of evaluation procedures for application to wildlife resource programs in general, and migratory waterfowl projects in particular,

(2) examination of relevant economic and biologic data for selected example waterfowl areas or particular locations in Canada, in order to determine migratory waterfowl values through utilization of the evaluation procedure in (1), and

(3) prepare a final report on the facts of the investigations carried out."

The following several pages contain coverage of the general problem examination of existing methods of evaluation, and general conclusions and recommendations for further research work.

Agricultural development and production has been supported by massive research programs throughout the life of Canada as a nation. The same thing has not been true to the same degree with respect to forestry and fisheries, and in the case of wildlife, resources made available for research have been abysmally inadequate. Planning for the conservation and the optimum use of the continental waterfowl resources is obviously urgent.

The Canadian Wildlife Service has gained approval for a program of acquiring necessary waterfowl habitat, as well as some incidental upland game habitat. Research is to be conducted in conjunction with this program. The annual $5 million budget proposed for this program is substantial. The effective use of the available money will, in all probability, be dependent upon a large part of this budget - or additional money - being available for a massive research effort. The first priority should be the refining of the problems of production and management. The second priority should be to maintain or expand prototype easement programs with the objective of investigating costs. This involves some modification of the program now designed. The revised priorities would presume the use of prototype easement programs to secure vital habitat threatened by immediate drainage, and using this habitat for essentially "test area" and experimental purposes.

The first step was in building research knowledge - in this instance on the economic side. It established to the satisfaction of the authors that there appears to be no alternative to the accepted economic technique for the establishment of "value" of waterfowl, and that such a technique will not result in the placing of a specific value on the individual bird, whether that bird is in a hunter's bag or seen through the lens of a camera or enjoyed by a bird-watcher.

The main clue to a most useful approach to the economic evaluation problem appears to lie in attempting to evaluate the resource habitat from the viewpoint of the resource users as well as the government agencies involved.

A number of figures occur in the text detailing numbers of hunters and fishermen and expenditures by these individuals in various areas. The figures are a very useful indication of where to spend money already budgeted to a fish and game agency but they did not of themselves justify that budget. They are not economic values but are a very useful basis for government policy decisions where an allocation of capital funds is necessary among certain activities. Clearly, analysis of "associated" spending by hunting or fishing may represent only a first attempt to get at recreation demands. They are meaningful only if other elements of that demand are brought in to provide a finder guide for government policy decision. Very little of this associated spending, however, finds its way to the farmer or rancher, who feels he produces the game and who suffers losses from wildlife depradation. The only direct economic value attributable to wildlife is normally the license fee totals.

The amount of hunter spending is not the economic value of the sport. No cost enters to limit this expression of demand as a means of establishing a price for the economic value. The economic value of the game is no more or no less than the amount someone, whether individual or government, will pay for it.

It may be of infinite worth, but unless the price is paid, associated measures of value or demand are of little worth since they don't pay for production or maintenance of wildlife populations. They are, however, of considerable guidance for those charged with the distribution of a given budget for wildlife conservation. The main challenge is still to establish what reasonable level or overall benefits can be claimed for the resource for the country as a whole, and so give some order of magnitude of the size of government budget which might be justified in total.

A sub-committee working on these programs in the U.S. indicated that the user-charge approach showed the most promise for early development into an evaluation procedure comparable to those used in evaluating other project functions. Under such a procedure, fish and hunting benefits would be based on estimated charges which the sportsman could be expected to pay for fishing and hunting privileges in project areas. A panel of experts on recreation values was established to develop an administrative schedule of daily unit values from a review of the avialable sources of applicable information and from their own experience and expert judgements. Such a panel approach would well be useful in Canada in the current situation.

Regarding these administrative values, the question is often asked "How has the system of administrative values work in actual practice in the U.S.?" It appears from our research that it has worked fairly well, but this conclusion is not shared by all the agencies in the State Fish and Game field. Some have viewed the values as a sellout of fish and wildlife to the construction agencies, based mainly on the fact that the new values were substantially lower than the old expenditure values. It is important to point out that in the U.S. simulated market values that have been attached to sport fish and wildlife have gained approval by the federal government as a whole and by the committees of Congress. Without such acceptance, putting a value on wildlife resources would be quite futile.

There is a major difference between an economic good and a free good, with the former having a price established by a private market. The critical question is whether wildlife can command a price that is high enough to change the land-use pattern so that the production of wildlife will become a rational substitute for the current production of some other economic good. Only then has wildlife an economic value, and only then does it represent an economic good rather than a free good. This being the case, it is not helpful and may well be very misleading, to speak of unit values of wildlife.

Under various circumstances, public spending for wildlife support on the basis of a government policy decision could be undertaken. For example, a policy decision could be made that a general value would be used to help measure and compare recreation values of wildlife for public projects - to establish an administrative 'price' because government feels recreation is so generally accepted to have value that it can be calculated for projects built by public funds as part of their justification. A policy decision might be made too, that based on evidence available, certain wildlife or waterfowl are likely to become economic goods within some reasonable time period, and this is certain enough to justify support of large populations in the interim. The cost of this would be the purchase of breeding habitat by government and/or hunters or other users.

The conclusion is unavoidable that the only means of establishing a price or value for wildlife is (1) by confronting the consumer with the cost and observing whether he will pay it, or (2) by establishing an administrative price of very limited applicability for use on government projects. This idea can of course be expanded to apply administrative prices to selected classified prime waterfowl habitat areas with the inference that some selection and physical justification process has already taken place.

A number of highlights are worth mentioning.

Placing short-term easements on essential habitat likely to be drained will, at minimum cost, provide waiting time to make final decisions. Also, data that is not now available and which is essential for determining how large the program is to be, may well become available later. Also, by buying time as the most popular constraint, breeding habitat can be tested and refined. In any event it is evident that there is certainly a need for the establishment of government priorities in order to gain control of what must be regarded as essential prime waterfowl habitat. This will involve establishing patterns of control, areas to test productivity of waterfowl over several years, to judge the effectiveness of the expenditures in the control areas in maintaining productivity and thereby providing an opportunity for both Canadian and U.S. hunters to hunt waterfowl in the area.

Where allocation of private land between agriculture and waterfowl is necessary, the only effective method of gaining control of the habitat will be through a cash payment, either for outright acquisition or for leasing the appropriate sporting rights. The capital value of this payment in total of course will have to be approximately equal to the opportunity cost of land in its highest possible alternative use. This use, however, has to be a realistic use and may well be as waterfowl habitat and not agriculture. Therefore the true opportunity cost of such land may well be somewhat lower than the present value of the surrounding prime agricultural land.

It is important to note that a five-year research program including continued experimentation with pilot project acquisition and other forms of control programs and evaluation of the results would be most helpful in establishing the full costs of producing waterfowl. Potential sources of user financing could also be investigated during such a period to compare costs and potential income. The cost of such research could be held to a minimum in Canada by using the U.S. acquisition program in the plains States as a means of testing assumptions, priorities and goals. A later chapter of this study will deal with the actual U.S. programs in some detail and with the lessons to be learned from them.

A research program would be useful if two items in particular were outlined.

(a) Investigation of an administrative price (fiat price) for project planning purposes and for amelioration. It is recommended that the possibility and feasibility of establishing an arbitrary value to be used in benefit-cost procedures in planned projects be investigated. Presumably these would have to be acceptable to provinces and agencies, as measures of loss from impoundment areas, together with acceptable procedures for amelioration and replacement. The assessment of replacing habitat lost by destruction might be the most valuable examination that could be made, assuming it could gain administrative acceptance.

(b) How many waterfowl are enough; what is the total cost of the upper limit; with what probability can it be reached, and what is the cost? A problem which has not been adequately dealt with to date is the question, How many? Its importance lies in the amount and cost of land and water necessary for a flight of, say, 70 million ducks, compared with the land and water inputs necessary for a flight of, say, 100 million ducks. There does not appear to be agreement on the necessary number of waterfowl among scientists in Canada, much less between Canada and the U.S. It appears that an effort is being made to prove that no matter what figure is proposed, more waterfowl are required. The crux of the matter is that a planning goal of, say, a minimum fall flight of 70 million can be planned for but an indeterminate, open-ended goal cannot. A smaller figure is probably also easier to guarantee by free planning than is a larger one, given such massive and unpredictable variables as drought.

The goal of the maximum feasible production of waterfowl is so loose a definition as to be almost meaningless. An annual flight of a specific number of birds however, can be analyzed in terms of cost and using a variety of assumptions.

Analysis also suggests that an analysis be made of potential sources of user revenues and the possibility of tapping these sources. Clearly the provinces will be of major importance in this and should be considered in any such assessment.

There are many situations where it may be possible to combine a program such as waterfowl habitat acquisition with significant social goals. The social value of preventing the use of some sub-marginal land may be much greater than the value of any waterfowl produced on the land after its closure. This is also true of removing some types of land from production where the returns from, say, the agricultural produce simply do not justify the costs involved over a period of years.

The foregoing summary deals with matters falling under the general heading of the problem of economic evaluation of wildlife resources. A final comment for recommendations is that the "failure to initiate a very large biologic-economic program would, in the view of the authors of this study, be a very grave mistake."

What may be concluded? Until very recently in Canada, little attempt at economic evaluation of recreation resources of any kind has been undertaken. To our knowledge there have been no extensive Canadian studies of overall outdoor recreation development demands into the future for such major types of demand as wildlife areas, or waterfowl hunting areas.

Regardless of the difficulties involved from an evaluation viewpoint, it is our belief that the wildlife agencies have a responsibility to demonstrate the usefulness and sound management of government monies spent on wildlife programs of all kinds, at least in broad economic terms.

It is clear to most objective observers that all the wetlands cannot possibily be saved for waterfowl, and that some of it quite reasonably will go to other competing uses. Therefore, wildlife agencies should concentrate on prime waterfowl habitat areas first. For this reason, there is an urgent need for a complete province-by-province Canadian inventory of all our wetlands.

In Canada, there is need for an early action program rather than simply more 'supply' type studies. Even if adequate waterfowl habitat is to be accessible to hunters seeking it in the short-term future, it appears urgent in number of regions of Canada that conservation programs to control drainage and other loss of wetlands be taken in hand in the immediate future.

The onus cannot be on the farmer or hunter to demonstrate where there is most need of government action to preserve wildlife habitat. The onus, on the other hand, is on the government agencies in the wildlife field to draw up plans of action which will face up to the problem of diminishing habitat before the decline is too far advanced for any permanent solution.

An immediate priority for the 1967 season should be completion of sample control areas in as widely scattered prime habitat regions of the country as possible. All such programs, either controlled by leases or some other form of holding investment by the Canadian Wildlife Service, will ideally be in areas where prime habitat loss and drainage is an established problem. One of the principal purposes of these widely dispersed samples will be that they be utilized as intensive study areas by the wildlife agencies involved, both at the federal and provincial levels. These intensive studies, however, must not be confined to biological "supply" type studies; they must also include extensive surveys of the users of the area, their distribution patterns, their expenditures, their hunting characteristics and so on.

The individual "bird" from the sportsman's viewpoint is far less significant than the existence of accessible "promising" wetland habitat, where waterfowl may or may not happen to appear on a given day. From an evaluation viewpoint, the bird is a fleeting thing, with no relevant established value, whereas the wetland habitat area can have value attached to it by its very potential of being a fixed area where sportsmen are willing to come in the hope of exploiting a temporary and seasonally recurring mobile resource.

The main objective of the agencies wrestling with the problem of placing economic values on wildlife resources is really to facilitate a more reasonable allocation of capital funds than would be the case from a series of arbitrary judgement decisions. Such allocation indicators, therefore, need only be reasonable indices of comparative benefits or values of the resource to the region in question, rather than accurate dollar values identifying the true incremental net economic benefits given to that region by the wildlife resources involved.

A panel of experts from various areas of Canada should be gathered together to discuss relevant levels for "user-day" values of wildlife in general, and waterfowl in particular, for appropriate regions or provincial zones across Canada. There may well be considerable variation in the typical seasonal totals between areas such as Boundary Bay or other salt-water hunting areas of B.C., the waterfowl areas of the Ottawa valley and south-western Ontario, and the pothole regions of central Saskatchewan.

It appears to be still true that the only way of establishing a price or value for wildlife is:

(1) by confronting the consumer with the cost and observing how many will pay it, or

(2) by establishing an administrative price of limited applicability for use on government financed projects.

Taking short-term action quickly on areas considered to be prime habitat and in danger of being lost, should be in the form of easements rather than outright purchase. This will buy time, without giving away flexibility for later necessary amendments to the decision.

In all the discussions on the needs for substantial areas of wetlands being conserved in the U.S. and Canada, and despite all the tone of urgency in both countries, it is exceedingly difficult to define the optimum target in the minds of the wildlife biologists. For example, if we were to comment specifically on waterfowl, some critical questions still not receiving any unanimity of answers are the following: How large a fall flight is adequate? Ten million, 25 million, 75 million, or 100 million? What should be the minimum targets for the years to 1970 and 1975 and for later succeeding years? Should the objectives be to ensure a steady growth in fall flight numbers to ensure that a growing waterfowl harvest and ever growing hunter numbers will not endanger the species? If so, what should the growth rate per annum be in the targets? These are all rather fundamental questions and require considerable further discussion by the agencies involved, both in

Canada and the U.S. Furthermore, it is fully realized that these questions open up many vistas, such as the effect of the weather and of predation being much more damaging than even a record number of duck-hunters.

Reduction in the wetland areas requiring actual assessment for acquisition or other control programs for wildlife will only be possible if the Canadian agencies most directly involved have a completed and classified wetland inventory for Canada at their disposal. The usefulness of such an inventory ranges from formulating overall habitat management plans to selecting individual wetlands for improvement and to providing a blueprint of areas which should be preserved as prime habitat. No effort should be spared to ensure that the Canadian Wildlife Wetland Inventory Program is completed on schedule, because of its potentially great usefulness in tackling the selection, valuation, and conservation problems across Canada.

It appears clearly that many if not all of the wildlife programs in the U.S., have given careful attention to the data available from completed wetland inventory programs, as the basis for selection of the habitat most critical to the nesting and breeding cycle of the continent's waterfowl population.

All the Canadian regions with any appreciable waterfowl populations must be considered for assessment since it may well be justifiable to have government agencies undertake expenditures for acquisition or other control of wetlands even in a number of areas of lower waterfowl productivity per square mile than, for example, the prairie pothole regions. The justification will have to be based largely on the value of the wetland habitat to that particular part of the country and to the hunters and sportsmen relying on that region for their sport.

It is our conclusion that in any Canadian province, the framework for primary evaluation of wildlife resources should be a well defined sub-provincial region such as "major waterfowl habitat regions." It is imperative that any such region have relevant user data and general economic data available for a reasonable period of years for evaluation purposes.

In the literature, the overwhelming weight of evidence points to the validity of the "man-day" of recreation as the basic unit of recreation benefit measurement.

In attempting any benefit-cost approach to wildlife it will probably be necessary to establish an apprpriate geographical and economic area for the analysis by leaving all the various factors external to the area as constant for the sake of simplicity.

A recommendation which occurs frequently in the literature is that the several federal and state agencies concerned with wildland should coordinate their programs, starting at the initial planning stage so as not to work at cross-purposes in the field of game production and management. If necessary, appropriate legislative action should be possible to facilitate or require such coordination. It is one of our major conclusions in this study that these recommendations are very relevant for Canadian agencies and that action is urgently required along these lines.

From our studies, it is clear that acquisition and control programs should move forward as rapidly as possible because of the extent of conversion of wildlands to other uses and because of the rapidly increasing cost of such land.

It is now widely recognized by many agencies that various types of recreation benefits can be very significant in particular areas. The magnitude of these benefits, however, is still a matter of wide difference of opinion. On a person-day-use basis, very substantial benefits can be computed. There is a tendency, however, to hold down the dollar value of a person-day and to put a ceiling on the benefits when calculated from such figures. There should be a general realization that recreation benefits are large and that they should be accepted at face value and not artificially discounted.

It is our contention throughout this study that the current wildlife Wetland Capability Inventory being carried out in Canada and, in particular, the waterfowl portion, should provide the basic data and information necessary for the first selection step in an evaluation procedure.

The Bureau of Land Management has a significant role to play in the U.S., and the potential value of any such agencies in Canada for example as an offshoot of the ARDA organization, may be something worth considering in Canada since an important prior requirement to a set of procedures for evaluation of particular land areas such as wildlife habitat, simply must assume the existence of some agency with a multi-use long-term responsibility for land management all across Canada.

In the current Canadian situation it is also suggested that a careful examination be made of the importance of any areas already acquired by any public agencies for their potential partial use as waterfowl habitat. Some may have been acquired because of some other major water resources project, such as flood control project, and have potentially high secondary use as waterfowl areas.

If, following the establishment of some broad guideline to evaluation procedures, it is desired to move in the direction of more sophisticated measurement, the prior availability of a suitable broad, analytical framework should attempt to be suggestive with respect to both types of data acquired, and approaches to further refinement in measurement.

Regarding demand measurement, the usefulness of cross-section land data from sample surveys of demand, should be explored for several typical waterfowl areas in various regions of the country, in order to test any suggested methodology of evaluation and also to test the validity of the scales of suggested values.

It would seem reasonable that there be come concentration of attention on evaluation, in more precise quantitative terms, at least the "A" priority habitat and hunting areas in each major region of a province.

In any evaluation method, care must be exercised to take proper account of not only the present, but the future hunter trends in any particular area.

The main difficulty of evaluating the recreational aspects of fish and wildlife stems mainly from the absence of any direct measure of value, rather than from such effect being inherently non-measurable.

The user expenditures method uses the per capita per-day expenditure incurred by hunters in connection with hunting activity as a basis for assessing the value of hunting. The expenditures used are those for equipment, food, lodging and transportation as the main items. The expenditures should be decreased by the amount which it is assumed would have been spent by the recreationist if he had not engaged in that activity that day.

The U.S. Fish and Wildlife Service has usually followed this so-called "sportsmen's expenditure" for evaluating recreational benefits of any given project. Current values used by the Fish and Wildlife Service to evaluate benefits of a day's use of hunting habitat vary from 50¢ to $6 per user-day.

If our evaluation methodology suggested for Canada is dependent largely on measuring our range of expenditure items by hunters or sportsmen as indicative at least of the comparative levels of benefits between regions, then it seems reasonable to suggest that a regional point of view or, at most, a provincial point of view, be chosen for the evaluation analysis.

It is our proposal, considering the problem of migratory waterfowl, across Canada and the features and problems associated with the hunters, the habitat, and the demand for hunting facilities, that a broad methodology based on expenditures as a measure of comparative secondary benefits in a particular region has considerable relevance as a useful approach.

After reviewing in considerable depth much of the relevant literature on the economic evaluation of wildlife resources, we must argue strongly in favour of some practical set of precedures which can be oriented to a local regional viewpoint. These procedures must also be workable from available statistics because in Canada in many instances in the wildlife field, the basic statistical data are still very sketchy and incomplete.

It appears that the most useful approach is along the line of exploring sportsmen's expenditures as an aid to achieving an assessment perspective on the broad regional values of waterfowl or wildlife resources. Since these expenditures however, indicate secondary rather than primary benefits, they can really only provide a guide or a comparative index among regions competing for funds rather than claiming to be a direct measure of the level of true benefits.

One major objective must be to define an appropriate waterfowl habitat region which is considerably smaller than a typical Canadian province, and where the data are available to permit a broad assessment of the wildlife resource values of that region. Within any of the defined major waterfowl habitat regions, the first selection stage must also include a ranking of the areas of prime waterfowl habitat, based on the numbered classifications in the current Canadian wetland inventory program. In this first stage of any regional assessment the objective will be to arrive simply at an acceptable listing of land areas in some priority order from highest to lowest on the basis mainly of their desirability as waterfowl breeding habitat.

In brief, it is our proposal that a simplified benefit-cost approach be followed assuming a provincial or regional viewpoint, rather than a national viewpoint from which to assess the economic values of the economic values of the waterfowl habitat. From study of a number of approaches in many areas, it is our conclusion that there is considerable relevance in equating economic benefits to the region with the net dollar values of existing fees and licenses paid by sportsmen, and in addition including all the measurable secondary values represented by these sportsmen's expenditures in that region.

It must be assumed in a number of areas where detailed regional surveys are lacking on the monetary and time expenditure levels and patterns of waterfowl hunters in Canada, they are not significantly different from the averages obtaining in the north central U.S. in areas of Wisconsin, Minnesota, North and South Dakota, and Montana.

Although forecasts of demand in the wildlife sector are clearly hazardous they are necessary for our suggested evaluation process. It is essential that the future levels of possible demand on the wetland habitat resources be estimated at least in broad terms. It is necessary, furthermore, from an economic evaluation standpoint, to extend the anlysis for an appropriate period of time. It is our proposal that this analysis be forty years.

It is suggested in general that there will be a modest growth in hunter numbers in Canada, and a steady growth in the number of days spent by the typical hunter in waterfowling, which accumulated will represent an annual growth pattern of demand of between 5 and 8% per year over the mid-term future. It is also suggested, based largely on surveys of fishing and hunting carried out by the U.S. Fish and Wildlife Service during the period from 1960 to 1965, that hunter expenditure levels per day will continue to increase at between 3 and 5% per year for the foreseeable future. The resultant forecast in the general case, beginning in year "One," would have a regional hunter number spending an agreed average number of days on waterfowl, and spending in the range of $5 to $7 per day, including all relevant expenditures, together yielding a regional total in dollars of benefits for comparison with other regions. These totals would be projected for the proposed, forty-year period, and from the above percent per year growth rates, the overall growth in values would range between 8% and 14% per year.

The annual discount factor used to calculate present value figures of benefits should represent, as closely as possible, the opportunity cost of funds being invested by the government concerned. It is proposed that the appropriate rate of discount for Canadian projects in the public sector is 5.1/2% per year.

Study of reports from many areas regarding actual costs per acre for acquired wetland reveals extremely wide variations. This may result in part from the location and quality of different wetland areas, and in part from the years of acquisition, but it also suggests strongly that outright acquisition should only be undertaken after careful study of hunting and other recreation values of the particular area or period of several years.

The current situation in Canada is one where detailed, sub-provincial knowledge of hunter members, days of waterfowl hunting, expenditures by hunters and others, and the apparent trends in such data, are incomplete and quite frequently not available for local regions. In this situation the soundest approach appears to be through a wide-ranging, consistent program of leases, easements, or other forms of holding investments, rather than by outright purchases of land.

It is important to emphasize that as the waterfowl permit data now being collected across Canada are analyzed and published in more detail, they will provide further good source of information on hunter origins by individual post-office locations if necessary. Such data will be particularly significant for local area evaluations which are largely dependent on improved hunter activity and expenditure data.

In summary, it is our conclusion that the suggested evaluation procedures for Canada set out in the text are practical. While certainly over-simplified of necessity, and conservative in the assumptions regarding hunter activity and average expenditure patterns used in the case example of the Redvers area, they are basically built on two reasonable foundations. Firstly, a sound physical selection and priority identification procedure on habitat; and secondly, on a broad economic analysis of both the present and future levels of expenditures, and fee costs to the sportsmen's groups directly involved."

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Abstract

Intensification of agricultural production on private lands in southwestern Manitoba has depleted wildlife habitat and reduced wildlife numbers concomitantly. An integral component of this dilemma is the failure of landowners to receive remuneration for wildlife produced on their property.

The practicum analysis focused on a model to estimate the opportunity cost of converting an acre of active agricultural land to wildlife habitat. This opportunity cost of wildlife habitat maintenance is the net value of the agricultural products that could be produced from the same resources plus the fixed costs of agricultural production.

The main thrust of the practicum was concerned with waterfowl wildlife. Literature review demonstrated that evaluation of waterfowl benefits to society in monetary terms was at best extremely difficult. Therefore the attempt to measure the added benefits to waterfowl production from wildlife habitat maintenance was restricted to a model which calculated a range of waterfowl production attainable from habitat manipulation.

Data for the model analyses were extracted from a 36 square mile study area delineated in the municipality of Odanah near the town of Minnedosa, Manitoba. This locality was considered suitable for such a study because of its high capability for agriculture and waterfowl production and because of the availability of these data.

The range of opportunity cost estimates derived was - $12.84 to $45.46 per acre dependant on farm size and crop price and yield conditions. Potential waterfowl production from manipulating habitat without predator control indicated by the practicum analysis and substantiated by literature review was 0.19 to 5.72 birds per acre.

It is concluded that wildlife habitat maintenance in southwestern Manitoba is feasible by land easements incorporating 40 acre legal subdivisions. Annual easement payments could be no less than $14 per acre of cropland converted and would likely have to be upwards of $20 per acre to stimulate landowner participation.

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CHAPTER 1 - INTRODUCTION

1.1 The Problem

Concern has been expressed over the continuing decline of wildlife habitat in southwestern Manitoba. The importance of this retrogression has become apparent due to a parallel fall in wildlife numbers. A principle cause of this dilemma has been the advance of modern agriculture (Nelson, 1973). Improved technology has intensified agricultural production. Concomitant with this trend has been an increase in cultivated acreage and a decrease in the remaining area of native bushland and wetlands.

An integral part of the problem relates to the fact that Manitoba landowners receive little or no monetary remuneration for wildlife produced on their land. Very little information has been gathered on the opportunity cost of converting lands used for agricultural production in southwestern Manitoba to lands used for wildlife production or wildlife habitat. This practicum is directed at improving this information base.

1.2 Background

A large part of the problem of declining waterfowl numbers in the Minnedosa pothole country can be attributed to efforts by individual landowners to improve their standard of living by increasing cultivated acreage. The resultant gain in cultivated land area is equalled by a loss of potential wildlife habitat. The changes to the landscape in the Minnedosa area are only a minute segment of the total effort by man to develop the land resource of North America. Without a doubt, land development has played a significant role in improving the economic welfare of society. At the same time however, more subtle components of our heritage have been affected in the opposite way. Migratory waterfowl are one of these. The decline in waterfowl numbers might be interpreted as a symptom that the vitality of the environment is endangered.

Involvement in such research brings continual confrontation with the question of the value of wildlife to society. Why should there be any attempt to preserve wildlife and wildlife habitat? Other researchers have been confronted with this question. The opinion of many is that the point has been reached where greater recognition must be given to wildlife values and to identify wildlife habitat as an important component of the landscape. Some of the first to submit their views on this subject were scientists. Biologists in particular are perceptive of subtle changes in the natural environment and often advocate some degree of conservation at least. Erhlich et al., (1958), soil scientists working in the area west of Lake Manitoba made the following statement: "Many of the economic and soil problems encountered in the West Lake map area can be attributed to improper land use. An overall program of soil conservation and water control is sorely needed in this area." Still another opinion is that expressed by Grower and Kabaluk (1973:77): "There is a need for diversity on the face of the land: marshes, sloughs, potholes, all add beauty and interest to the countryside, as well as playing important roles in the hydrologic cycle. We can no longer afford to drain or abuse such areas, having gone as far as we can safely go in reducing these natural features."

Although society as a whole is more aware and more conscious of individual life style, other social values and attitudes are changing as well. This new train of thought relates to the following quote from Aldo Leopold (Wisconsin Conservation Bulletin, 1947:4): "The practice of conservation must spring from a conviction of what is ethically and esthetically right, as well as what is economically expedient. A thing is right only when it tends to preserve the integrity, stability, and beauty of the community, and the community includes the soil, water, fauna and flora, as well as people." In recent years, the public has begun to think in the same way as Leopold and the word "environment" has become a household word. At the same time, wildlife is beginning to assume status as a symbol of the earth's health and well-being.

Evidence of this new role was passage of the Canada Wildlife Act and the preliminary debates on the bill. If statements made by Members of Parliament represent the viewpoints of their constituents, then the concern is genuine. The Honourable Jack Davis, Federal Minister of the Environment (Hansaard, 1973:3540) said: "It must be a determined objective of all levels of government, of all individuals and of all organizations in this country to preserve as much variety in nature as we possible can." The Honourable J. A. Maclean (Malpaque) stated that the chief value of wildlife is the pleasure they give to people living in a given environment and that this has importance in maintaining future quality of life. He added that protection of endangered species involves man's encroachment on wildlife habitat, his unwise cropping of certain species and most important his economic activities. Man has used air, water, and land as receptacles for effluent from industry (Hansaard, 1973). Another Member of Parliament, Mr. Don Blenkarn (Peel South), commented that it is the responsibility of the Government of Canada to protect the heritage of our nation in terms of wild animals who were here prior to the coming of man. In order to justify our occupation of one-half of North America, we must protect those things that are here naturally to ensure their availability for our descendants. "We must draw on the knowledge, feelings, experience, and understanding of those who of their own volition live a life which respects the wild creatures around them" (Hansaard, 1973:3578). Mr. Mark Rose (Fraser Valley West) expressed his position in this way: "Now that bigger populations, more products and by-products of technology, greater use of resources and proliferation of wastes are lowering the quality of our lives - perhaps even threatening our survival - it is surely time to make intelligent choices which, at best, may preserve a reasonable quality of life and, at worst, will avoid disaster for our species" (Hansaard, 1973:3585). Overall these comments seem to indicate that there is a genuine concern for the fate of wildlife in Canada and that there is a belief that wildlife and wildlife habitat do benefit society.

In Manitoba, some insight into the government's position with respect to wildlife can be gained from provincial natural resource policy. Guidelines For The Seventies might be interpreted as an expression of possible government philosophy in this area. Volume 1 states: "Careful management of renewable resources is necessary to ensure that they are not wasted or destroyed, that they continue to regenerate for the benefit of future Manitobans, and that where there are competing uses of natural resources, the conflicts can be resolved in a way which will produce maximum benefits." In relation to waterfowl, this statement reflects the conflict between wildlife and agriculture in the Minnedosa pothole country. The difficulty is that landowners profit from agricultural production while they receive nothing for wildlife produced on their land. Guidelines For The Seventies adds that preservation of wildlife can enhance recreation potential. However, this type of land use potential is of little concern to most farmers.

Annual Reports of the Department of Mines, Resources, and Environmental Management also relate to the problem in question. These reports should not be interpreted as policy but they do indicate the direction of government thought. The 1969 Report said: "Demand is steadily increasing for crops of dwindling wildlife resources produced in shrinking habitat. User interest in wildlife is diversifying and increasing in intensity. At the same time, competition by other land uses is increasing, often at the expense of wildlife habitat. The need for progressive management programs to provide adequate opportunity for optimum wildlife production and use is greater now than ever before, and will increase."

The discussion thus far has done little to clarify the actual benefits of wildlife habitat maintenance. However, the purpose of this section is to demonstrate that the Federal and Provincial Governments have already recognized that benefits of wildlife and wildlife habitat are important enough to warrant passage of specific legislation in order that these benefits may be maintained and/or increased for future generations. Two pieces of legislation which have particular significance to waterfowl are the Migratory Birds Convention Act and the Canada Wildlife Act. The Canada Wildlife Act was passed July 27, 1973. Section (2) stipulates that all provisions respecting wildlife extend to wildlife habitat as well. The Act provides the Federal Minister of the Environment with the power to undertake, promote, or recommend steps for the encouragement of public cooperation in wildlife conservation and interpretation. Also, the Minister can implement wildlife research programs, establish advisory committees and coordinate wildlife policies and programs in cooperation with Provincial Governments. With respect to public lands the Minister may take charge of all wildlife research facilities on such lands, advise on any wildlife research, conservation, and interpretation being carried out on such lands, and carry out measures for the conservation of wildlife on such lands not inconsistent with any law respecting wildlife in the province in which the lands are situated. In addition, the Federal Government has means, through the Minister of the Environment, to enter into agreements with the governments of any province to provide for:

1) "the undertaking of wildlife research, conservation and interpretation programs and measures, the administration of land for such purpose or the construction, maintenance and operation of facilities and works related thereto; and

2) the payment of contributions in respect of the costs of such programs and measures."

The agreements referred to will specify the portion of costs to be paid by each agency, the authority responsible for undertaking, operating, and maintaining the program, and the proportions of any revenues generated payable to each agency. Besides these, programs with municipalities, other organizations, and individuals for the same intents, may be established with the approval of a Provincial Government. The Act also makes provision for acquisition or lease of land for the research, conservation, and interpretation of migratory birds or other wildlife of concern within a province.

The Migratory Birds Convention Act was passed with the intent of protecting not only waterfowl but all migratory birds. Generally the Act states which birds may not be killed, captured, or molested and the periods in each year or number of years when these activities may not be carried out. The Act provides regulations for limiting the number of migratory game birds that may be taken by a person in any specified time during a hunting season and for regulating the number of migratory game birds killed in a season that a person may have in possession. In addition, the Act regulates sale, purchase and shipment of migratory birds, governs bait restrictions, regulates hunting methods and equipment, and states controls for scientific and avicultural permits. The significance of this Act is its expression of concern by legislators over the fate of migratory birds.

In the U.S. a myriad of Federal and State legislation germaine to wildlife has been passed. Some examples are the Cropland Adjustment Program, the Soil Bank Program, and the Water Bank Program. Passage of Public Law 91-559, the Water Bank Act, on December 19, 1970, was realization of the value of the nation's wetlands and of the dilemma facing the wetland habitat. Section 2 outlines the objectives of the Act.

> "The Congress finds that it is in the public interest to preserve, restore, and improve the wetlands of the Nation, and thereby to conserve surface waters, to preserve and improve habitat for migratory waterfowl and other wildlife resources, to reduce runoff, soil, and wind erosion and contribute to flood control, to contribute to improved water quality and reduce stream sedimentation, to contribute to improved subsurface moisture, to reduce acres of new land coming into production and to retire lands now in agricultural production, to enhance the natural beauty of the landscape, and to promote comprehensive and total water management planning."

In addition, the Water Bank Act provides the U.S. Department of Agriculture (U.S.D.A.) with the authority to enter into wetland easement programs with landowners in important migratory waterfowl nesting and breeding areas.

Passage of this type of legislation demonstrates the concern of North Americans over loss of basic elements of our heritage. In Canada it provides Provincial and Municipal Governments with the capacity to deal with the problem. In respect to Manitoba's wildlife habitat loss, and in particular the waterfowl habitat loss in the Minnedosa pothole country, justification for maintenance and improvement of habitat and waterfowl numbers is already well founded.

1.3 Objectives

1) To determine the costs and benefits of maintaining and increasing wildlife habitat on private lands in the study area.

2) To determine alternative, feasible, habitat maintenance and development schemes for the study area, taking into account the information gained in objective 1).

1.4 Precepts

1) Field experimentation did not constitute part of the study. Data used were collected from existing studies and records.

2) The concepts and costs derived in the study may be applicable to other parts of the province.

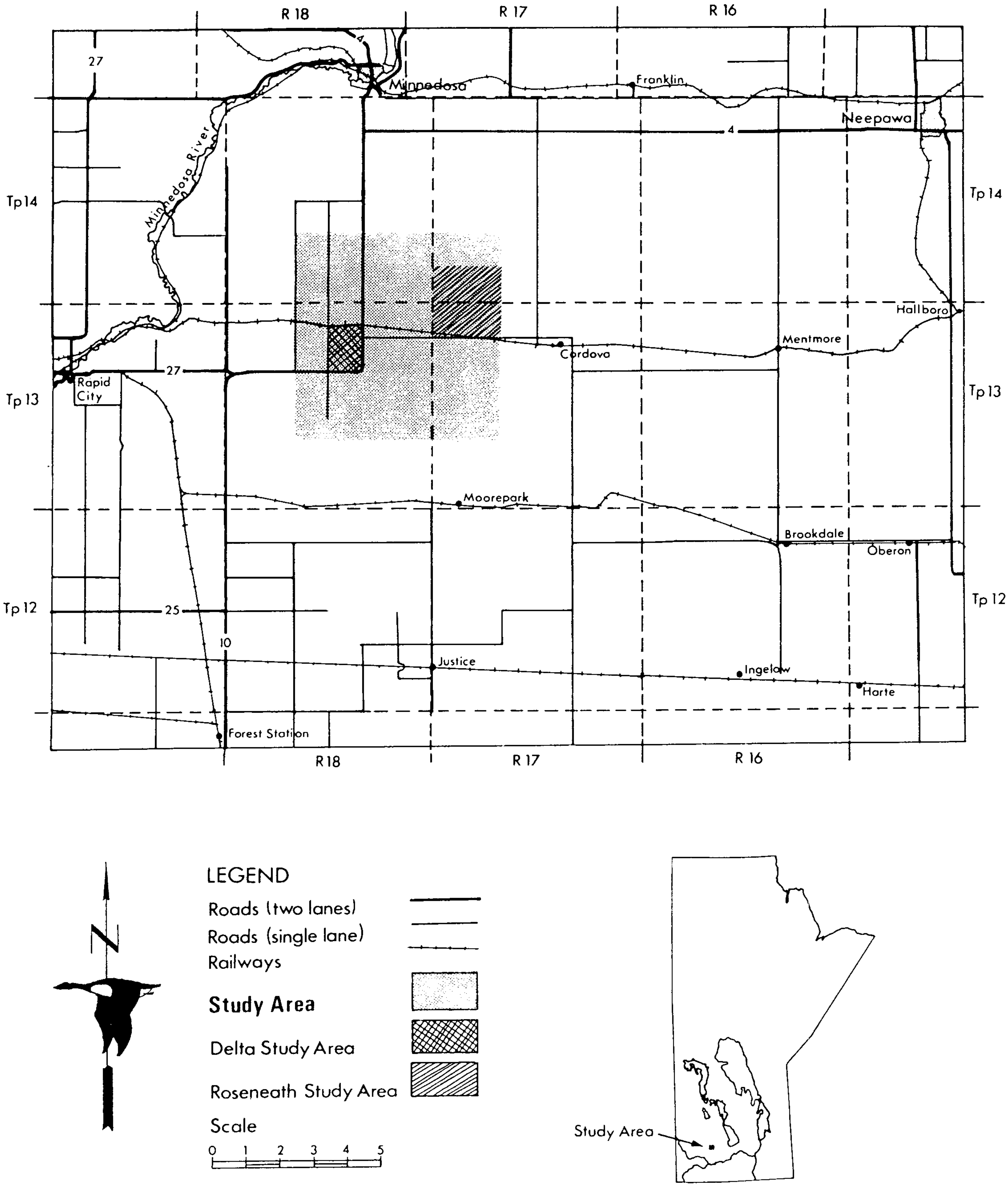
3) The study is concerned primarily with the deterioration of waterfowl habitat. Therefore, the majority of the determinations concerning wildlife in the study area will be related to waterfowl.

1.5 Study Area

1.51 Location

A study area was chosen in the vicinity of the town of Minnedosa in southwestern Manitoba in the municipality of Odanah. This locality in Manitoba is suitable for such a study

LOCATION OF STUDY AREA



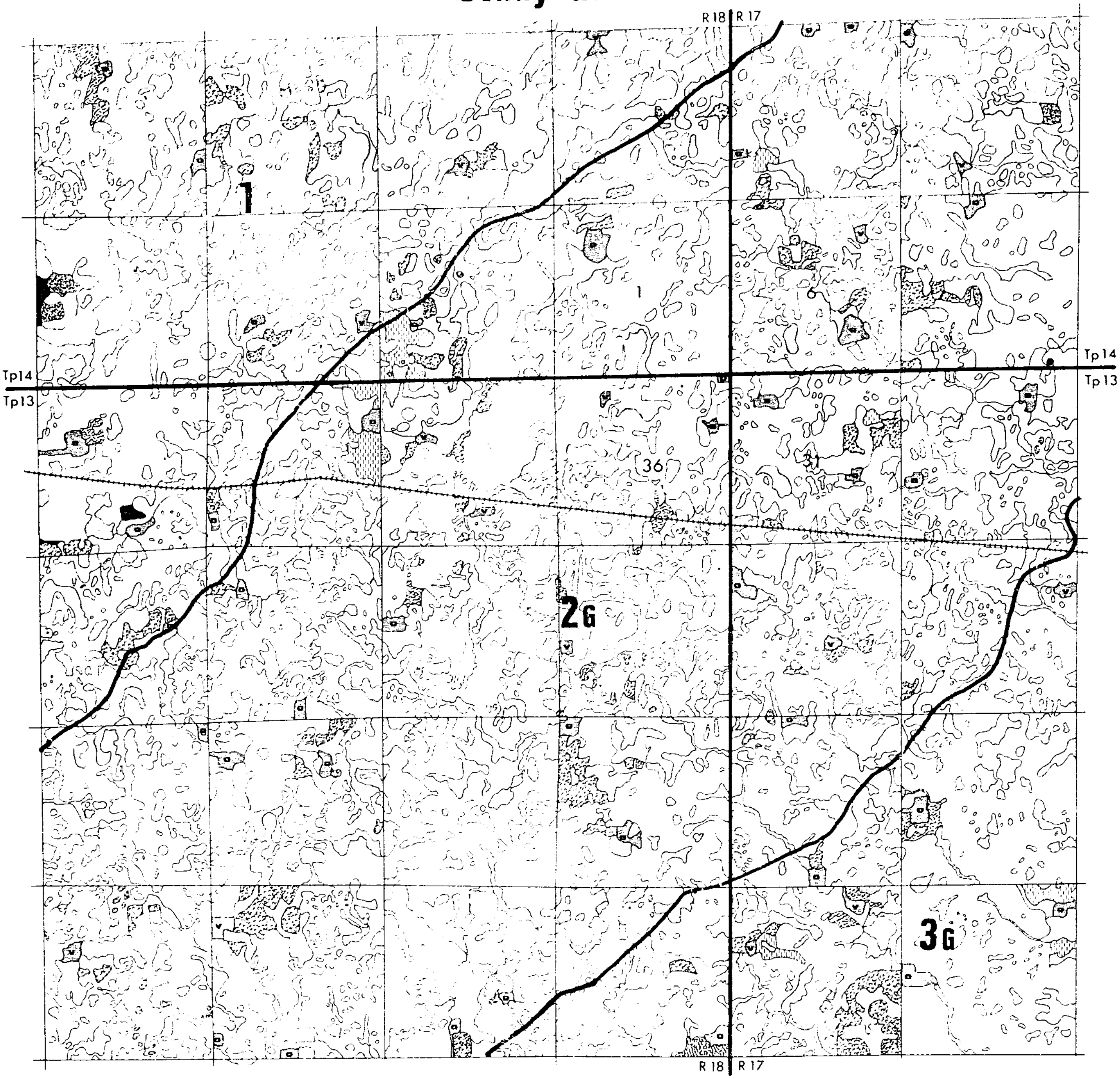
because a considerable amount of information is available on agriculture and wildlife capability and production. The study area is situated in the heart of the "Minnedosa pothole country", which makes up part of the aspen parkland of Manitoba (Kiel et al., 1972).

The size of the study area is equal to one township but is made up of parts of four surveyed townships (13-17w., 13-18w., 14-17w., 14-18w.). It is bounded on the northwest by section 9-14-18, on the northeast by 8-14-17, on the southeast by 17-13-17, and on the southwest by 16-13-18. Included in this area is a 2560 acre test plot of the Delta Waterfowl Research Station and the 960 acre "Roseneath study area" of the United States Department of the Interior (U.S.D.I.), Bureau of Sport Fisheries and Wildlife and the Canadian Wildlife Service (C.W.S.) in sections 27-13-18 and 34-13-18.

1.52 Land use

The study area is situated within the aspen parklands of Manitoba. This is a transition zone between the prairies on the south and the mixed woods and coniferous forests on the north (Bird, 1930). Characteristic of this zone is an intermingling of aspen groves and grasslands. The land in the study area is used to produce cultivated crops and for grazing as well. On the basis of seeded acreage, wheat is the most important crop followed by oats, tame hay, barley, flax, rape, mixed grains and rye (see Table 5). Cattle constitute the most important class of livestock. Taking into account all of Crop District 9, cattle outnumber hogs 13:1 and sheep 56:1

Study area



LAND USE: COVER TYPES

- H – Native hayland but suitable for arable culture.
- B – Native bushland but suitable for arable culture.
- C – Arable land presently under cultivation.
- F – Arable land presently under tame forage.
- G – Non-arable land presently under native grass.
- P – Non-arable potholes with adjoining native vegetation, which may include bush and/or scrub.
- V – Vacant farm site.
- O – Occupied farm site.

LAND USE: CAPABILITY

Agriculture $2^{7}_{T}6^{3}_{W}$

class 2_T — Soils having moderate limitations, mainly topographical, that restrict the range of crops or require moderate conservation practices.

class 6_W — Soils in this class are capable only of producing perennial forage crops and are susceptible to excess water.

Wildlife – Ungulates 3^{G}_{D}

class 3^{G}_{D} — Lands in this class have a poor distribution of suitable landforms imposing slight limitations to the production of ungulates.

Wildlife – Waterfowl 1, 2_G, 3_G

class 1 — Lands having no significant limitations to the production of waterfowl.

class 2_G — Lands having a poor interspersion of pothole types imposing very slight limitations to the production of waterfowl.

class 3_G — Lands having a poor interspersion of pothole types imposing slight limitations to the production of

(M.D.A., 1972). Of the total land area in Crop District 9, cropland and summer fallow make up 65.4 percent, pasture composes 5.6 percent, and unimproved land totals 27.2 percent (M.D.A., 1972). Tentative percentages provided by C.W.S. for 1970 on transects 1-11 inclusive of Kiel et al. (1972) showed that from 1964 to 1970, cultivated and cleared land increased from 68.9 percent to 82.8 percent, woodlots and bushland decreased from 21.4 percent to 8.6 percent, and wetlands decreased from 9.7 percent to 8.6 percent of the total land area in the Minnedosa pothole country.

1.53 Soil capability for agriculture

The Canada Land Inventory (C.L.I.) land capability classification for agriculture designates 70 percent of the soils in the study area as class 2 and 30 percent as class 6. Class 2 soils are deep and have a good water holding capacity. They are moderately high to high in productivity for a fairly wide range of field crops. The soils of this classification in the study area are limited somewhat by topography. They have 2-5 percent multiple slopes or 5-9 percent simple slopes, making erosion a potential hazard. Class 6 soils are capable only of producing perennial forage crops and improvement practices are not feasible. The soils in this classification in the study area are seriously limited by poor drainage and are flooded a large part of the year. These soils are not considered a dependable source of either native hay or grazing (Jenkins, 1973).

1.54 Land capability for ungulate-wildlife

White-tailed deer is the indicator species used to classify the capability of the lands in the study area for ungulate wildlife. The rating is class 3, indicating that capability is moderately high but that productivity may be reduced in some years. The study area has a limitation which is subclassed G. This symbol refers to landform and suggests that there is a poor distribution or interspersion of suitable landforms for optimum ungulate habitat. This subclass is applied where there is an insufficient mixture of natural "edge" for the ungulate species (Goulden, 1973).

1.55 Land capability for waterfowl-wildlife

The land within the study area boundaries is categorized into three waterfowl capability classifications. Approximately 35 percent of the area is class 1, 50 percent is class 2G and 15 percent is class 3G. Class 1 capability lands have no significant limitations to the production of waterfowl. Capability is very high on these lands because of a variety and abundance of fertile soils with good water holding characteristics and topography which is well suited to the formation of wetlands. The water area types within this classification are both shallow and deep permanent marshes, and deep open water bodies with well developed marsh edges. Lands in class 2 have very slight limitations to the production of waterfowl and thus capability is high. The topography on these lands is more undulating than rolling: a higher proportion of the wetlands are small, temporary ponds or deep, open water areas with poorly developed marsh edges. Class 3 lands have slight limitations to the production of waterfowl with a moderately high capability. Productivity may be reduced in some years due to drought. These lands have a high proportion of both temporary and semi-permanent shallow marshes poorly interspersed with deep marshes and bodies of open water. Both the class 2 and class 3 capability lands in the study area are subclassed G. This signifies that landform is a limiting factor on these lands. Due to landform, there is a poor interspersion of temporary, semi-permanent, or permanent water bodies (Hutchinson and Adams, 1974).

CHAPTER 2 - LITERATURE REVIEW

2.1 Waterfowl Production

2.11 Waterfowl population trends

The farmland surrounding the town of Minnedosa represents the finest unit of waterfowl production habitat in Manitoba and is one of the best in Canada (Kiel et al., 1972). Nevertheless, waterfowl production has declined continuously in recent years. Data in Table 1 for two study areas in the Minnedosa district indicate the transition (Stoudt, 1967). There has been a shift from a predominance of mallards to blue-winged teal. Table 2 shows that average mallard brood production per square mile fell from 11.0 for 1949-1955 to 5.2 for 1964-1967 in the Roseneath study area. Overall, blue-winged teal brood production decreased and brood production for all species fell from 46.0 to 27.6 in the Roseneath study area.

Table 1 exhibits trends in breeding pair densities of waterfowl in the Minnedosa pothole country. Average mallard breeding density decreased from 28 per square mile in 1949-1955 to 16 per square mile in 1963-1972. At the same time blue-winged teal increased from 21 to 31 pairs per square mile. The average number of breeding pairs of all species increased from 90 to 100 per square mile.

Table 1 . Waterfowl breeding pair densities in the Minnedosa pothole country (pairs per square mile).

	Roseneath study area	Minnedosa study area		
	1949-55	1964	1963-72	1973
mallard	28	24	16	17
b.w. teal	21	49	31	22
canvasback	8	11	9	6
American widgeon	7	7	4	1
ruddy duck	6	14	12	1
pintail	6	8	5	2
redhead	5	5	5	4
shoveler	4	11	5	1
gadwall	2	5	4	2
g.w. teal	2	0	2	2
scaup	1	9	6	4
r. necked duck	0	1	1	1
all species	90	144	100	63

[a] Source: Stoudt, J. H. 1967. A preliminary report on the status of mallard populations in the pothole region of Manitoba, Saskatchewan and Alberta. Presented at Waterfowl Seminar, Delta Waterfowl Research Station, Aug. 17 + 18. 12 pp.

Stoudt, J. H. 1972. Waterfowl progress report May-June. Bureau of Sport Fisheries and Wildlife, Northern Prairie Wildlife Research Centre, Jamestown, N.D., U.S.

Table 2 . Waterfowl production in the Minnedosa pothole country (broods per square mile).

	Roseneath study area		Minnedosa study area		
	1949-55	1964-67	1964-67	1962-72	1964*
mallard	11.0	5.2	4.5	3.2	9.0
b.w. teal	10.0	10.3	8.5	8.1	17.3
all species	46.0	27.6	29.0	24.1	48.2

[a] Source: Stoudt, J. H. 1967. A preliminary report on the status of mallard populations in the pothole region of Manitoba, Saskatchewan and Alberta. Presented at Waterfowl, Delta Waterfowl Research Station, Aug. 17 + 18. 12 pp.

Stoudt, J. H. 1973. Waterfowl progress report May-August. Bureau of Sport Fisheries and Wildlife, Northern Prairie Wildlife Research Center, Jamestown, N.D., U.S.

* 1964 was the year of highest production.

In summary, the following trends are evident in the Minnedosa pothole country:

1) mallard breeding pair density and brood production have decreased.

2) blue-winged teal breeding pair density has increased but brood production has decreased.

3) breeding pair density of the total waterfowl population has remained fairly constant but brood production has decreased.

4) the ratio of mallards to blue-winged teal has decreased from 1.1:1 in 1949-1955 to 0.5:1 in 1964-1967

(Stoudt, 1967).

5) mallards as a percentage of the total population have decreased from 24 percent in 1949-1955 to 19 percent in 1964-1967 (Stoudt, 1967).

6) blue-winged teal as a percentage of the total population have increased from 22 percent in 1949-1955 to 37 percent in 1964-1967 (Stoudt, 1967).

2.12 Nesting success

Nesting success can be defined as the proportion of nests in which the eggs are hatched. Nesting success for the North Central United States and the Prairie Provinces in general has declined from 63 percent in the 1930's to 29 percent in the 1950's (Miller, 1971). Nelson (1973) reported that nesting success decreased from 60-80 percent in the 1930's to 30-40 percent in the 1950's and continues to decline below 30 percent in the 1970's. Evans and Wolfe (1967) found nesting success as low as 11 percent in Nebraska while Kirsch (1969) reported 22 percent and Martz (1967) reported 26 percent in North Dakota. More recent and pertinent results are those of Herzog (1973) who monitored a 100 acre cover block which is part of the four square mile study area of the Delta Waterfowl Research Station. These four square miles are within the practicum study area as well. His findings showed that nesting success in the entire four square mile area was 27 percent in 1973 and 9 percent in 1972.

Comparisons of nesting success for various land uses in 1967-1970 showed success to be 44 percent on idled land, 27 percent on grazed land, 29 percent on mowed land, and 14 percent on cultivated land (Miller, 1971).

2.13 The effect of intensified land use on waterfowl

Increased demand for agricultural products has led to greater intensification in agricultural land use. As increased land acreage comes under cultivation, upland cover is reduced and that remaining is in narrow bands. In addition, wetlands are lost to drainage and filling. Nelson (1973) stated that the decline in waterfowl nesting success in the prairie region over the past 40 years is due primarily to intensive agriculture, a gradual decline in the habitat base and increased mammalian predation. Several authors have expressed the opinion that declining nesting success is due to greater intensity of land use (Kirsch 1969, Miller 1971, Milonski 1958, Sellers 1973, and Stoudt 1967). Dwyer (1970) compared waterfowl breeding in agricultural and non-agricultural land in Manitoba. He suggested that pair densities reflected cover conditions when comparing agricultural and non-agricultural areas. "This study showed that apparently characteristics of the land adjacent to potholes, such as undisturbed nesting cover and upland physiognomy, are more important in attracting breeding waterfowl than pothole characteristics such as fertility." The literature indicates that different species of waterfowl have been affected differently by changes in land use. Land use practices have had an effect on all upland nesting ducks, but probably to a lesser extent on blue-winged teal and late-nesters (Stoudt, 1967). Moyle (1964) showed that mallards were more successful than blue-winged teal in areas where agricultural activity was light. The opposite was true where agricultural activity was more intense. This might account for the decreased mallard production and increased blue-winged teal production noted earlier by Stoudt (1967).

In the Minnedosa region, Fritzell (1972) observed that ducks were more attracted to roadside ponds than those away from access routes. Oetting and Cassel (1971) found the same phenomena in North Dakota. The reason is that roadside right-of-ways and farmyards provide the best cover in the remaining habitat. In Fritzell's study, over 80 percent of the nests were found in narrow bands of cover, slough edges, fence rows and roadsides. More than 65 percent were located less than 50 feet from water.

Changes in land use have had a detrimental effect on all species of waterfowl in the Minnedosa area. Sixteen species of ducks are native to this region. In addition to the 12 species listed in Table 1, the bufflehead, American goldeneye, white-winged scoter and black duck occasionally nest here (Kiel et al., 1972). In the past, the Minnedosa pothole region was noted primarily for its capability to produce mallards. In addition, approximately 10 percent of the canvasback population of North America nested here in the 1950's (Kiel et al., 1972). Now the canvasback duck population is critically low and mallard duck production has declined severely. "The Minnedosa mallard population has not been stationary over the past 20 years and the decline is primarily due to a lack of production caused by insufficient nesting cover combined with severe nest predation "

(Sellers, 1973:21).

2.14 The effect of burning cover

A practice common in the Minnedosa area is that of fall and spring burning. Farmers burn pond edges, stubble fields, brushy areas, roadside ditches, ditch banks, and road shoulders. All these locations serve as nesting cover for breeding waterfowl. The purpose of the burning is to control wild oats, willow and aspen growth, and weeds, for clearing brush, for removing stubble, to remove "old bottom" from a potential hay crop, to remove roadside vegetation, to dry out fields in the spring, to increase hay production and because "my father did it" (Fritzell, 1972). Removal of upland vegetation has a particularly severe effect on early nesters such as the mallard and the pintail. Burning also increases the probability of successful predation (Stoudt, 1967). Interestingly, Fritzell (1972) found that few farmers thought fire was detrimental to wildlife, especially ducks.

Burned areas with new plant growth may receive less predator activity. Any nests located therein are more likely to be successful (Fritzell, 1972). Fritzell (1972) noted that experiments with controlled burning as a management technique have been tried. However, regrowth from annually burned areas does not provide sufficient cover for nesting waterfowl.

2.15 The effect of predation

The influence of predation on waterfowl populations along with its interaction with habitat quality has become increasingly apparent in recent years (Nelson, 1973). Nest destruction is a major limiting factor to waterfowl production. Declining nesting success is the primary result. In the prairie region, and in the Minnedosa area in particular, the principal mammalian predators are the raccoon, the striped skunk, and the red fox. In addition, potential nest predators include the dog, the badger, the mink, the short-tailed weasel, the woodchuck, Franklin's ground squirrel, the thirteen-lined ground squirrel, the crow, the magpie, and the marsh hawk (Balser et al., 1968). Raccoons and skunks prey largely on eggs. Red foxes take a significant number of ground nesting birds on the nest, especially during early spring (Nelson, 1973).

Lack of habitat has increased efficiency of predation because predators have less total area to search. In addition, much of the remaining habitat is in narrow bands. This is especially true around potholes where the land has been cultivated as close as possible to the water's edge. These narrow bands of cover attract predators, especially when they are near water. Possibly this is due to the activity patterns of small predators such as the skunk and raccoon (Nelson, 1972). Increased predation in strips of cover has been noted by Fritzell (1972), Kirsch (1969), and Moyle (1964).

Much of the predator problem in the Minnedosa district is related to the raccoon. In recent years there has been a surge in the numbers of this animal. Kiel et al., (1972) stated that in the 1920's this animal was exceedingly rare in southern Manitoba. By 1960 tracks were common around potholes and by 1964 there was abundant signs of raccoon activities around potholes and road kills were seen. The raccoon is a well known predator of waterfowl throughout its range in the U.S. It frequents the edge of water bodies in search of food and is an adept swimmer, thus posing a significant predation problem.

An additional factor thought to have an effect on nesting success in the Minnedosa area attributable to predators is the reduction of coyote numbers and a parallel increase in the red fox population. Since a coyote hunts a larger range than a fox, removal of a pair of coyotes provides habitat for several pairs of foxes. The red fox frequents a much smaller area but hunts much more intensively (Leitch, Personal communication).

Often farmers will cultivate around a nest or will lift their machinery hydraulically until a nest is passed. This allows an island of vegetation to remain. Because predators are attracted to small clumps of cover, Milonski (1958) suggested to farmers in the Portage Plains area of Manitoba to leave as little vegetation as possible when moving equipment about a nest. In addition, he found that predation on mallard nests was twice as great as on pintails because the mallard prefers tall cover, as does the mammalian predator.

2.16 The effect of hunting pressure

Several authors have documented the effects of hunting pressure on local populations of breeding waterfowl. Nelson (1973) said that the heavy harvest of local breeding birds before they migrate was becoming a problem in some midwestern states. He recognized that similar difficulties were being encountered in Manitoba and Saskatchewan. In the Minnedosa pothole region hunting pressure is fairly heavy because of the proximity to Brandon and Winnipeg. Of five areas where mallards were studied for a 16 to 19 year period in South Dakota, North Dakota, Manitoba and Saskatchewan, Stoudt (1967) observed that hunting pressure was greatest in the Minnedosa region. Hunting seasons have generally been opening later since the 1950's, thereby increasing the pressure on the late migrating species which include the mallard. Blue-winged teal escape this pressure because of their early migratory characteristics. The majority leave Manitoba before the season opens (Stoudt, 1967). However, the results of Sellers (1973) suggest that lack of cover had affected breeding mallard populations more than hunting pressure.

2.2 Wildlife Management Principles

It has been suggested that habitat quantity and quality have deteriorated significantly on private lands in the agricultural region surrounding Minnedosa. One of the problems now facing wildlife managers is how to obtain maximum wildlife production and utilization from existing habitat in order to meet public demand for consumptive and non-consumptive uses of wildlife. The inter-relationship of three factors determines the production potential of a wildlife production unit. These factors are:

1) biotic potential - the genetic ability of any species to reproduce. This factor alone is never limiting. The numbers that do survive to reproductive maturity are influenced

by other environmental variables.

2) habitat quality - the elements of a unit area necessary to sustain wildlife populations. The elements referred to include food, water, and vegetative cover. The most important component of high quality habitat is the vegetative cover. The highest potential for wildlife production occurs with a maximum vegetative density and diversity of species. Cover is most essential during reproductive periods and during extreme weather conditions. It also plays an important role in predator-prey relationships.

3) habitat quantity - this factor is critical because in many species, behavioural characteristics such as territorialism sets an upper bound on the number of individuals that can occupy a unit of habitat. Although these limits are not known for each species, Titman (1973) estimated that the upper limit for nesting pairs of mallards in the Minnedosa pothole country was 27 per square mile. Since mallard activity centres do overlap, Titman stated that this density could exceed 27 pairs per square mile. However, it is understood that overcrowding results in social stress or damage to the habitat. This in turn limits the population (Nelson, 1973).

Waterfowl production in the Minnedosa pothole country was at a peak during the early 1950's. Kiel et al., (1972) estimated the waterfowl breeding density of the area at 106 pairs per square mile, placing it among the highest densities in North America. These authors stated that the annual fall flight from the 4100 square mile pothole country was at least 1 million birds during the period from 1949-1954. "Its overall consistency of production and high breeding population merit the Minnedosa's districts description as one of the best duck producing areas in North America" (Kiel et al., 1972).

2.3 Habitat And Land Use

2.31 The effect of alternate land use on habitat

Studies carried out by the Northern Prairie Wildlife Research Center of the U.S.D.I. Bureau of Sport Fisheries and Wildlife, reveal that by changing land use, wildlife production and waterfowl production in particular can be affected. Changing land use implies habitat improvement. One of their management objectives is "the maintenance of habitat of sufficient quantity and quality to support a continental breeding population similar to that of 1956-62" (Nelson, 1972:1). In this time span, breeding duck populations ranged from 25 to 50 million and averaged 32 million, producing fall flights of 40 to over 120 million ducks.

Nelson (1972) stated that emphasis must be placed on production habitat. In the words of the Mississippi Flyway Council (1970), "Place the preservation of the production centers upon which all the flyway states depend so heavily, in a position of top priority, and expedite the determination of the best ways to preserve them." The most critical factors in the reproductive cycle of waterfowl are an adequate wetland base and nesting cover, both integral parts of production habitat. In the past, the emphasis seemed to be on preserving water bodies. The vital role of attractive and secure nesting cover as a part of production habitat was overlooked. All of the common ducks, except some of the divers such as the canvas-back and redhead, nest on the ground not in the wetlands (Nelson, 1972).

Nelson (1973) pointed out the need to recognize waterfowl habitat as a dynamic system consisting of many wetland types and upland cover. He added that duck production studies have been carried out since 1965 on mixed grass prairie areas in grazed, hayed, and non-use status, planted haylands, croplands, retired croplands planted to grass-legume mixtures and kept in non-use (agriculturally inactive) for 5-10 years, and in miscellaneous cover types. Of all nesting cover types available to prairie ducks, the highest nest densities and hatching rates occurred in tall, dense undisturbed cover on recently retired cropland.

2.32 Manipulated habitat

To restore a unit of retired cultivated land to a vegetative cover suitable for wildlife production, the land may be sown to a grass-legume mixture. Cool season introduced grasses and legumes combined with volunteer annual and biennial forbs create optimum nesting cover. One of the best mixtures observed was alfalfa and sweet clover blended with intermediate wheatgrass (*Agropyron intermedium*) and tall wheatgrass (*A. elongatum*). This research was carried out by the Northern Prairie Wildlife Research Center at Jamestown, North Dakota as well. Their findings demonstrated that idled croplands seeded to these grass-legume mixtures were the most beneficial to waterfowl and other ground-nesting birds. In addition, it was noticed that haying and grazing of upland nesting cover in the prairie region was detrimental to ground-nesting birds. This type of cover lacks the mulch layer. Fewer nesting attempts were attracted than in undisturbed vegetation. Most importantly, hatching success is greater in non-use cover than in grazed and hayed habitats (Nelson, 1972).

Another factor which must be regarded when establishing habitat is the size and shape of the cover unit. Best performance in the U.S. experiments were on blocks of 40-150 acres. Nelson (1972) recommends that cover blocks be no smaller than 40 acres. Apparently blocks of habitat are more productive than linear strips or circular strips around the periphery of a wetland.

In summary, the factors to be considered for the establishment of wildlife habitat are:

1) the growth form and species composition of upland vegetation most attractive to ground-nesting birds in a particular area.

2) the minimal and optimal size of cover blocks required to meet desired nest density and success.

3) the time interval over which the cover types will remain in optimal condition before further manipulation is required.

4) the type of manipulation which is the most efficient, effective and/or economical.

5) the effects of various predators in relation to the size of the cover area, to cover type, and to cover

conditions (Nelson, 1973).

2.33 The effect of manipulated habitat on waterfowl

Studies were conducted from 1968 to 1972 by the Northern Prairie Wildlife Research Center on farmlands taken out of agricultural production under the Cropland Adjustment Program (C.A.P.) of the U.S.D.A. The fields were retired in 1966 and 1967 and were planted with a mixture of bromegrass, intermediate wheatgrass, and alfalfa.

In 1971 and 1972, 10 C.A.P. fields retired in 1967 were monitored. The fields were in scattered locations and were not subject to predator control. No haying or grazing was carried out. Field size ranged from 28 to 133 acres. Table 3 indicates that on 549 acres of C.A.P. land searched in 1971, nest density was over 5 times greater and nesting success was 17 percent higher than nearby active agricultural lands. In 1972, 709 acres of C.A.P. land were searched. Nest density was 6 times higher and nesting success was slightly higher than on adjacent active agricultural land. These results seem to indicate a strong selectivity by nesting hens toward C.A.P. fields. On these fields, blue-winged teal, gadwalls, and mallards comprised 41, 24, and 20 percent of the nests. Duckling production ranged from 0.8 to 6.9 per acre and averaged 2.9 per acre.

One particular 125 acre C.A.P. field sown to a grass-legume mixture in 1966 produced some exceptional results. From May, 1969 to August, 1971 an intensive predator control program was conducted in this area. Results of duck production on this

Table 3 . Waterfowl production on croplands retired in the U.S. under the Cropland Adjustment Program (C.A.P.).

Year	C.A.P. land		Active ag. land	
	Nests/100a.	Nesting success	Nests/100a.	Nesting success
1971	34	65%	6	51%
1972	54	58%	9	54%

[a] Source: Duebbert, H. F. 1973. Early successional grass-legume cover and nesting ducks, U.S. Bureau of Sport Fisheries and Wildlife, Northern Prairie Wildlife Research Center, Jamestown, N.D.

[b] data for 1971 collected from 549 a. and for 1972 from 709 a.

Table 4 . Waterfowl production on a predator controlled C.A.P. field of 125 acres.

Year	C.A.P. field				Adjacent land	
	Predator control	Nests	Equivalent nest density (prs./sq.m.)	Nesting success (%)	Observed nest density (prs./sq.m.)	Nesting success (%)
1968	no	61	311	79	47	30
1969	yes	127	648	70	-	-
1970	yes	248	1265	97	-	-
1971	yes	180	918	98	-	-
1972	no	323	1647	90	162	-

[a] Source: Duebbert, H. F. 1973. Early successional grass-legume cover and nesting ducks, U.S. Bureau of Sport Fisheries and Wildlife, Northern Prairie Wildlife Research Center, Jamestown, N.D.

[b] largest increase on C.A.P. land was by mallards, from 4 prs./ sq. mile in 1968 to 47 prs./sq. mile in 1972.

field are given in Table 4. The number of nests increased from 61 in 1968 to 323 in 1972. Nesting success for these two years was 79 percent and 90 percent respectively. In addition, breeding populations in the region surrounding the field showed increases. The mid-May 1972 breeding population on a 3.1 square mile circular area around the field was 162 pairs per square mile. Brood counts for mid-July on the 3.1 square mile area totalled 30 per square mile. Duebbert (1973) stated that one of the principal factors accounting for this increase was probably the homing of hens to an area of high hatching and brood rearing success. Predator control is not a widely used management practice in North America because of the difficulties and expense involved. In this instance, it undoubtedly contributed to the high waterfowl production success in this field (Duebbert, 1973).

2.4 Difficulties In The Economic Evaluation Of Waterfowl

In the past, the criterion most often used by resource planners in comparing alternate land uses was an economic value or more simply a dollar value. In this respect, individual farmers in the Minnedosa pothole country are resource planners. When faced with the choice of producing agricultural products on their land or producing wildlife, agriculture is the obvious selection. Farmers receive no monetary remuneration for wildlife produced on their land. When making a decision, readily identifiable economic benefits resulting from land development will normally prove more compelling to someone making a decision involving capital investment to lease, buy, or rent that land than a general statement of its scenic beauty and abundant wildlife (Hedlin Menzies and Associates Ltd., 1967).

The value of wildlife habitat is directly related to its production of, or capability to sustain wildlife. The product of the habitat, the wildlife itself, offers many benefits which will be discussed subsequently. However, the main difficulty has been encountered in the attempt to place a value on these benefits. In evaluating the recreational aspects of fish and wildlife, there is no direct measure of the value (Hedlin Menzies and Associates Ltd., 1967). Most public outdoor recreation opportunities are supplied free of charge and conventional market indicators of the value of the resource are not applicable. However, because there is no market price does not mean that there is no value. The problem is measuring the value.

Ralph Hedlin discussed this very problem in a paper presented at the Saskatoon Wetlands Seminar in 1967. He found that wildlife managers were continually trying to place a dollar value on a duck as if it were a market good. However, it is inevitable that it is not. In the case of a market good, the normal forces of supply and demand determine the price of the product. A duck is not a market good in the same sense that wheat or farmland is. It is available to the consumer at zero price in terms of a direct charge and therefore can be considered a free good. On the producer side, a duck is still essentially a free good because landowners in Manitoba, at least, normally do not charge hunters for hunting privileges on a "bagged bird" basis. If an attempt is always made to put a value on a duck, the difficulty in assessing the recreational opportunity is even greater because it is produced in one area and consumed in another. Since the duck is a free good, its value cannot be transferred or directly attributed. As soon as it flies away it is irrelevant as an economic asset to an individual farmer and relevant economically only as an asset to any individual as one of twenty million Canadians. After it flies across an international boundary then it is irrelevant to me as a Canadian. "We will suffer nothing but frustration, however, if we continue to approach the waterfowl evaluation problem by somehow trying to place a value on the "bird". As long as we consider the duck as the value element in arriving at the economic value of the wetland, I submit that this problem will evade solution" (Hedlin, 1967). From the economist's viewpoint the value of wetlands must be related to its potential value in alternative economic uses. The moment the opportunity costs (equivalent costs of foregoing the benefits of alternative use such as agriculture) becomes the criterion for determining the value of that wetland, the actual unit cost of ducks becomes irrelevant. A more logical approach than evaluating the duck is to evaluate the habitat areas as parcels of land open to several potential uses. The evaluation of alternatives and wider economic evaluation should be on the productive waterfowl habitat area, the one part of the waterfowl resource which is not a free good. Hedlin submits that economists with the best intentions in the world will be unable to put an economic value on a duck. However, he believes there is considerable merit in attempting to put a reasonable economic value on particular major land regions across the country, from the point of view of their overall value as waterfowl habitat regions.

In a report by Hedlin Menzies and Associates Ltd. (1967) this viewpoint is further substantiated by the authors. They state: "Unfortunately in much of the assessment and argument on waterfowl evaluation to date, the whole emphasis has been placed, wrongly in our opinion, on some attempt at achieving a 'value per duck'." Their argument is that in actual evaluation of waterfowl habitat, the physical costs and benefits per duck are not relevant.

2.5 Attempts At The Economic Evaluation Of Waterfowl

The analysis followed in this practicum will not include any attempt to establish dollar values for individual wildlife species or for recreation associated with them. However, a review of some of the methods developed by others will be conducted. Most of these relate to hunting. The assumption made is that it is not the game itself which is valued by the consumer but the recreation which the game provides. Unfortunately the relationship between the available game and the quantity and quality of hunting that it provides is a largely unexplored area (Pearse, circa 1968). Nevertheless, resource planners have demanded means of evaluating wildlife to provide a basis of comparison of alternate land uses. Some of the more common methods are summarized below.

1) <u>user expenditure method</u>

This method measures the amount that recreationists spend in pursuit of their chosen activity involving waterfowl and uses the amount spent as an assessment of the value. With respect to waterfowl hunting the principle expenditures included are those on equipment, food, lodging and transportation.

One of the main disadvantages of this approach is that it will give high values to products of remote sites because of the large transportation costs and low values to areas which are easily accessible. In fact, the opposite is quite possible. Another drawback of this method is that it emphasizes cost rather than value and confuses cost with value. Actually this method only measures the cost of access.

2) <u>values obtained from commercial shooting preserves</u>

This approach assumes that the value of any duck is equivalent to the price paid to shoot a duck at a commercial game farm. This price is fixed because of location. In addition, the birds can be hunted at low cost in terms of travel and expense. Application of this method assumes that the value per bird is the same for all locations when in fact this value will be influenced by accessibility of the location, quality of the recreation experience, etc. Remote waterfowl populations will not have the same value as birds raised at privately owned recreation areas. This approach also suggests that the value of a harvested duck may be applied to all ducks, when actually an unharvested duck may contribute no benefit whatsoever to hunters although it may benefit viewers. An additional disadvantage is the assumption that viewer benefits can be differentiated from hunter benefits.

This method may reflect only the value of benefits in excess of those available free at public areas rather than the true value of the recreation experience. The true value will be underestimated.

3) arbitrary units of value

Several agencies of the United States government have adopted arbitrary units of value for wildlife resources. These values are admittedly not necessarily correct (Grower and Kabaluk, 1973).

4) willingness to pay

In attempting to solve the problem of evaluating non-priced recreation, economists have tried to determine the willingness of recreationists to pay for access to recreation facilities that they use without charge. The measure is estimated by asking the most they would be prepared to pay for access rather than do without or ask the minimum that they would have to be paid to willingly abstain from the recreation.

This measure is called "consumer surplus" and results from a demand curve constructed to indicate what consumers would pay for various units of recreation rather than go without them. Although sound in theory the method is not practical because it means constructing a demand curve for each area so that its value may be imputed. Also demand curves derived from travel cost information overlook time spent in travel. This underestimates the actual demand for a given resource and thus the value given to the resource when used for recreation (Pearse Bowden, 1970).

5) recreation day approach

This method evolved from case studies of particular sites and estimates the value of a day's recreation to hunters or viewers of wildlife. There are two classifications within this approach.

i) The direct approach is a survey of recreationists to determine the price they would be willing to pay if they were required to do so.

ii) The indirect approach involves making inferences regarding willingness to pay on the basis of observations of recreationists' behaviour and expenditures.

Grower and Kabaluk (1973) felt that this was the best approach because of the emphasis on willingness to pay. Nevertheless, they stated that this method still has several disadvantages. Answers by recreationists to hypothetical questions may be biased, (a) because they presently use the resource to enjoy the experience free of any charge and therefore are unable to be objective, and (b) because they suspect that they may be charged a rate in the future based on their answers. Secondly, travel cost information may be biased for the reasons mentioned previously. Thirdly, there is an emotional factor toward the value of recreational resources among many recreationists.

None of these approaches are totally acceptable although some are more satisfactory than others. Initially part of the objective of this practicum was to use existing data to establish dollar values that would result from improving waterfowl production in the Minnedosa pothole country through wildlife habitat maintenance. This would entail establishing a dollar value per duck. After extensive literature review in this area, it appears that none of the economic methods for evaluating the waterfowl resource and that none of the values that have been established per bird, are acceptable. Nonetheless, so long as a resource is supplied free of charge, it represents a greater addition to total welfare than when other goods or services must be sacrificed for it (Pearse Bowden, 1970). Therefore, there will be no further attempt in this practicum to justify wildlife habitat maintenance solely in economic terms by identifying dollar values for waterfowl or to resolve this argument. However, the literature review includes a resume of the biologic, sociologic and economic benefits of wildlife and wildlife habitat.

2.6 Benefits Attributable To Wildlife And Wildlife Habitat

1) Benefits from waterfowl hunting

Hunters benefit from the recreational value of the hunting experience. The recreational benefit is mostly made up by the pursuit of the game and only partially by the game itself. A dead bird is only partial measure of hunting success to the hunter. In economic terms this might be measured by the amount that a hunter is willing to pay for a day's hunting. License fees from both resident and non-resident hunters contribute to the provincial economy. Hedlin Menzies and Associates Ltd. (1967) suggested that license fee totals are the only direct economic value attributable to wildlife.

The province also receives benefit in the form of expenditures on equipment, lodging, etc. In the case of resident hunters these benefits might still accrue to the province if the resource was unavailable providing the assumption is made that these monies would be spent on other recreation activities at alternate sites. Expenditure benefits to Manitoba from non-resident hunters would be lost if the resource was no longer available.

2) Benefits from nature observation

Many Manitobans receive enjoyment from viewing wildlife and wildlife habitat. This is direct recreational enjoyment to bird-watchers, naturalists, etc. Resource use of this type is non-consumptive so long as the sites are not over-used. In the U.S., nature observation has been the fastest growing outdoor recreation since World War II next to fishing and boating on reservoirs. In this case there may be some economic benefit from the expenditures of residents and non-residents viewing Manitoba wildlife.

3) Aesthetic or vicarious consumption benefits

These benefits are derived by the way in which wildlife enhance the quality of the environment by its very existence. This includes the pleasure that people receive from seeing birds and animals. The benefit does not have to accrue directly to the user. Pearse (1968) said that people who do not recreate may value the opportunity to do so, either for themselves or for others. Enjoyment from the knowledge that a resource simply exists is termed the "museum effect". This type of benefit is relevant especially where unique and irreplacable phenomena of nature are involved. In the case of endangered species, this type of benefit is particularly high. In relation to wildlife and wildlife habitat, this type of benefit must be considered to be increased when a species is becoming scarce or in danger of becoming so, when the habitat is a unique or an important source of the endangered species, or when decisions concerning resource use are detrimental to the endangered species and irreversible (Grower and Kabaluk, 1973).

4) Benefits from scientific research

Scientific research on biological communities has importance both immediately and in the future. For example, the practicum study area contains smaller study areas which have been used by the Canadian Wildlife Service and the Delta Waterfowl Research Station to study wildlife and biotic communities. In addition, parts of the practicum study area have been used by the U.S.D.I. Bureau of Sport Fisheries and Wildlife to investigate waterfowl biology.

5) Benefits from commercial fur harvesting

Wetlands are an important source of furbearers such as muskrat, fox, raccoon, and mink. This represents a source of income to trappers. Expenditures generated by trapping can be categorized as benefits to the province and trapping produces some employment in the furrier industry. In addition, the Provincial Government receives a royalty from all furs taken.

6) Benefits from watershed management

During seasonal dry periods or prolonged drought, wetlands lose much of their water. As rains and runoff come, they become natural storage reservoirs for excess water, releasing it gradually into streams, aquifers, and the air. Operating under natural conditions, wooded bottomlands are among the most efficient flood and nutrient retardation sites. Following dry periods, their soils serve as natural sponges to absorb and hold back water. If a stream overflows its bank, trees and brush serve as brakes and shock absorbers, slowing the flow, encouraging deposition of sediments and nutrients, and levelling out the flood crests. Wetlands also serve a function as natural filters and water-purifying agents. The primary source of water for wetlands is that which flows across the soil carrying silt, pesticide residues, fertilizers, gases, and minerals which are concentrated and carried by flowing water. Sediments become trapped in wetland basins while the minerals and other nutrients are incorporated into the growth of aquatic and hydrophytic plants. When the water continues to downstream reservoirs and lakes, it flows free of most or all sediment and of most contaminants that it has picked up from the soil (Jahn and Trefethen, 1973). Thus watershed management is beneficial by maintaining the biologic and economic viability of those lands being managed.

7) <u>Benefits from soil conservation</u>

Planted or natural vegetation maintained by habitat management stabilizes the soil and prevents erosion. This in turn helps to maintain the land capability for profitable agricultural production.

CHAPTER 3 - METHODOLOGY

3.1 Practicum Methodology

The practicum analysis involved an investigation of two alternate land uses in the Minnedosa pothole country, agricultural production and waterfowl production. Part of the objective was to determine the opportunity cost of agricultural production in this locality to estimate the cost of converting croplands to areas used for wildlife habitat. To accomplish this, a model was developed to calculate estimates of this opportunity cost.

Previously, the rationale was stated for not attempting to derive dollar values for individual wildlife species or their enjoyment, either consumptively or non-consumptively, by Manitobans (see sections 2.4 and 2.5). However, the benefits attributable to wildlife and wildlife habitat were outlined (see section 2.6). In addition to this, it was considered desirable to determine a range of numbers of waterfowl that could conceivably be produced from wildlife habitat management. To achieve this, a waterfowl production model was developed. Together, these two models provided estimates of the opportunity cost of leasing private lands for wildlife habitat maintenance and estimates of the number of migratory wildfowl that could be produced by converting farmed lands to wildlife habitat. The end result is a range of values for the cost of producing waterfowl.

In addition, an analysis was carried out to compare the cost of land easement and the cost of land purchase. Also included in the practicum is a synopsis of some of the other factors considered pertinent to a discussion of the feasability of wildlife habitat maintenance (see CHAPTER 5).

3.2 The Opportunity Cost Model

Available agricultural data were used to develop a model for determining agricultural productivity, agricultural production costs, profits from agricultural production and the opportunity cost of agricultural production for the study area. Agricultural productivity was calculated using a range of alternate price and yield conditions. The inputs used for the framework of the model included crop types, seeded acreages of crop types, crop prices, crop yields, soil types, and farm size. These were applied to the framework in conjunction with the assumptions of the model to produce a hypothetical concept, a composite acre. It is an acre of cultivated land comprised of the proportions of crops and summer fallow specified in Table 5. The assumptions underlying this concept are:

1) The seeded acreage in Crop District 9 is comprised entirely of wheat, oats, barley, flax, rye, mixed grains, rape, tame hay, and summer fallow.

2) Agricultural productivity can be estimated accurately considering only small grain production. Livestock production is not accounted for.

3) Maximum agricultural productivity and thus maximum opportunity cost is achieved from those land units cultivated for small grain production (Prairie Agri-Mgmt.

Consultants Ltd., 1970). The value of these lands for agricultural production may be used as a base for estimating opportunity costs of other units (native haylands, forage croplands, arable bushlands, and wetlands).

All calculations within the model are based on the entirety of Crop District 9 and then applied to the study area according to the assumptions made. This approach has three advantages.

1) The crop district technique implies a broader, more general approach so that any biases that might arise from extracting data from or applying data to the study area only, are reduced.

2) Most agricultural data collected by Federal and Provincial Government sources are categorized by Census Division (Federal) or Crop District (Provincial). In Manitoba some of the Census Division boundaries are the same as those of the Crop Districts. Crop District 9 is identical to Census Division 10.

3) The entire methodology could be applied to other "pothole" areas of Manitoba using the relevant Crop District or Census Division data.

To further understanding of the reasoning behind the "Opportunity Cost Model", additional explanation of the concept of opportunity cost is required. Agricultural production and wildlife production represent two alternate resource uses. In either case there is a cost to society. These social costs of production are the costs to society when its resources are employed to produce a given commodity. When the resources are employed to produce a certain product (agricultural products), the amount of another product (waterfowl) that can be produced from those resources is less (Mansfield, 1970). The alternative cost of producing a certain product is the net value of the other products that could have been produced alternatively, by the resources used in its production (Mansfield, 1970). Thus the cost of producing waterfowl will be equal to the value of the goods produced from agricultural production. As stated by Cole (1973), "An opportunity cost is the sacrifice entailed in giving up some quantity of the next-best alternative in order to achieve a most desired end."

In the practicum model, opportunity costs were determined considering private land ownership by individual farmers. To accomplish this, the gross revenue generated from agricultural production was determined. This was the value of crop yield multiplied by crop price. Fixed and annual operating costs were accounted for to obtain figures for total production costs. The differences in the estimates for agricultural productivity and production costs equaled pure profits earned by the landowner.

If a landowner continued farming, he would have gross revenue from production to pay fixed and annual operating costs. By renting his land, as would be the case in an easement program, his operating costs become zero on the rented land. However, fixed costs, which in the practicum model include investment in land and buildings and taxes, would still have to be paid. Therefore, fixed costs were added to pure profits to determine an estimate for the opportunity cost.

Economic theory provided some explanation as to why the opportunity cost includes the total pure profit. A perfect leasing system results in an equitable division of the product among the owners of the various resources employed in production (Heady, 1964). In other words, in a land rental agreement, the portion of the pure profit that the landlord and the tenant should receive is equal to that portion of total resource investment that each makes. As applied to the model, the landlord would receive that portion of total pure profit that fixed costs comprise of total costs. The tenant theoretically should receive that portion of total pure profit that operating costs make up of total costs. Heady (1964) states that the share of the total product to any one of the resource owners is established by the quantity of the various resources which each contributes and the marginal productivity of specific resources. However, this division of total pure profit to a perfect leasing system in theory, is not the same as the opportunity cost. The assumption is that the landlords or the owners of private land in the study area, would be content to remain farming. To provide sufficient incentive to landowners to give up their land for a use other than agricultural production, they must be paid an amount at least equal to what they would receive from producing agricultural products themselves. The opportunity cost is an estimate of this amount.

3.3 Waterfowl Production Model

In a study examining the feasibility of a wildlife habitat maintenance program, some indication of potential wildlife production is desirable. The objective of this model was to develop a range of figures for waterfowl produced per acre of land under easement. These figures gave some indication of waterfowl production on an individual acre basis for all species. A comparison of these with the range of values calculated for the opportunity cost of easement, provided a range of possible costs per duck produced. Assumptions made were:

1) A program could be initiated whereby active agricultural land could be rented from landowners in the Minnedosa pothole district for the expressed purpose of improving waterfowl production.

2) Lands under easement would be blocks no less than 40 acres in size. These would be seeded with a suitable grass-legume forage mixture considered optimal for waterfowl production in that area.

3) Breeding pair density and nesting success of waterfowl can be increased by the application of the practices listed under assumptions (1) and (2).

4) Nesting success as applied to the model includes renesting attempts.

5) Data for production of mallards can be applied to all species of waterfowl nesting in the study area. This assumption was made because mallard data were the most abundant.

6) Any bird reaching the class III or fledged brood stage is considered a bird produced. In this classification, birds are considered to be older than 45 days and to be flying or near flight stage (Dzubin and Gollop, 1973).

7) Birds produced include those that would have been produced under the conditions that existed before easement and those that would be produced from improvement of habitat conditions.

8) Private lands managed for habitat improvement would not be subjected to predator control.

Table 1 specifies that the average density of breeding pairs in the Minnedosa area for 1963-1972 was 100 pairs per square mile for all species. This figure was used in the model as a minimum for breeding pairs. Calculations were computed increasing breeding pair density by increments of 20 to 200 and by increments of 40 from 200 to 600 (see Table 17). These breeding pair densities were extracted from a square mile basis in order to demonstrate potential waterfowl production from concentrating nesting pairs on smaller areas.

In the waterfowl production model, calculations are made for nesting success from 20-100 percent at 10 percent increments. This assumes that nesting success would be no less than 20 percent on manipulated habitat.

Dzubin and Gollop (1973) reported that the average class III brood size for early and late season nesting mallards for 1952-1955 in the Roseneath study area near Minnedosa was 6.1. This figure was used in the model as the number of birds produced per successful nesting pair of any species of waterfowl in the study area. Use of it gave numbers of waterfowl produced per square mile. Results were converted to an acre basis by dividing by 640, producing a range of potential waterfowl production from manipulated habitat.

CHAPTER 4 - RESULTS

4.1 Agricultural Productivity

4.11 Seeded acreages

Annual seeded acreages of wheat, oats, barley, flax, tame hay and summer fallow for the years 1963 to 1972 were obtained from Yearbooks of Manitoba Agriculture, published by the Manitoba Department of Agriculture (M.D.A.). Data were not available on a Crop District basis for rye, mixed grain, and rape from this source. Therefore, the 1966 and 1971 Censuses of Canada were examined to gain an indication of seeded acreages for these crops.

Figures in Table 5 demonstrate average annual seeded acreages for the crop years 1963 to 1972. In the case of rye, mixed grains, and rape these are not ten year averages but an average figure calculated from the 1966 and 1971 census data.

4.12 Crop prices

The prices used in this part of the analysis were average final payments for Manitoba, to the farmer, after deduction of transport, handling, administrative, and storage costs. Table 6 reveals that the five year average prices for all crops except tame hay from 1968 to 1972 were lower than either the five year average from 1963 to 1967 or the ten year average from 1963 to 1972. On this basis it was decided that the ten year averages were the most acceptable.

At the time the analysis was carried out, estimates for the 1973 crop year were not available. Subsequently, estimates were obtained (Daciw, Personal communication). These are recorded in Table 10.

4.13 Crop yields

Technology in the agriculture industry has increased the average yield of most farm crops. Table 7 demonstrates this fact for the crops comprising a composite acre in this analysis. The highest average yields were recorded for the five year period from 1968 to 1972. These yields were used in the calculation of agricultural productivity.

4.14 Agricultural productivity

Productivity for each crop was calculated by multiplying the average price by the average yield. Representative prices and yields were determined for each crop as indicated in sections 4.12 and 4.13. However, the managerial ability of individual farmers has an effect on the yields of crops. Not every farmer will produce an average yield. Some will consistently have above average yields and some will always have less than average yields. To account for managerial ability, a range of yields for each crop was calculated by taking 10 percent increases or decreases from the average to a maximum or minimum of 50 percent about the mean. These values are demonstrated in Table 8 and give an indication of the range of possible yields. It is assumed that the upper range represents yields which are attainable and that the total is realistic.

Crop prices have been relatively stable over the ten

Table 5 . Average seeded acreages and percentages of crop types comprising a composite acre.

Crop type	Average seeded acreage (000's of acres)	% of composite acre
wheat	182.4	25.54
oats	110.6	15.49
barley	60.6	8.49
flax	37.7	5.28
rye	10.6	1.48
mixed grains	14.6	2.05
rape	16.0	2.24
tame hay	65.3	9.14
summer fallow	216.3	30.29
total	714.1	100.00

[a] Source: Dominion Bureau of Statistics 1966. Census of Canada, Agriculture, data for commercial farms, western provinces. The Queen's Printer, Ottawa.

Manitoba Dept. of Agriculture, 1963-1972. Yearbooks of Manitoba Agriculture. Queen's Printer, Winnipeg, Manitoba.

Statistics Canada. 1971. Census of Canada, Agriculture, western provinces.

year period from which data were deducted (1963-1972). In 1973 record high prices prevailed for grain crops. To account for this, 10 percent intervals to a maximum or minimum of 50 percent about the mean were calculated for the crop prices used (averages from 1963-1972). These values are represented in

Table 6 . Crop prices for Manitoba ($).

Crop	Average price 1963-1967	Average price 1968-1972	Average price 1963-1972
wheat	1.67	1.48	1.57
oats	0.66	0.60	0.63
barley	1.04	0.92	0.98
flax	2.81	2.68	2.75
rye	1.16	0.95	1.05
mixed grains	0.84	0.75	0.80
rape	2.43	2.39	2.41
tame hay	17.04	19.00	18.02
summer fallow	-	-	-

[a] Source: Manitoba Dept. of Agriculture, 1963-1972. Yearbooks of Manitoba Agriculture. Queen's Printer. Winnipeg, Manitoba.

[b] All prices per bushel except tame hay which is per ton.

Table 9.

When the analysis was conducted, estimates for the 1973 crop year were not available. These estimates were subsequently obtained as stated previously. A comparison of the 1973 crop prices with the prices used in the analysis (average of 1963-1972) is presented in Table 10. Also included in this table are the prices which result from averaging the 1973 prices into a ten year average (1964-1973) and into a five year average (1969-1973). The averages which include the 1973 estimates are higher for all crops than the averages used in the practicum

Table 7 . Average yields for crops comprising a composite acre.

Crop	Avg. yield 1963-1967	Avg. yield 1968-1972	Avg. yield 1963-1972
wheat	23.5	25.5	24.5
oats	41.3	47.6	44.5
barley	31.8	37.1	34.5
flax	10.2	11.2	10.7
rye	21.5	21.7	21.6
mixed grains	36.9	41.6	39.3
rape	15.8	18.5	17.3
tame hay	1.86	2.01	1.93
summer fallow	-	-	-

[a] Source: Manitoba Dept. of Agriculture. 1963-1972. Yearbooks of Manitoba Agriculture, Queen's Printer. Winnipeg, Manitoba.

[b] Yields are bushels per acre except tame hay which is tons per acre.

analysis. However, this was accounted for in the practicum by establishing a range of prices to a maximum of 50 percent above the averages and to a minimum of 50 percent below the averages of the specified crops. A comparison of prices in Tables 9 and 10 demonstrates that both the five year average prices (1969-1973) and the ten year average prices (1964-1973) in which the 1973 crop price estimates are included, are less than the highest prices calculated for all crops in the practicum analysis.

Table 8 . Crop yield possibilities.

Crop	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
wheat	12.7	15.3	17.8	20.4	22.9	25.5	28.1	30.6	33.2	35.7	38.3
oats	23.8	28.6	33.3	38.1	42.8	47.6	52.4	57.1	61.9	66.6	71.4
barley	18.5	22.3	26.0	29.7	33.4	37.1	40.8	44.5	48.2	51.9	55.7
flax	5.6	6.7	7.8	9.0	10.1	11.2	12.3	13.4	14.6	15.7	16.8
rye	10.9	13.0	15.2	17.4	19.5	21.7	23.9	26.0	28.2	30.4	32.6
mixed g.	20.8	25.0	29.1	33.3	37.4	41.6	45.8	49.9	54.1	58.2	62.4
rape	9.2	11.1	12.9	14.8	16.6	18.5	20.4	22.2	24.1	25.9	27.8
tame h.	1.00	1.21	1.41	1.61	1.81	2.01	2.21	2.41	2.61	2.81	3.02

[a] Yields are bushels per acre except tame hay which is tons per acre.

Table 9 . Crop price possibilities ($).

Crop	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
wheat	.78	.94	1.10	1.26	1.51	1.57	1.73	1.88	2.04	2.20	2.36
oats	.31	.38	.44	.50	.57	.63	.69	.76	.82	.88	.95
barley	.49	.59	.69	.78	.88	.98	1.08	1.18	1.27	1.37	1.47
flax	1.37	1.65	1.92	2.20	2.47	2.75	3.03	3.30	3.58	3.85	4.13
rye	.52	.63	.73	.84	.94	1.05	1.16	1.26	1.37	1.47	1.58
mixed g.	.40	.48	.56	.64	.72	.80	.88	.96	1.04	1.12	1.20
rape	1.20	1.45	1.69	1.93	2.17	2.41	2.65	2.89	3.13	3.37	3.62
tame h.	9.01	10.81	12.61	14.42	16.22	18.02	19.82	21.62	23.43	25.23	27.03

[a] Prices are dollars per bushel except tame hay which is dollars per ton.

Table 10 . Comparison of 1973 crop price estimates with crop prices used in analysis of agricultural opportunity costs ($).

Crop	*Avg. 1963-1972	Est. 1973	Est. avg. 1964-1973	Est. avg. 1969-1973
wheat	1.57	4.50	1.85	2.10
oats	0.63	1.35	0.71	0.75
barley	0.98	2.35	1.12	1.21
flax	2.75	9.75	3.44	4.06
rye	1.05	2.75	1.20	1.30
mixed g.	0.80	1.85	0.90	0.98
rape	2.41	5.65	2.73	3.13
tame h.	18.02	30.00	19.40	21.30

*Prices used in practicum model.

Multiplication of all the possible yield and price combinations gives a range of productivity values which account for differential managerial ability and market condtions. These calculations produce productivity values or estimates of gross revenue for each crop on an individual acre basis. Appendix 1 contains these values.

4.15 Composite acre agricultural productivity

An agricultural productivity value per composite acre for each crop yield and crop price combination was obtained by summing the result of:

crop yield x crop price x percent of composite acre for the eight crops. These results are summarized in Table 11. The entire set of results is listed in Appendix 2.

4.2 Agricultural Production Costs

Costs of production for agriculture were obtained from an unpublished report by Framingham et al. (1973). In this report, production cost data were categorized by Crop District. Within individual Crop Districts, further subdivision was made by soil type and farm size. Crop District 9, containing the practicum study area, was delineated into two soil types. The actual soil associations comprising both soil types are presented in Table 12. Soil type 1 soils are considered to be easier to cultivate than soil type 2 soils and have correspondingly lower production costs. The entire study area is in the Newdale soil association which is classified as clay loam. Clay loam is included in the soil type 2 category (see Table 12). All production costs associated with lands in the study area were soil type 2 costs. Nevertheless, the entire analysis was carried out using both soil types in order that the results be applicable to other soil associations outside the study area but within Crop District 9.

Data for production costs were also subdivided according to farm size. Three farm sizes were utilized.

farm size 1 less than 240 acres

farm size 2 240-759 acres

farm size 3 greater than 759 acres

Table 13 states production costs for each farm size in both soil types for all the relevant crops and summer fallow. Once again however, these costs must be converted to a composite acre basis. To obtain a composite acre production cost

Table 12 . Classification of soil types in Crop District 9 for agricultural production cost data.

Soil type 1	Soil type 2
sand	clay loam
loamy sand	silty clay
loamy very fine sand	sandy clay loam
sandy loam	silty clay loam
very fine sandy loam	sandy clay
loam	clay
silt loam	
silt	

[a] Source: Framingham, C., W. Craddock and L. Baker. 1973. Alternative futures for Manitoba agriculture: the application of a model for the analysis of agricultural income: employment, price, production, and farm size policy alternatives. Draft Research Bulletin, Dept. of Agricultural Economics, University of Manitoba.

for each farm size in both soil types, the production cost for each crop was multiplied by the percentage of the composite acre it represents. The sum of these figures gave the production cost per composite acre. Production costs for each crop are presented in Table 13 while composite acre production costs are given in Table 14.

4.3 Profits Derived From Agricultural Production

Profits per composite acre were determined by taking the difference of the values calculated for composite acre agricultural production costs and for composite acre agricult-

Table 13 . Agricultural production costs per acre for crops comprising a composite acre ($).

Crop	Soil type 1			Soil type 2		
	farm size 1	farm size 2	farm size 3	farm size 1	farm size 2	farm size 3
wheat	27.43	22.57	20.29	28.05	22.85	20.48
oats	30.01	24.77	22.16	31.10	25.05	22.30
barley	25.93	20.93	18.52	26.74	21.21	18.70
flax	24.91	20.69	18.08	26.12	20.70	18.95
rye	27.91	23.10	20.88	28.45	23.37	21.07
mixed g.	28.67	23.51	20.96	29.66	23.78	21.10
rape	25.80	21.45	18.74	27.14	21.44	19.38
tame h.	28.63	14.33	14.33	28.63	14.33	14.33
fallow	18.02	15.52	13.73	20.93	15.98	14.31

[a] Source: Framingham, C., W. Craddock and L. Baker, 1973. Alternative futures for Manitoba agriculture: the application of a model for the analysis of agricultural income: employment, price, production, and farm size policy alternatives. Draft Research Bulletin, Dept. of Agricultural Economics, University of Manitoba.

Table 14 . Agricultural production costs per composite acre ($).

Farm size	Soil type 1	Soil type 2
1	24.84	26.32
2	19.78	20.08
3	17.76	18.08

[a] Farm size 1 is less than 240 a., farm size 2 is 240-759 a., and farm size 3 is greater than 759 a.

ural productivity.

The range of profits possible considering farm size, soil type, crop yield and crop price is listed in Table 15. Profits possible under all combinations of these factors are found in Appendix 3.

4.4 Agricultural Opportunity Cost

To determine the agricultural opportunity cost, fixed costs of production were added to the figures which represented profits per composite acre (see page 46). For Crop District 9 and the study area, these fixed costs were the same for any acre of land, regardless of soil type or farm size. The estimates were $6.10 per acre annually for investment in land and buildings and $1.22 per acre annually for taxes (Framingham et al., 1973). This gave a total fixed cost of $7.32 per acre each year.

The range of possible opportunity costs derived in the practicum model is demonstrated in Table 16. All possible opportunity costs calculated utilizing the combinations of farm size, soil type, crop price, and crop yield are found in Appendix 4.

4.5 Waterfowl Production

Results from the waterfowl production model provided a range of values for duck production that would be potentially attainable from habitat manipulation and maintenance using the assumptions stated previously. The minimum calculated was 0.19 ducks produced per acre at a breeding pair density of

Table 15 . Profits per composite acre ($).

Farm size 1

Crop price	Soil type 1: Crop yield Avg.-50%	Soil type 1: Avg.	Soil type 1: Avg.+50%	Soil type 2: Crop yield Avg.-50%	Soil type 2: Avg.	Soil type 2: Avg.+50%
Avg.-50%	-18.68	-12.45	- 6.24	-20.16	-13.93	- 7.72
Avg.	-12.42	+ 0.09	+12.56	-13.90	- 1.39	+11.08
Avg.+50%	- 6.18	+12.60	+31.38	- 7.66	+11.12	+29.90

Farm size 2

Crop price	Soil type 1: Crop yield Avg.-50%	Soil type 1: Avg.	Soil type 1: Avg.+50%	Soil type 2: Crop yield Avg.-50%	Soil type 2: Avg.	Soil type 2: Avg.+50%
Avg.-50%	-13.62	- 7.39	- 1.18	-13.92	- 7.69	- 1.48
Avg.	- 7.36	+ 5.15	+17.62	- 7.66	+ 4.85	+17.32
Avg.+50%	- 1.12	+17.66	+36.44	- 1.42	+17.36	+36.14

Farm size 3

Crop price	Soil type 1: Crop yield Avg.-50%	Soil type 1: Avg.	Soil type 1: Avg.+50%	Soil type 2: Crop yield Avg.-50%	Soil type 2: Avg.	Soil type 2: Avg.+50%
Avg.-50%	-11.60	- 5.37	+ 0.84	-11.92	- 5.69	+ 0.52
Avg.	- 5.34	+ 7.17	+19.64	- 5.66	+ 6.85	+19.32
Avg.+50%	+ 0.90	+19.68	+38.46	+ 0.58	+19.36	+38.14

[a] Farm size 1 is less than 240 a., farm size 2 is 240-759 a., and farm size 3 is greater than 759 a.

Table 16 . Agricultural opportunity cost per composite acre ($).

	Farm size 1					
	Soil type 1			Soil type 2		
Crop price	Crop yield					
	Avg.-50%	Avg.	Avg.+50%	Avg.-50%	Avg.	Avg.+50%
Avg.-50%	-11.36	- 5.13	+ 1.08	-12.84	- 6.61	- 0.40
Avg.	- 5.10	+ 7.41	+19.88	- 6.58	+ 5.93	+18.40
Avg.+50%	+ 1.14	+19.92	+38.70	- 0.34	+18.44	+37.22

	Farm size 2					
	Soil type 1			Soil type 2		
Crop price	Crop yield					
	Avg.-50%	Avg.	Avg.+50%	Avg.-50%	Avg.	Avg.+50%
Avg.-50%	-6.30	- 0.07	+ 6.14	-6.60	- 0.37	+ 5.84
Avg.	-0.04	+12.47	+24.94	-0.34	+12.17	+24.64
Avg.+50%	+6.20	+24.98	+43.76	+5.90	+24.68	+43.46

	Farm size 3					
	Soil type 1			Soil type 2		
Crop price	Crop yield					
	Avg.-50%	Avg.	Avg.+50%	Avg.-50%	Avg.	Avg.+50%
Avg.-50%	-4.28	+ 1.95	+ 8.16	-4.60	+ 1.63	+ 7.84
Avg.	+1.98	+14.49	+26.96	+1.66	+14.17	+26.64
Avg.+50%	+8.22	+27.00	+45.78	+7.90	+26.68	+45.46

[a] Farm size 1 is less than 240 a., farm size 2 is 240-759 a., and farm size 3 is greater than 759 a.

100 pairs per square mile and a nesting success of 20 percent and the maximum was 5.72 ducks per acre at 600 pairs per square mile and a nesting success of 100 percent. Personal communication with Harvey Miller (1974) indicated that a maximum observed in studies conducted by the Northern Prairie Wildlife Research Center was 8.4 ducks hatched per acre without predator control and 18.7 ducks hatched per acre with predator control. Duebbert (1974) reported that the average hatch was 2.0 ducks per acre on ten grass-legume cover plots from 30-133 acres monitored in South Dakota, while the average number of ducks hatched on several hundred acres of cropland, grazing land, haylands, and miscellaneous cover in the same area was 0.2 per acre.

The same studies from the Northern Prairie Wildlife Research Center indicated that the density of breeding pairs will increase on retired croplands sown to a grass-legume cover as this vegetation matures. As the stand becomes tall, dense, and rank over a period of years, it reaches an optimum for attracting nesting birds. To maintain vigor, manipulation at 5-10 year intervals is essential. Nelson (1973) feels that breeding pairs of dabbling ducks can be concentrated much more than previously thought without affecting reproductive efficiency. He adds that there is strong evidence of differential productivity by age classes in diving ducks and possibly in dabblers. This must be considered when assessing production from an observed breeding pair population. In addition, differences in behavioural and physiological characteristics that influence the breeding biology of various species of

Table 17 a . Waterfowl production potential in the Minnedosa pothole country.

Breeding pair density	Nesting success %	Ducks to flight	Ducks per acre	Breeding pair density	Nesting success %	Ducks to flight	Ducks per acre
100	20	122	0.19	120	20	146	0.23
	30	183	0.29		30	220	0.34
	40	244	0.38		40	293	0.46
	50	305	0.48		50	366	0.57
	60	366	0.57		60	439	0.69
	70	427	0.67		70	512	0.80
	80	488	0.76		80	586	0.92
	90	549	0.86		90	659	1.03
	100	610	0.95		100	732	1.14
140	20	171	0.27	160	20	195	0.30
	30	256	0.40		30	293	0.46
	40	342	0.53		40	390	0.61
	50	427	0.67		50	488	0.76
	60	512	0.80		60	586	0.92
	70	598	0.93		70	683	1.07
	80	683	1.07		80	781	1.22
	90	769	1.20		90	878	1.37
	100	854	1.33		100	976	1.52

Table 17 b . Waterfowl production potential in the Minnedosa pothole country.

Breeding pair density	Nesting success %	Ducks to flight	Ducks per acre	Breeding pair density	Nesting success %	Ducks to flight	Ducks per acre
180	20	220	0.34	200	20	244	0.38
	30	329	0.51		30	366	0.57
	40	439	0.69		40	488	0.76
	50	549	0.86		50	610	0.95
	60	659	1.03		60	732	1.14
	70	769	1.20		70	854	1.33
	80	878	1.37		80	976	1.53
	90	988	1.54		90	1098	1.72
	100	1098	1.72		100	1220	1.91
240	20	293	0.46	280	20	342	0.53
	30	439	0.69		30	512	0.80
	40	586	0.92		40	683	1.07
	50	732	1.14		50	854	1.33
	60	878	1.37		60	1025	1.60
	70	1025	1.60		70	1196	1.87
	80	1171	1.83		80	1366	2.13
	90	1318	2.06		90	1537	2.40
	100	1464	2.29		100	1708	2.67

Table 17 c . Waterfowl production potential in the Minnedosa pothole country.

Breeding pair density	Nesting success %	Ducks to flight	Ducks per acre	Breeding pair density	Nesting success %	Ducks to flight	Ducks per acre
320	20	390	0.61	360	20	439	0.69
	30	586	0.92		30	659	1.03
	40	781	1.22		40	878	1.37
	50	976	1.53		50	1098	1.72
	60	1171	1.83		60	1318	2.06
	70	1366	2.13		70	1537	2.40
	80	1562	2.44		80	1757	2.75
	90	1757	2.75		90	1976	3.09
	100	1952	3.05		100	2196	3.43
400	20	488	0.76	440	20	537	0.84
	30	732	1.14		30	805	1.26
	40	976	1.53		40	1074	1.68
	50	1220	1.91		50	1342	2.10
	60	1464	2.29		60	1610	2.52
	70	1708	2.67		70	1879	2.94
	80	1952	3.05		80	2147	3.51
	90	2196	3.43		90	2416	3.78
	100	2440	3.81		100	2684	4.19

Table 17 d . Waterfowl production potential in the Minnedosa pothole country.

Breeding pair density	Nesting success %	Ducks to flight	Ducks per acre	Breeding pair density	Nesting success %	Ducks to flight	Ducks per acre
480	20	586	0.92	520	20	634	0.99
	30	878	1.37		30	952	1.49
	40	1171	1.83		40	1269	1.98
	50	1464	2.29		50	1586	2.48
	60	1757	2.75		60	1903	2.97
	70	2050	3.20		70	2220	3.47
	80	2342	3.66		80	2538	3.97
	90	2635	4.12		90	2855	4.46
	100	2928	4.58		100	3172	4.96
560	20	683	1.07	600	20	732	1.14
	30	1025	1.60		30	1098	1.72
	40	1366	2.13		40	1464	2.29
	50	1708	2.67		50	1830	2.86
	60	2050	3.20		60	2196	3.43
	70	2391	3.74		70	2562	3.85
	80	2733	4.27		80	2928	4.58
	90	3074	4.80		90	3294	5.15
	100	3416	5.34		100	3660	5.72

waterfowl must be better understood for more effective management.

In habitat studies in South Dakota nest densities of 1.5-2.5 per acre were found in a predator control area (Duebbert, 1973). This is equivalent to a nesting density of 960-1600 nests per square mile. Without predator control, Nelson (1973) reported nest densities of .39-.94 per acre. This is equivalent to 250-602 nests per square mile. Nesting success was 76-79 percent in the non-predator control area. Sellers (1973) found mallard breeding pair densities of 66 ± 5 in 1971 after releasing hen mallards in an area near Minnedosa in 1969 and 1970. The release area is within the practicum study area. However, only 9 percent of these hens produced broods. Sellers' experiment showed that mallard pairs could be concentrated. Titman (1973) calculated that considering space requirements, mallards in the Minnedosa pothole country could exceed a density of 27 pairs per square mile. The highest breeding pair density recorded in the Minnedosa area for all species was 144 pairs per square mile in 1964 (Stoudt, 1973).

Kalmbach (1939) stated that a nesting success of 70 percent was a reasonable standard which over a period of years would increase wildfowl populations. Nesting success of 50-80 percent has been observed on retired croplands without predator control and up to 98 percent with predator control.

4.6 The Cost Of Land Easement Versus Land Purchase

From an economic standpoint some interesting figures resulted from comparing the selling price of land in the study area to the estimated costs of land easement in this vicinity. Land prices are presently increasing. Contact with municipal assessment officials at Minnedosa showed that prices from mid 1973 to the end of 1973 were approximately $100 per cultivated acre. Estimated prices per cultivated acre of land on May 1, 1974 were closer to $125 and speculation was that prices could go up to $150 per cultivated acre (Grant, Personal communication).

In contrast, one can look at the cost of easement of agricultural land in terms of an annual rental fee. The cost of the test plot of the Delta Waterfowl Research Station located within the practicum study area was $20 per acre per year (Jones, Personal communication). A project being undertaken by the Northern Prairie Wildlife Research Center has an estimated annual rental fee of $25 per acre. The findings of the practicum analysis suggest that the minimum annual payment that could be made on soils farmed in the study area is $14.17. This is the opportunity cost on soil type 2, farm size 3 when price and yield conditions are average. This figure is likely low and the $20-$25 range is probably closer to what would have to be paid.

Table 18 is a summary of net present values when estimated annual payments of $14, $17, $20 and $25 are discounted at rates of 8 percent, 10 percent, 12 percent and 15 percent over a period of "n" years. In this analysis, calculations were done for periods of 5 years to 10 years, 15 years, and 20 years. In order for agricultural land to be

Table 18 a . Present value ($) of a series of "n" alternate payments with varied discount rates.

Payment = $14

Years	Discount rate			
	8%	10%	12%	15%
5	55.90	53.07	50.47	46.93
6	64.72	60.97	57.55	52.98
7	72.88	72.88	63.90	58.24
8	80.46	74.69	69.55	62.82
9	87.46	80.63	74.59	66.81
10	93.94	86.03	79.10	70.27
15	119.83	106.48	95.35	81.86
20	137.45	119.20	104.57	87.63

Payment = $17

Years	Discount rate			
	8%	10%	12%	15%
5	67.88	64.45	61.29	56.98
6	78.59	74.04	69.89	64.33
7	88.50	82.76	77.59	70.72
8	97.70	90.70	84.46	76.28
9	106.20	97.90	90.58	81.12
10	114.07	104.47	96.05	85.32
15	145.50	129.30	115.79	99.40
20	166.91	144.74	126.97	106.40

Table 18 b . Present value ($) of a series of "n" alternate payments with varied discount rates.

Payment = $20

Years	Discount rate			
	8%	10%	12%	15%
5	79.86	75.82	72.10	67.04
6	92.46	87.10	82.22	75.68
7	104.12	97.36	91.28	83.20
8	114.94	106.70	99.36	89.74
9	124.94	115.18	106.56	95.44
10	134.20	122.90	113.00	100.38
15	171.18	152.12	136.22	116.94
20	196.36	170.28	149.38	125.18

Payment = $25

Years	Discount rate			
	8%	10%	12%	15%
5	99.83	94.78	90.13	83.80
6	115.58	108.88	102.78	94.60
7	130.15	121.70	114.10	104.00
8	143.68	133.38	124.20	112.18
9	156.18	143.98	133.20	119.30
10	167.75	153.63	141.25	125.48
15	213.98	190.15	170.28	146.18
20	245.45	212.85	186.73	156.48

optimized for wildlife production, it must be maintained in a suitable vegetative cover for at least 5 years. For this reason, 5 years was chosen as a minimum for this section of the practicum analysis.

Assuming that it would cost $125 per acre to purchase land outright in the study area, an agency interested in sponsoring a wildlife habitat maintenance program would be faced with the decision of purchasing land at a minimum of $125 per acre or entering an easement program where annual payments are a minimum of $14 per acre and likely $20 or $25 per acre. Table 18 demonstrates that at a discount rate of 8 percent, an annual payment of $20 reaches a present value of $125 after 9 years and an annual payment of $25 achieves a present value of $125 at between 6 and 7 years. At a 12 percent discount rate, an annual payment of $20 per year does not equal a present value of $125 until after 10 years and a payment of $25 reaches a present value of $125 after approximately 8 years.

CHAPTER 5 - DISCUSSION OF RESULTS

5.1 The Opportunity Cost Model

Composite acre agricultural productivity is outlined in Table 11. This is a summarization of the results of Appendix 2 and gives estimates of the revenue generated under alternate price and yield conditions from an acre of land cultivated to the crops specified in the composite acre concept. These values are assumed to be unaffected by soil type and farm size. The maximum productivity is $56.22 when crop price and crop yield are both 50 percent above average. Minimum productivity is $6.16 when price and yield are 50 percent below average and the productivity when price and yield are average is $24.93.

Table 15 summarizes the results of Appendix 3. Profits per composite acre are less on soil type 2 under all price and yield conditions for all three farm sizes. This is due to higher production costs on soil type 2 soils than on soil type 1 soils and identical agricultural productivity on both soil types. On either soil type, profit per composite acre increases with increasing farm size because production costs decrease as farm size increases. Examination of Table 15 reveals this trend.

Soil type 2 soils occupy the entire study area. Profits in the study area are -$1.39 per acre on farm size 1 for average price and yield, $4.85 per acre on farm size 2 and $6.85 per acre on farm size 3. Profit is maximized when price and yield are 50 percent above the average. These values equal $29.90 on farm size 1, $36.14 on farm size 2, and $38.14 on farm size 3.

The endpoint of the analysis was the calculation of agricultural opportunity cost per composite acre. Opportunity costs follow identical trends to composite acre profits. Values are larger for all price and yield conditions on soil type 1 than soil type 2 and opportunity cost increases with increasing farm size. With average conditions on farm sizes 1, 2 and 3, opportunity costs are $5.93, $12.17 and $14.17 on soil type 2 for the three farm sizes respectively. Maximum opportunity cost on the three farm sizes when price and yield are 50 percent above average equals $37.22, $43.46 and $45.46.

5.2 Cost Of Waterfowl Production

The practicum analysis demonstrated that with the assumptions made, the estimated opportunity cost or the cost of leasing land which has been used for production of small grain crops within the study area was $14.17 per acre when price and yield conditions were average. Besides, a range of figures for potential waterfowl production attainable by manipulating habitat was calculated. This was 0.19 - 5.72 ducks produced per acre of land reverted to habitat. If habitat manipulation proved as successful in the Minnedosa pothole as it has been in the U.S., then the upper part of this range is attainable.

Assuming that waterfowl could be produced at a rate of 1-6 ducks per acre of manipulated habitat and that the cost

Table 19 . The cost of producing a duck under alternate easement payment and waterfowl production conditions ($ per duck).

Easement payment($)	Ducks produced per acre					
	1	2	3	4	5	6
14	14.00	7.00	4.66	3.50	2.80	2.33
20	20.00	10.00	6.67	5.00	4.00	3.33
25	25.00	12.50	8.33	6.25	5.00	4.25
30	30.00	15.00	10.00	7.50	6.00	5.00
35	35.00	17.50	11.67	8.75	7.00	5.83

of annual land easement was $14 - $35 per acre, then the cost of producing a duck would be between $2.33 and $35. Table 19 presents a range of costs per duck produced under alternate conditions.

Review of the literature showed that the easement payments offered in Manitoba and in North Dakota were $20 and $25 per acre on projects carried out by the Delta Waterfowl Research Station and the Northern Prairie Wildlife Research Center respectively. These figures represented a payment for each acre of cultivated farmland converted to wildlife habitat.

5.3 <u>The Cost Of Land Easement Versus Land Purchase</u>

This analysis demonstrated that from a purely economic standpoint, the attractiveness of purchase compared to easement is dependent on the length of time over which the habitat is to be maintained and on the annual rental fee that would be paid in an easement program. As indicated by Table 18, with an annual easement rental fee of $14, a net present value of $125 is not reached until between 15 and 20 years with an 8 percent discount rate and until after 20 years at the other discount rates used. At any discount rate, as the annual easement rental cost per acre increases, the net present value of $125 is achieved in a shorter time period. If the desire is to manipulate the land for wildlife production indefinitely, then the purchase alternative is more economically feasible. At any of the easement payments indicated in Table 18, a net present value of $125 is achieved in a longer period of time as discount rate increases. The choice of purchase versus easement is complicated if one speculates at a decrease in the value of land to the 1972 price of $80 (M.D.A., 1972) or an increase to $150. Once again the key factor is the length of time for which the land is to be managed for wildlife production.

This analysis only accounted for the cost of the land. It did not include the cost of land treatment and seed and the cost of program evaluation. However, these costs must be absorbed whether the land is purchased or rented. In addition, this was only an economic consideration. The sociological implications of land purchase versus land easement may be much more significant.

GENERAL CONSIDERATIONS NOT STUDIED IN DETAIL

5.4 Wildlife Habitat Planning Model

5.41 Components

Implementation of a wildlife habitat maintenance program could be carried out by a government or a private sponsoring agency. The practicum analysis has estimated the opportunity costs of easement on lands used for small grain production. This is to be interpreted as a base for estimating the opportunity cost of land easement of other unit types or combinations of these types found in the study area as well. The opportunity cost of easement of land used for small grain production is the highest of all land available because it is the most valuable to the landowner. In planning a wildlife habitat maintenance program, several factors would have to be taken into account if land units of 40 acres or multiples of 40 acres were to be rented. Administratively, it would be desirable to utilize 40 acre legal subdivisions or groups of these. Overall, the following factors should be considered:

1) amount and type of land units available.
2) potential of different land types for waterfowl production.
3) cost of easement of different land types.
4) cost and difficulty of establishing habitat on different land types.
5) return on investment from different land types.

5.42 Amount and type of land units available

Data was obtained from municipal assessment authorities in Minnedosa, Manitoba on the amount and type of land which exists in the practicum study area. This information classifies the land into various units as it is assessed for taxation purposes. The assessment relates the capability of the land for agricultural production. Five general land types are classified. These are listed below with the estimated percentage of the total land area in the study area which they make up.

1) cultivated croplands - 60-65 percent
2) tame foragelands - less than 5 percent
3) native haylands - less than 5 percent
4) arable bushlands - less than 5 percent
5) wetlands - 25-30 percent

Wetlands are classified as non-arable waste sloughs by municipal assessment authorities and make up approximately 25-30 percent of the land area. This area is not all water however. The majority is vegetative cover around the periphery of potholes and may include bush and/or scrub. Although arable bushland is less than 5 percent of the total area, the total land area occupied by trees is greater than this. Data updated by C.W.S., Winnipeg for transects 1-11 inclusive of Kiel et al. (1972) estimated that woodlots and bushland made up 8.6 percent of the land area in a portion of the Minnedosa pothole country in 1970. These same estimates reported 8.6 percent as the portion of wetland remaining in the area.

In choosing potential 40 acre legal subdivisions for easement, it is unlikely that there would be many homogeneous blocks of land other than cultivated units and units classified as wetlands by municipal assessment.

5.43 Potential of different land types for waterfowl production

Retired croplands sown to a grass-legume forage mixture have shown the best results for improving waterfowl production. Nesting success increased from a range of 20-30 percent to a range of 70-80 percent with similar increases in densities of nesting birds (Nelson, 1973). On active agricultural land, tame forage land units are likely producing more waterfowl per acre than land sown for small grain production. The reasons are twofold. This type of crop has a more permanent vegetative cover and secondly, there is less disturbance by agricultural activity.

Providing upland cover can be established equal to that on land previously cultivated for small grain production, waterfowl production should be equal as well. This potential will decline as limiting factors such as stoniness, drainage, and topography restrict the growth of the prescribed grass-legume mixture.

Native haylands in the study area exist mainly in small pockets and in narrow bands. Birds nesting in these sites now are subjected to severe predation. Increasing waterfowl production potential by habitat manipulation in these areas might be more difficult than the previous two land types because of poorer soil conditions. These areas may have higher water tables and alkaline soil conditions. Unless a tall, rank, dense stand of moisture and alkaline tolerant vegetation could be established, these areas might be better left in their natural vegetative cover. If the area of native hay is a part of a 40 acre habitat parcel, wildlife production within it might be improved simply by manipulating habitat in the remainder of the 40 acre block. This possibility has been suggested by the data gathered by Herzog (1973).

Potential for waterfowl production on arable bushland units is difficult to assess because of the problem in nest searching wooded areas. Mallards will nest in this type of habitat (Jones, Personal communication). Nesting is not restricted around the edges of these units but overall the potential is likely less than that of the other land units. Nevertheless, easement of these areas might be considered to maintain habitat for white-tailed deer, upland game birds, and other wildlife species. Production potential for the wetland units is good but actual production is poor because available cover is insufficient. Existing vegetation is not of suitable quantity to support good waterfowl production. A common practice of Minnedosa farmers is to burn this vegetation in the spring and fall. Termination of this practice alone would improve production.

In determining the feasibility of easement of various 40 acre blocks, waterfowl production potential of each land type within a 40 acre unit should be considered. The objective would be to maximize wildlife production on small managed units. To accomplish this, the potential on each land unit type should be investigated. Although the study area and much of the Minnedosa pothole country contains a high proportion of class 1 waterfowl habitat, some stratification within capability classes still exists.

5.44 Cost of easement of different land types

Cultivated land used for small grain production is the most valuable to the farmer. The opportunity cost of using this land type for waterfowl production is the highest. In the practicum analysis this assumption was made and it was decided that this opportunity cost might be used as a base for determining the opportunity cost of easement of other land types.

Forage crops are grown in the study area because some farming enterprises necessitate production of feed for livestock, as part of a crop rotation, or because of soil limitations to small grain production. If the land has potential for small grain production equal to that of other cultivated units, then the rental fee would have to be equal as well. However, if limiting factors exist, the payment would be less.

The value of native haylands for agricultural production is less than croplands and tame forage lands. Annual easement payments or the opportunity cost of leasing is less as well. Arable bushland units have potential for small grain production but this involves a clearing cost to the landowner. It would not be feasible for a sponsoring agency to lease this type of land unit, pay the cost of clearing, and then attempt to establish habitat for waterfowl. However, there would be benefits from renting this type of land for wildlife other than waterfowl. In determining the opportunity cost of easement, consideration would have to be given to soil capability, present value of small grain production, and clearing costs. Because the potential for small grain production involves a clearing cost to the landowner, the opportunity cost of easement is less than that for cultivated cropland and tame forage units but greater than native haylands.

The cost of easement for wetland units would be zero in terms of lost agricultural production. The only way that an agriculture opportunity cost exists for these wetlands is if they were drained. After drainage, the value of the land for agricultural production and the resultant opportunity cost for easement would be equal to the present value of crop production minus the cost of drainage. However, field observation indicates that most of the present economically feasible drainage has taken place. Those wetlands remaining would be very costly to drain. Thus the cost of easement of wetlands would be the smallest of any of the land types in the study area.

5.45 Cost and difficulty of establishing habitat on different land types

Differences in the cost of producing a grass-legume cover on different land types will depend on soil type and capability, soil limitations, and topography. These factors will affect the ease of seeding and rate of seeding needed. Poorer soil conditions may necessitate a heavier rate of seeding, application of fertilizer, or may affect the cost of machinery, fuel, and labour. This cost will be the least for cropland because soil conditions should be the best on these units. Estimates from the Northern Prairie Wildlife Research Center experiment were $12.50 per acre for land treatment and seed.

The cost of habitat establishment on forage units will be equal to or greater than that incurred on land used for small grain production. Forage lands would have to be ploughed, worked and then sown whereas cropland would require less tilling. On native haylands, this cost might be greater because of the need for ploughing and tilling of the land and due to the limitations of moisture and alkalinity mentioned previously.

Clearing arable bushland in anticipation of waterfowl production is not feasible. If the bushland was being considered for other wildlife species, manipulation of the vegetative cover would not be necessary.

In regard to wetland units, establishment of a grass-legume cover in place of the native vegetation which remains around the potholes would be very difficult. Farmers have cultivated as closely as possible to the edges of the potholes. Those vegetative rings which remain are probably impossible to cultivate. However, the production potential of this native vegetation which remains could be enhanced for waterfowl by controlled burning.

For these reasons, the cost and difficulty of establishing habitat must also be looked at in considering the feasibility of a wildlife habitat maintenance program. On some land unit types, simple management techniques may be more beneficial than an attempt to change the vegetative cover. These techniques in conjunction with cover establishment on adjacent areas of different land units might combine to increase the benefit to wildlife production even more.

5.46 <u>Return on investment from different land types</u>

Retired croplands or cultivated lands formerly used for small grain production have shown excellent waterfowl production in experiments carried out in the U.S. (Nelson, 1973). Establishing a grass-legume vegetation increases waterfowl production substantially. This type of land will be the most expensive to take out of agricultural production but waterfowl production on this land type may have the greatest potential after retirement. Waterfowl production data from manipulating habitat on other land types is not as abundant and is not as encouraging.

If good upland cover could be grown on tame forage land units, waterfowl production potential should be as high as habitat established on retired croplands. Waterfowl production potential would decline as existing soil limitations decrease the quality of the grass-legume cover. As mentioned previously, limitations do not necessarily have to exist. If they do however, the opportunity cost of leasing these land unit types would decrease accordingly. Therefore waterfowl produced per dollar invested could equal or exceed that on retired croplands.

If a unit of native hayland was to be leased for habitat, field observation would be required to determine the feasibility of seeding vegetation. This might be one instance where it would be more profitable to leave the stand of native vegetation. The opportunity cost of easement of this type of land unit is less than that of lands used for production of small grains and lands used for forage production because its value for production of agricultural products is less. Although its potential for waterfowl production may be less as well, the return in ducks per dollar invested may be equal to or greater than the previous two land types because the opportunity cost is lower.

Easement of arable bushland units would probably provide a lower return in waterfowl per dollar invested than the other land types. Some nesting might take place within and around the fringe of the bushland (Jones, Personal communication). However, this return would be increased due to the benefit of habitat for other wildlife species. The opportunity cost of this type of unit would be less than that of the retired cropland and tame forage units but greater than that of the native hay unit because it has potential for arable culture. In addition, there would be no cost for land treatment and seeding.

Maintaining wetlands alone is not the complete answer to the improvement of waterfowl production in the Minnedosa pothole area. It has been stated that a lack of good upland nesting cover to complement wetlands is a key reason for the demise of North American waterfowl. The importance of maintaining a specified amount of wetlands to insure the continued presence of a base is apparent. In fact the potential of any of the other four land unit types to produce waterfowl is contingent upon the existence of a variety of wetland types. The opportunity cost of maintaining wetlands in the study area is the lowest of any of the land types because the value of these areas for producing agricultural products is the least. Therefore, the return on investment may be equal to or greater than each of the other land types providing other land types are under easement as well. In effect, some ratio of upland to wetland greater than that which presently exists is needed to increase waterfowl production on these units. Simply by reducing haying and grazing and eliminating burning around the periphery of potholes, production of waterfowl would increase.

5.5 The Landowner Model

In a discussion of the feasibility of a wildlife habitat maintenance program, consideration must be given to the problem from the point of view of the landowner. He will decide whether to lease his land or not. Some of the factors which might influence this decision are discussed below.

5.51 Farm size

Land ownership for the study area was analyzed by including the perimeter of land one mile outside the study area. Separation of legal landowners showed that 23 owned 240 acres or less, 47 owned 240-760 acres and 3 owned more than 760 acres of land. M.D.A. (1972) reported that the average census farm size in Crop District 9 was 543 acres. This average farm size is greater than the average of 6 of the other 14 Crop Districts in Manitoba.

Agricultural production costs decline as farm size increases (Framingham, 1973). The practicum analysis showed that profits per acre are greater under alternate price and yield conditions as farm size increases because of decreased production costs. Any farmer faced with the decision of entering an easement program would have to be convinced that the average annual payment offered would give him a fair return on his land and make up for the increase in production costs. These costs rise because his real farm size decreases. For the payment to be acceptable, it should be higher for larger farmers. Figures from the practicum demonstrate that under some price and yield conditions, landowners on farms less than 240 acres in size are losing money.

In fact, previous figures for land ownership in the study area include only legal landowners and do not account for rentals. If rented land was included in the calculation of farm size, the average would increase. Nevertheless, some landowners in the study area presently own farms which are less than 240 acres in size. The decision to rent a block of land no less than 40 acres in size may be more difficult for these smaller landowners because 40 acres represents a significant percentage of his total land area.

5.52 Easement payment

The consideration of the per acre cost of an easement program made by the wildlife habitat planning agency is the same one which the landowner has to make. From his point of view, it becomes an easement payment for each acre of his land which he might decide to rent. Some landowners have an idea of the profits that they earn on an individual acre basis. A calculation could be made by the wildlife habitat planning agency of the profits earned by the landowners. The findings would demonstrate that under identical soil conditions, crop yields, and crop prices, the larger landowner will earn more than the smaller landowner, simply because his costs of production are less. From a sociological point of view, it would probably be unacceptable to pay larger farmers more per acre as an annual rent because of this condition. Therefore, a price would have to be established which is acceptable to all parties. Field observation could be used as a technique to determine soil limitations which affect the value of the land for agricultural production. A variation in annual payments could be made according to these.

5.53 Type of farming enterprise

The practicum analysis of opportunity cost was simplified by making the assumption that all profit from farming accrued from small grain production. In reality, livestock production will be a part of some farming enterprises. For this reason, landowners may be unwilling to part with tame forage lands or native haylands. The opportunity cost of leasing these land types might be less than lands used for small grain production as mentioned in section 5.44. Landowners who are strictly grain farmers would be more apt to rent these land types providing they considered the payments to be greater than the value of the hay from these lands.

Other than the payment price offered, there are no apparent reasons why landowners would be unwilling to allow wetland units and arable bushland units to come under easement unless they had plans to clear or drain. The reluctance to rent land would probably be greatest for cultivated land which has been sown to small grain crops in previous years. However, the easement payment would have to be large enough to equal the return from agricultural production and to offset the increase in production costs that would result from decreasing cultivated acreage.

5.6 Factors For Consideration In An Easement Program

In organizing an easement program, it would be feasible legally and administratively to consider only legal 40 acre sub-divisions. Each quarter section contains four 40 acre sections. By making such a stipulation, only entire legal sub-divisions could be contracted to easement. Thus a unit of land under easement would have to be 40 acres in size or some multiple of forty acres (more than one legal sub-division). This provision would simplify the delineating of easement units.

Each 40 acre parcel will be different. In the

Minnedosa pothole country, 40 acre units without any wetland complexes would be rare. Biologically it is not necessary to have wetlands within the cover block because brood rearing habitat is different than nesting habitat. Once hatched, the hen will lead the brood to water. Nelson (1972) recommends that the largest single block of wetlands and uplands be established that is possible, contingent upon the landowner. Some judgement would have to be made at the field level as to qualifying wetland acreage, depending in part on the abundance and distribution of various wetland types on surrounding lands to insure adequate brood-rearing habitat within one mile from temporary ponds and nesting cover.

The planning of an easement program would require a priority rating for the desired land units. However, it is unlikely that many homogeneous 40 acre legal subdivisions would be found except in the cultivated cropland category. Therefore, it would be necessary to incorporate heterogeneous 40 acre units. Choice of these would depend on the factors discussed in the framework of the "Wildlife Habitat Planning Model" and how these factors relate to the proportions of each land unit type in the easement blocks.

5.7 Advantages Of Land Easement Versus Land Purchase

1) Landowners are likely to be more responsive to a land easement program than outright purchase providing the annual easement payment is high enough. The reason is that an easement does not have to be a permanent commitment.

2) From an economic standpoint, land purchase

becomes more feasible than land easement the longer the land is to be maintained for wildlife production and the higher the easement payment.

3) Administration of a wildlife habitat maintenance program would be less difficult if land was purchased providing surrounding landowners could be trusted not to disturb the habitat by grazing, mowing, and burning, etc. However, an easement with a binding legal contract might induce adequate communication between the tenant and the landowner and adequate monitoring of the land under easement so that disturbance of manipulated habitat would be minimal.

4) Easement would enable a greater acreage to be under control for wildlife production quickly.

5) Easement of land would allow a time lag during which the actual production potential for wildlife of a unit of land could be determined. This would aid the decision to purchase the unit or to continue leasing or to terminate any program on the land.

6) Leasing avoids having to make a premature decision before all necessary information is available (Hedlin Menzies and Associates Ltd., 1967).

7) If a landowner has no plans to drain wetlands or to clear arable bushland, leasing these provides him with income and does not commit him to losing them permanently.

8) If a landowner leases areas of his land, he is not likely to feel that he is giving up something of considerable value forever, especially as he will be paid an annual rent.

CHAPTER 6 - CONCLUSIONS

6.1 Conclusions

1) Wildlife habitat maintenance in southwestern Manitoba is feasible if it is undertaken using land easements. Annual easement payments could be no less than $14 per acre for cultivated cropland and would likely have to be $20 or more per acre to provide sufficient incentive to attract landowner participation. Payments for other land unit types (native haylands, forage croplands, arable bushlands and wetlands) should be scaled down according to their capability for the production of agricultural products.

2) The longer the period of time for which land is to be converted to and maintained as wildlife habitat, the more economically attractive land purchase becomes in comparison with land easement. This factor increases with increasing discount rate as well.

3) Potential waterfowl production to the fledged brood stage from manipulated habitat may be as high as 6 birds per acre.

4) Literature review indicated that wildlife and wildlife habitat are beneficial to society. The value is high and the benefits are definable. However, actual measurement of the benefits in economic terms is at best extremely difficult.

5) Literature review demonstrated that to maximize wildlife production potential, habitat manipulation

should be carried out on blocks of land no less than 40 acres in size. To simplify administration of a wildlife habitat maintenance program, these blocks should be 40 acre legal sub-divisions.

6.2 Considerations For Habitat Maintenance Resulting From The Conclusions

1) If an easement program was undertaken, private lands should be contracted to an easement for a period of no less than 5 years in order to maximize wildlife production benefits.

2) If an easement program was undertaken, no burning, draining, haying, grazing or disturbance of vegetation or landform should be allowed on private lands under easement.

3) If an easement program was undertaken, any land treatment and seeding necessary on blocks of private land under easement should be carried out by the legal landowner, where he agrees to do so, for an acceptable price.

4) If an easement program was undertaken, monitoring of lands under easement should be done to determine the effects of habitat manipulation on waterfowl production, the vegetative mixes that produce optimal cover on different soil types, when cover conditions necessitate further manipulation, and if landowners are adhering to the stipulations of the easement contract.

5) Further research should be conducted to outline all factors which should be included in such a program from a legal standpoint including terms of the contract,

etc. In addition an investigation into the possibility of an annual easement with an option to purchase clause would be useful.

6) Further research should be conducted to define a system for estimating easement payments of land unit types other than croplands (native haylands, forage croplands, arable bushlands and wetlands) according to their capability to produce agricultural products and using the opportunity cost of a cropland easement as a base.

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Appendix 1 a. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. -50%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	0.78	9.91	11.93	13.88	15.91	17.86	19.89	21.92	23.87	25.90	27.85	29.87
Oats	0.31	7.38	8.87	10.32	11.81	13.27	14.76	16.24	17.70	19.19	20.65	22.13
Barley	0.49	9.07	10.93	12.74	14.55	16.37	18.18	19.99	21.81	23.62	25.43	27.29
Flax	1.37	7.67	9.18	10.69	12.33	13.84	15.34	16.85	18.36	20.00	21.51	23.02
Rye	0.52	5.67	6.76	7.90	9.05	10.14	11.28	12.43	13.52	14.66	15.81	16.95
Mixed g.	0.40	8.32	10.00	11.64	13.32	14.96	16.64	18.32	19.96	21.64	23.28	24.96
Rape	1.20	11.04	13.32	15.48	17.76	19.92	22.20	24.48	26.64	28.92	31.08	33.36
Tame h.	9.01	9.01	10.90	12.70	14.51	16.31	18.11	19.91	21.71	23.52	25.32	27.21
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1 b. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. -40%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	0.94	11.94	14.38	16.73	19.18	21.53	23.97	26.41	28.76	31.21	33.56	36.00
Oats	0.38	9.04	10.87	12.65	14.48	16.26	18.09	19.91	21.70	23.52	25.31	27.13
Barley	0.59	10.92	13.16	15.34	17.52	19.71	21.89	24.07	26.26	28.44	30.62	32.86
Flax	1.65	9.24	11.06	12.87	14.85	16.67	18.48	20.30	22.11	24.09	25.91	27.72
Rye	0.63	6.87	8.19	9.58	10.96	12.29	13.67	15.06	16.38	17.77	19.15	20.54
Mixed g.	0.48	9.98	12.00	13.97	15.98	17.95	19.97	21.98	23.95	25.97	27.94	29.95
Rape	1.45	13.34	16.10	18.71	21.46	24.07	26.83	29.58	32.19	34.95	37.56	40.31
Tame h.	10.81	10.81	13.08	15.24	17.40	19.57	21.73	23.89	26.05	28.21	30.38	32.65
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1 c. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. -30%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	1.10	13.97	16.83	19.58	22.44	25.19	28.05	30.91	33.66	36.52	39.27	42.13
Oats	0.44	10.47	12.58	14.65	16.76	18.83	20.94	23.06	25.12	27.24	29.30	31.42
Barley	0.69	12.77	15.39	17.94	20.49	23.05	25.60	28.15	30.71	33.25	35.81	38.43
Flax	1.92	10.75	12.86	14.98	17.28	19.39	21.50	23.62	25.73	28.03	30.14	32.26
Rye	0.73	7.96	9.49	11.10	12.70	14.24	15.84	17.45	18.98	20.59	22.19	23.80
Mixed g.	0.56	11.65	14.00	16.30	18.65	20.94	23.30	25.65	27.94	30.30	32.59	34.94
Rape	1.69	15.55	18.76	21.80	25.01	28.05	31.27	34.48	37.52	40.73	43.77	46.98
Tame h.	12.61	12.61	15.26	17.78	20.30	22.82	25.35	27.87	30.39	32.91	35.43	38.08
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1 d. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. -20%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	1.26	16.00	19.28	22.43	25.70	28.85	32.13	35.41	38.56	41.83	44.98	48.26
Oats	0.50	11.90	14.30	16.65	19.05	21.40	23.80	26.20	28.55	30.95	33.30	35.70
Barley	0.78	14.43	17.39	20.28	23.17	26.05	28.94	31.82	34.71	37.60	40.48	43.45
Flax	2.20	12.32	14.74	17.16	19.80	22.22	24.64	27.06	29.48	32.12	34.54	36.96
Rye	0.84	9.16	10.92	12.77	14.62	16.38	18.23	20.08	21.84	23.69	25.54	27.38
Mixed g.	0.64	13.31	16.00	18.62	21.31	23.94	26.62	29.31	31.94	34.62	37.25	39.94
Rape	1.93	17.76	21.42	24.90	28.56	32.04	35.71	39.37	42.85	46.51	49.99	53.65
Tame h.	14.42	14.42	17.45	20.33	23.22	26.10	28.98	31.87	34.75	37.64	40.52	43.55
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1 e. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. -10%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	1.51	19.18	23.10	26.88	30.80	34.58	38.50	42.43	46.21	50.13	53.91	57.83
Oats	0.57	13.57	16.30	18.98	21.72	24.40	27.13	29.87	32.55	35.28	37.96	40.70
Barley	0.88	16.28	19.62	22.88	26.14	29.39	32.65	35.90	39.16	42.42	45.67	49.02
Flax	2.47	13.83	16.55	19.27	22.23	24.95	27.66	30.38	33.10	36.06	38.78	41.50
Rye	0.94	10.25	12.22	14.29	16.36	18.33	20.40	22.47	24.44	26.51	28.58	30.64
Mixed g.	0.72	14.98	18.00	20.95	23.98	26.93	29.95	32.98	35.93	38.95	41.90	44.93
Rape	2.17	19.96	24.09	27.99	32.12	36.02	40.15	44.27	48.17	52.30	56.20	60.33
Tame h.	16.22	16.22	19.63	22.87	26.11	29.36	32.60	35.85	39.09	42.33	45.58	48.98
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1 f. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg.	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	1.57	19.94	24.02	27.95	32.03	35.95	40.04	44.12	48.04	52.12	56.05	60.13
Oats	0.63	14.99	18.02	20.98	24.00	26.96	29.99	33.01	35.97	39.00	41.96	44.98
Barley	0.98	18.13	21.85	25.48	29.11	32.73	36.36	39.98	43.61	47.24	50.86	54.59
Flax	2.75	15.40	18.43	21.45	24.75	27.78	30.80	33.83	36.85	40.15	43.18	46.20
Rye	1.05	11.45	13.65	15.96	18.27	20.48	22.79	25.10	27.30	29.61	31.92	34.23
Mixed g.	0.80	16.64	20.00	23.28	26.64	29.92	33.28	36.64	39.92	43.28	46.56	49.92
Rape	2.41	22.17	26.75	31.09	35.67	40.01	44.59	49.16	53.50	58.08	62.42	67.00
Tame h.	18.02	18.02	21.80	25.41	29.01	32.62	36.22	39.82	43.43	47.03	50.64	54.42
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1 g. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. +10%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	1.73	21.97	26.47	30.79	35.29	39.62	44.12	48.61	52.94	57.44	61.76	66.26
Oats	0.69	16.42	19.73	22.98	26.29	29.53	32.84	36.16	39.40	42.71	45.95	49.27
Barley	1.08	19.98	24.08	28.08	32.08	36.07	40.07	44.06	48.06	52.06	56.05	60.16
Flax	3.03	16.97	20.30	23.63	27.27	30.60	33.94	37.27	40.60	44.24	47.57	50.90
Rye	1.16	12.64	15.08	17.63	20.18	22.62	25.17	27.72	30.16	32.71	35.26	37.82
Mixed g.	0.88	18.30	22.00	25.61	29.30	32.91	36.61	40.30	43.91	47.61	51.22	54.91
Rape	2.65	24.38	29.42	34.19	39.22	43.99	49.03	54.06	58.83	63.87	68.64	73.67
Tame h.	19.82	19.82	23.98	27.95	31.91	35.87	39.84	43.80	47.77	51.73	55.69	59.86
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1 h. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. +20%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	1.88	23.88	28.76	33.46	38.35	43.05	47.94	52.83	57.53	62.42	67.12	72.00
Oats	0.76	18.09	21.74	25.31	28.96	32.53	36.18	39.82	43.40	47.04	50.62	54.26
Barley	1.18	21.83	26.31	30.68	35.05	39.41	43.78	48.14	52.51	56.88	61.24	65.73
Flax	3.30	18.48	22.11	25.74	29.70	33.33	36.96	40.59	44.22	48.18	51.81	55.44
Rye	1.26	13.73	16.38	19.15	21.92	24.57	27.34	30.11	32.76	35.53	38.30	41.08
Mixed g.	0.96	19.97	24.00	27.94	31.97	35.90	39.94	43.97	47.90	51.94	55.87	59.90
Rape	2.89	26.59	32.08	37.28	42.77	47.97	53.47	58.96	64.16	69.65	74.85	80.34
Tame h.	21.62	21.62	26.16	30.48	34.81	39.13	43.46	47.78	52.10	56.43	60.75	65.29
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1 i. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. +30%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	2.04	25.91	31.21	36.31	41.62	46.72	52.02	57.32	62.42	67.73	72.83	78.13
Oats	0.82	19.52	23.45	27.31	31.24	35.10	39.03	42.97	46.82	50.76	54.61	58.55
Barley	1.27	23.50	28.32	33.02	37.72	42.42	47.12	51.82	56.52	61.21	65.91	70.74
Flax	3.58	20.05	23.99	27.92	32.22	36.16	40.10	44.03	47.97	52.27	56.21	60.14
Rye	1.37	14.93	17.81	20.82	23.84	26.72	29.73	32.74	35.62	38.63	41.65	44.66
Mixed g.	1.04	21.63	26.00	30.26	34.63	38.89	43.26	47.63	51.90	56.26	60.53	64.90
Rape	3.13	28.80	34.74	40.38	46.32	51.96	57.91	63.85	69.49	75.43	81.07	87.01
Tame h.	23.43	23.43	28.35	33.04	37.72	42.41	47.09	51.78	56.47	61.15	65.84	70.76
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 1 j. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. +40%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	2.20	27.94	33.66	39.16	44.88	50.38	56.10	61.82	67.32	73.04	78.54	84.26
Oats	0.88	20.94	25.17	29.30	33.53	37.66	41.89	46.11	50.25	54.47	58.61	62.83
Barley	1.37	25.35	30.55	35.62	40.69	45.76	50.83	55.90	60.97	66.03	71.10	76.31
Flax	3.85	21.56	25.80	30.03	34.65	38.89	43.12	47.36	51.59	56.21	60.45	64.68
Rye	1.47	16.02	19.11	22.34	25.58	28.67	31.90	35.13	38.22	41.45	44.69	47.92
Mixed g.	1.12	23.30	28.00	32.59	37.30	41.89	46.59	51.30	55.89	60.59	65.18	69.89
Rape	3.37	31.00	37.41	43.47	49.88	55.94	62.35	68.75	74.81	81.22	87.28	93.69
Tame h.	25.23	25.23	30.53	35.57	40.62	45.67	50.71	55.76	60.80	65.85	70.90	76.19
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

x

Appendix 1 k. Agricultural productivity ($) per acre for specified crops under alternate price and yield conditions.

Crop	Price	Yield										
	Avg. +50%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	2.36	29.97	36.11	42.01	48.14	54.04	60.18	66.32	72.22	78.35	84.25	90.39
Oats	0.95	22.61	27.17	31.64	36.20	40.66	45.22	49.78	54.25	58.81	63.27	67.83
Barley	1.47	27.20	32.78	38.22	43.66	49.10	54.54	59.98	65.42	70.85	76.29	81.88
Flax	4.13	23.13	27.67	32.21	37.17	41.71	46.26	50.80	55.34	60.30	64.84	69.38
Rye	1.58	17.22	20.54	24.02	27.49	30.81	34.29	37.76	41.08	44.56	48.03	51.51
Mixed g.	1.20	24.96	30.00	34.92	39.96	44.88	49.92	54.96	59.88	64.92	69.84	74.88
Rape	3.62	33.30	40.18	46.70	53.58	60.09	66.97	73.85	80.36	87.24	93.76	100.64
Tame h.	27.03	27.03	32.71	38.11	43.52	48.92	54.33	59.74	65.14	70.55	75.95	81.63
Fallow	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 2 a. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. -50%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	0.78	2.53	3.05	3.54	4.06	4.56	5.08	5.60	6.10	6.61	7.11	7.63
Oats	15.49	0.31	1.14	1.37	1.60	1.83	2.06	2.29	2.52	2.74	2.97	3.20	3.43
Barley	8.49	0.49	0.77	0.93	1.08	1.24	1.39	1.54	1.70	1.85	2.01	2.16	2.32
Flax	5.28	1.37	0.40	0.48	0.56	0.65	0.73	0.81	0.89	0.97	1.06	1.14	1.22
Rye	1.48	0.52	0.08	0.10	0.12	0.13	0.15	0.17	0.18	0.20	0.22	0.23	0.25
Mixed g.	2.05	0.40	0.17	0.21	0.24	0.27	0.31	0.34	0.38	0.41	0.44	0.48	0.51
Rape	2.24	1.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
Tame h.	9.14	9.01	0.82	1.00	1.16	1.33	1.49	1.66	1.82	1.98	2.15	2.31	2.49
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	6.16	7.44	8.65	9.91	11.14	12.39	13.64	14.85	16.11	17.33	18.60

Appendix 2 b. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. -40%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	0.94	3.05	3.67	4.27	4.90	5.50	6.12	6.75	7.35	7.97	8.57	9.19
Oats	15.49	0.38	1.40	1.68	1.96	2.24	2.52	2.80	3.08	3.36	3.64	3.92	4.20
Barley	8.49	0.59	0.93	1.12	1.30	1.49	1.67	1.86	2.04	2.23	2.41	2.60	2.79
Flax	5.28	1.65	0.49	0.58	0.68	0.78	0.88	0.98	1.07	1.17	1.27	1.37	1.46
Rye	1.48	0.63	0.10	0.12	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.30
Mixed g.	2.05	0.48	0.20	0.25	0.29	0.33	0.37	0.41	0.45	0.49	0.53	0.57	0.61
Rape	2.24	1.45	0.30	0.36	0.42	0.48	0.54	0.60	0.66	0.72	0.78	0.84	0.90
Tame h.	9.14	10.81	0.99	1.20	1.39	1.59	1.79	1.99	2.18	2.38	2.58	2.78	2.98
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	7.46	8.98	10.45	11.97	13.45	14.96	16.45	17.94	19.44	20.93	22.43

Appendix 2 c. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. -30%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	1.10	3.57	4.30	5.00	5.73	6.43	7.16	7.89	8.60	9.33	10.03	10.76
Oats	15.49	0.44	1.62	1.95	2.27	2.60	2.92	3.24	3.57	3.89	4.22	4.54	4.87
Barley	8.49	0.69	1.08	1.31	1.52	1.74	1.96	2.17	2.39	2.61	2.82	3.04	3.26
Flax	5.28	1.92	0.57	0.68	0.79	0.91	1.02	1.14	1.25	1.36	1.48	1.59	1.70
Rye	1.48	0.73	0.12	0.14	0.16	0.19	0.21	0.23	0.26	0.28	0.30	0.33	0.35
Mixed g.	2.05	0.56	0.24	0.29	0.33	0.38	0.43	0.48	0.53	0.57	0.62	0.67	0.72
Rape	2.24	1.69	0.35	0.42	0.49	0.56	0.63	0.70	0.77	0.84	0.91	0.98	1.05
Tame h.	9.14	12.61	1.15	1.39	1.63	1.86	2.09	2.32	2.55	2.78	3.01	3.24	3.48
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	8.70	10.48	12.19	13.97	15.69	17.44	19.21	20.93	22.69	24.42	26.19

Appendix 2 d. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. -20%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	1.26	4.09	4.92	5.73	6.56	7.37	8.21	9.04	9.85	10.68	11.49	12.33
Oats	15.49	0.50	1.84	2.22	2.58	2.95	3.31	3.69	4.06	4.42	4.79	5.16	5.53
Barley	8.49	0.78	1.23	1.48	1.72	1.97	2.21	2.46	2.70	2.95	3.19	3.44	3.69
Flax	5.28	2.20	0.65	0.78	0.91	1.05	1.17	1.30	1.43	1.56	1.70	1.82	1.95
Rye	1.48	0.84	0.14	0.16	0.19	0.22	0.24	0.27	0.30	0.32	0.35	0.38	0.41
Mixed g.	2.05	0.64	0.27	0.33	0.38	0.44	0.49	0.55	0.60	0.65	0.71	0.76	0.82
Rape	2.24	1.93	0.40	0.48	0.56	0.64	0.72	0.80	0.88	0.96	1.04	1.12	1.20
Tame h.	9.14	14.42	1.32	1.59	1.86	2.12	2.39	2.65	2.91	3.18	3.44	3.70	3.98
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	9.94	11.96	13.93	15.95	17.90	19.93	21.92	23.89	25.90	27.87	29.91

Appendix 2 e. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. -10%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	1.51	4.90	5.90	6.87	7.87	8.83	9.83	10.84	11.80	12.80	13.77	14.77
Oats	15.49	0.57	2.10	2.52	2.94	3.36	3.78	4.20	4.63	5.04	5.46	5.88	6.30
Barley	8.49	0.88	1.38	1.67	1.94	2.22	2.50	2.77	3.05	3.32	3.60	3.88	4.16
Flax	5.28	2.47	0.73	0.87	1.02	1.17	1.32	1.46	1.60	1.75	1.90	2.05	2.19
Rye	1.48	0.94	0.15	0.18	0.21	0.24	0.27	0.30	0.33	0.36	0.39	0.42	0.45
Mixed g.	2.05	0.72	0.31	0.37	0.43	0.49	0.55	0.61	0.68	0.74	0.80	0.86	0.92
Rape	2.24	2.17	0.45	0.54	0.63	0.72	0.81	0.90	0.99	1.08	1.17	1.26	1.35
Tame h.	9.14	16.22	1.48	1.79	2.09	2.39	2.68	2.98	3.28	3.57	3.87	4.17	4.48
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	11.50	13.84	16.13	18.46	20.74	23.05	25.40	27.66	29.99	32.29	34.62

Appendix 2 f. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price						Yield					
Crop	Percent	Avg.	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	1.57	5.09	6.13	7.14	8.18	9.18	10.23	11.27	12.27	13.31	14.32	15.36
Oats	15.49	0.63	2.32	2.79	3.25	3.72	4.18	4.65	5.11	5.57	6.04	6.50	6.97
Barley	8.49	0.98	1.54	1.86	2.16	2.47	2.78	3.09	3.39	3.70	4.01	4.32	4.63
Flax	5.28	2.75	0.81	0.97	1.13	1.31	1.47	1.63	1.79	1.95	2.12	2.28	2.44
Rye	1.48	1.05	0.17	0.20	0.24	0.27	0.30	0.34	0.37	0.40	0.44	0.47	0.51
Mixed g.	2.05	0.80	0.34	0.41	0.48	0.55	0.61	0.68	0.75	0.82	0.89	0.95	1.02
Rape	2.24	2.41	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50
Tame h.	9.14	18.02	1.65	1.99	2.32	2.65	2.98	3.31	3.64	3.97	4.30	4.63	4.97
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	12.42	14.95	17.42	19.95	22.40	24.93	27.42	29.88	32.41	34.87	37.40

Appendix 2 g. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. +10%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	1.73	5.61	6.76	7.86	9.01	10.12	11.27	12.41	13.52	14.67	15.77	16.92
Oats	15.49	0.69	2.54	3.06	3.56	4.07	4.57	5.09	5.60	6.10	6.62	7.12	7.63
Barley	8.49	1.08	1.70	2.04	2.38	2.72	3.06	3.40	3.74	4.08	4.42	4.76	5.11
Flax	5.28	3.03	0.90	1.07	1.25	1.44	1.62	1.79	1.97	2.14	2.34	2.51	2.69
Rye	1.48	1.16	0.19	0.22	0.26	0.30	0.33	0.37	0.41	0.45	0.48	0.52	0.56
Mixed g.	2.05	0.88	0.38	0.45	0.53	0.60	0.67	0.75	0.83	0.90	0.98	1.05	1.13
Rape	2.24	2.65	0.55	0.66	0.77	0.88	0.99	1.10	1.21	1.32	1.43	1.54	1.65
Tame h.	9.14	19.82	1.81	2.19	2.55	2.92	3.28	3.64	4.00	4.37	4.73	5.09	5.47
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	13.68	16.45	19.16	21.94	24.64	27.41	30.17	32.88	35.67	38.36	41.16

Appendix 2 h. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. +20%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	1.88	6.10	7.35	8.55	9.79	10.99	12.24	13.49	14.69	15.94	17.14	18.39
Oats	15.49	0.76	2.80	3.37	3.92	4.49	5.04	5.60	6.17	6.72	7.29	7.84	8.40
Barley	8.49	1.18	1.85	2.23	2.60	2.98	3.35	3.72	4.09	4.46	4.83	5.20	5.58
Flax	5.28	3.30	0.98	1.17	1.36	1.57	1.76	1.95	2.14	2.33	2.54	2.74	2.93
Rye	1.48	1.26	0.20	0.24	0.28	0.32	0.36	0.40	0.45	0.48	0.53	0.57	0.61
Mixed g.	2.05	0.96	0.41	0.49	0.57	0.66	0.74	0.82	0.90	0.98	1.06	1.15	1.23
Rape	2.24	2.89	0.60	0.72	0.84	0.96	1.07	1.20	1.32	1.44	1.56	1.68	1.80
Tame h.	9.14	21.62	1.98	2.39	2.79	3.18	3.58	3.97	4.37	4.76	5.16	5.55	5.97
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	14.92	17.96	20.91	23.95	26.89	29.90	32.93	35.86	38.91	41.87	44.91

Appendix 2 i. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. +30%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	2.04	6.62	7.97	9.27	10.63	11.93	13.29	14.64	15.94	17.30	18.60	19.95
Oats	15.49	0.82	3.02	3.63	4.23	4.84	5.44	6.05	6.66	7.25	7.86	8.46	9.07
Barley	8.49	1.27	2.00	2.40	2.80	3.20	3.60	4.00	4.40	4.80	5.20	5.60	6.01
Flax	5.28	3.58	1.06	1.27	1.47	1.70	1.91	2.12	2.32	2.53	2.76	2.97	3.18
Rye	1.48	1.37	0.22	0.26	0.31	0.35	0.40	0.44	0.48	0.53	0.57	0.62	0.66
Mixed g.	2.05	1.04	0.44	0.53	0.62	0.71	0.80	0.89	0.98	1.06	1.15	1.24	1.33
Rape	2.24	3.13	0.65	0.78	0.90	1.04	1.16	1.30	1.43	1.56	1.69	1.82	1.95
Tame h.	9.14	23.43	2.14	2.59	3.02	3.45	3.88	4.30	4.73	5.16	5.59	6.02	6.47
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	16.15	19.43	22.62	25.92	29.12	32.39	35.64	38.83	42.12	45.33	48.62

Appendix 2 j. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. +40%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	2.20	7.14	8.60	10.00	11.46	12.87	14.33	15.79	17.19	18.65	20.06	21.52
Oats	15.49	0.88	3.24	3.90	4.54	5.19	5.83	6.49	7.14	7.78	8.44	9.08	9.73
Barley	8.49	1.37	2.15	2.59	3.02	3.45	3.89	4.32	4.75	5.18	5.61	6.04	6.48
Flax	5.28	3.85	1.14	1.36	1.59	1.83	2.05	2.28	2.50	2.72	2.97	3.19	3.42
Rye	1.48	1.47	0.24	0.28	0.33	0.38	0.42	0.47	0.52	0.57	0.61	0.66	0.71
Mixed g.	2.05	1.12	0.48	0.57	0.67	0.76	0.86	0.96	1.05	1.15	1.24	1.34	1.43
Rape	2.24	3.37	0.69	0.84	0.97	1.12	1.25	1.40	1.54	1.68	1.82	1.96	2.10
Tame h.	9.14	25.23	2.31	2.79	3.25	3.71	4.17	4.63	5.10	5.56	6.02	6.48	6.96
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	17.39	20.93	24.37	27.90	31.34	34.88	38.39	41.83	45.36	48.81	52.35

Appendix 2 k. Agricultural productivity ($) per composite acre under alternate price and yield conditions.

Crop type and percent of composite acre		Price	Yield										
Crop	Percent	Avg. +50%	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Wheat	25.54	2.36	7.65	9.22	10.73	12.29	13.80	15.37	16.94	18.44	20.01	21.52	23.09
Oats	15.49	0.95	3.50	4.21	4.90	5.61	6.30	7.00	7.71	8.40	9.11	9.80	10.51
Barley	8.49	1.47	2.31	2.78	3.24	3.71	4.17	4.63	5.09	5.55	6.02	6.48	6.95
Flax	5.28	4.13	1.22	1.46	1.70	1.96	2.20	2.44	2.68	2.92	3.18	3.42	3.66
Rye	1.48	1.58	0.25	0.30	0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76
Mixed g.	2.05	1.20	0.51	0.62	0.72	0.82	0.92	1.02	1.13	1.23	1.33	1.43	1.54
Rape	2.24	3.62	0.75	0.90	1.05	1.20	1.35	1.50	1.65	1.80	1.95	2.10	2.25
Tame h.	9.14	27.03	2.47	2.99	3.48	3.98	4.47	4.97	5.46	5.95	6.45	6.94	7.46
Fallow	30.29	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.00	-	18.66	22.48	26.18	29.98	33.67	37.44	41.22	44.90	48.71	52.40	56.22

Appendix 3 a. Profits ($) per composite acre(soil type 1, farm size 1) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-18.68	-17.40	-16.19	-14.93	-13.70	-12.45	-11.20	-9.99	-8.73	-7.51	-6.24
Avg.-40%	-17.38	-15.86	-14.39	-12.87	-11.39	- 9.88	- 8.39	-6.90	-5.40	-3.91	-2.41
Avg.-30%	-16.14	-14.36	-12.65	-10.87	- 9.15	- 7.40	- 5.63	-3.91	-2.15	-0.42	1.35
Avg.-20%	-14.90	-12.88	-10.91	- 8.89	- 6.94	- 4.91	- 2.92	-0.95	1.06	3.03	5.07
Avg.-10%	-13.34	-11.00	- 8.71	- 6.38	- 4.10	- 1.79	0.56	2.82	5.15	7.45	9.78
Avg.	-12.42	- 9.89	- 7.42	- 4.89	- 2.44	0.09	2.58	5.04	7.57	10.03	12.56
Avg.+10%	-11.16	- 8.39	- 5.68	- 2.90	- 0.20	2.57	5.33	8.04	10.83	13.52	16.32
Avg.+20%	- 9.92	- 6.88	- 3.93	- 0.89	2.05	5.06	8.09	11.02	14.07	17.03	20.07
Avg.+30%	- 8.69	- 5.41	- 2.22	1.08	4.28	7.55	10.80	13.99	17.28	20.49	23.78
Avg.+40%	- 7.45	- 3.91	- 0.47	3.06	6.50	10.04	13.55	16.99	20.52	23.97	27.51
Avg.+50%	- 6.18	- 2.36	1.34	5.14	8.83	12.60	16.38	20.06	23.87	27.56	31.38

Appendix 3 b. Profits ($) per composite acre(soil type 1, farm size 2) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-13.62	-12.34	-11.13	-9.87	-8.64	-7.39	-6.14	-4.93	-3.67	-2.45	-1.18
Avg.-40%	-12.32	-10.80	- 9.33	-7.81	-6.33	-4.82	-3.33	-1.84	-0.34	1.15	2.65
Avg.-30%	-11.08	- 9.30	- 7.59	-5.81	-4.09	-2.34	-0.57	1.15	2.91	4.64	6.41
Avg.-20%	- 9.84	- 7.82	- 5.85	-3.83	-1.88	0.15	2.14	4.11	6.12	8.09	10.13
Avg.-10%	- 8.28	- 5.94	- 3.65	-1.32	0.96	3.27	5.62	7.88	10.21	12.51	14.84
Avg.	- 7.36	- 4.83	- 2.36	0.17	2.62	5.15	7.64	10.10	12.63	15.09	17.62
Avg.+10%	- 6.10	- 3.33	- 0.62	2.16	4.86	7.63	10.39	13.10	15.89	18.58	21.38
Avg.+20%	- 4.86	- 1.82	1.13	4.17	7.11	10.12	13.15	16.08	19.13	22.09	25.13
Avg.+30%	- 3.63	- 0.35	2.84	6.14	9.34	12.61	15.86	19.05	22.34	25.55	28.84
Avg.+40%	- 2.39	1.15	4.59	8.12	11.56	15.10	18.61	22.05	25.58	29.03	32.57
Avg.+50%	- 1.12	2.70	6.40	10.20	13.89	17.66	21.44	25.12	28.93	32.62	36.44

Appendix 3 c. Profits ($) per composite acre(soil type 1, farm size 3) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-11.60	-10.32	-9.11	-7.85	-6.62	-5.37	-4.12	-2.91	-1.65	-0.43	0.84
Avg.-40%	-10.30	- 8.78	-7.31	-5.79	-4.31	-2.80	-1.31	0.18	1.68	3.17	4.67
Avg.-30%	- 9.06	- 7.28	-5.57	-3.79	-2.07	-0.32	1.45	3.17	4.93	6.66	8.43
Avg.-20%	- 7.82	- 5.80	-3.83	-1.81	0.14	2.17	4.16	6.13	8.14	10.11	12.15
Avg.-10%	- 6.26	- 3.92	-1.63	0.70	2.98	5.29	7.64	9.90	12.23	14.53	16.86
Avg.	- 5.34	- 2.81	-0.34	2.19	4.64	7.17	9.66	12.12	14.65	17.11	19.64
Avg.+10%	- 4.08	- 1.31	1.40	4.18	6.88	9.65	12.41	15.12	17.91	20.60	23.40
Avg.+20%	- 2.84	0.20	3.15	6.19	9.13	12.14	15.17	18.10	21.15	24.11	27.15
Avg.+30%	- 1.61	1.67	4.86	8.16	11.36	14.63	17.88	21.07	24.36	27.57	30.86
Avg.+40%	- 0.37	3.17	6.61	10.14	13.58	17.12	20.63	24.07	27.60	31.05	34.59
Avg.+50%	0.90	4.72	8.42	12.22	15.91	19.68	23.46	27.14	30.95	34.64	38.46

Appendix 3 d. Profits ($) per composite acre(soil type 2, farm size 1) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-20.16	-18.88	-17.67	-16.41	-15.18	-13.93	-12.68	-11.47	-10.21	-8.99	-7.72
Avg.-40%	-18.86	-17.34	-15.87	-14.35	-12.87	-11.36	- 9.87	- 8.38	- 6.88	-5.39	-3.89
Avg.-30%	-17.62	-15.84	-14.13	-12.35	-10.63	- 8.88	- 7.11	- 5.39	- 3.63	-1.90	-0.13
Avg.-20%	-16.38	-14.36	-12.39	-10.37	- 8.42	- 6.39	- 4.40	- 2.43	- 0.42	1.55	3.59
Avg.-10%	-14.82	-12.48	-10.19	- 7.86	- 5.58	- 3.27	- 0.92	1.34	3.67	5.97	8.30
Avg.	-13.90	-11.37	- 8.90	- 6.37	- 3.92	- 1.39	1.10	3.56	6.09	8.55	11.08
Avg.+10%	-12.64	- 9.87	- 7.16	- 4.38	- 1.68	1.09	3.85	6.56	9.35	12.04	14.84
Avg.+20%	-11.40	- 8.36	- 5.41	- 2.37	0.57	3.58	6.61	9.54	12.59	15.55	18.59
Avg.+30%	-10.17	- 6.89	- 3.70	- 0.40	2.80	6.07	9.32	12.51	15.80	19.01	22.30
Avg.+40%	- 8.92	- 5.39	- 1.95	1.58	5.02	8.56	12.07	15.51	19.04	22.49	26.03
Avg.+50%	- 7.66	- 3.84	- 0.14	3.66	7.35	11.12	14.90	18.58	22.39	26.08	29.90

Appendix 3 e. Profits ($) per composite acre(soil type 2, farm size 2) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-13.92	-12.64	-11.43	-10.17	-8.94	-7.69	-6.44	-5.23	-3.97	-2.75	-1.48
Avg.-40%	-12.62	-11.10	- 9.63	- 8.11	-6.63	-5.12	-3.63	-2.14	-0.64	0.85	2.35
Avg.-30%	-11.38	- 9.60	- 7.89	- 6.11	-4.39	-2.64	-0.87	0.85	2.61	4.34	6.11
Avg.-20%	-10.14	- 8.12	- 6.15	- 4.13	-2.18	-0.15	1.84	3.81	5.82	7.79	9.83
Avg.-10%	- 8.58	- 6.24	- 3.95	- 1.62	0.66	2.97	5.32	7.58	9.91	12.21	14.54
Avg.	- 7.66	- 5.13	- 2.66	- 0.13	2.32	4.85	7.34	9.80	12.33	14.79	17.32
Avg.+10%	- 6.40	- 3.63	- 0.92	1.86	4.56	7.33	10.09	12.80	15.59	18.28	21.08
Avg.+20%	- 5.16	- 2.12	0.83	3.87	6.81	9.82	12.85	15.78	18.83	21.79	24.83
Avg.+30%	- 3.93	- 0.65	2.54	5.84	9.04	12.31	15.56	18.75	22.04	25.25	28.54
Avg.+40%	- 2.69	0.85	4.29	7.82	11.26	14.80	18.31	21.75	25.28	28.73	32.27
Avg.+50%	- 1.42	2.40	6.10	9.90	13.59	17.36	21.14	24.82	28.63	32.32	36.14

Appendix 3 f. Profits ($) per composite acre(soil type 2, farm size 3) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-11.92	-10.64	-9.43	-8.17	-6.94	-5.69	-4.44	-3.23	-1.97	-0.75	0.52
Avg.-40%	-10.62	-9.10	-7.63	-6.11	-4.63	-3.12	-1.63	-0.14	1.36	2.85	4.35
Avg.-30%	-9.38	-7.60	-5.89	-4.11	-2.39	-0.64	1.13	2.85	4.61	6.34	8.11
Avg.-20%	-8.14	-6.12	-4.15	-2.13	-0.18	1.85	3.84	5.81	7.82	9.79	11.83
Avg.-10%	-6.58	-4.24	-1.95	0.38	2.66	4.97	7.32	9.58	11.91	14.21	16.54
Avg.	-5.66	-3.13	-0.66	1.87	4.32	6.85	9.34	11.80	14.33	16.79	19.32
Avg.+10%	-4.40	-1.63	1.08	3.86	6.56	9.33	12.09	14.80	17.59	20.28	23.08
Avg.+20%	-3.16	-0.12	2.83	5.87	8.81	11.82	14.85	17.78	20.83	23.79	26.83
Avg.+30%	-1.93	1.35	4.54	7.84	11.04	14.31	17.56	20.75	24.04	27.25	30.54
Avg.+40%	-0.69	2.85	6.29	9.82	13.26	16.80	20.31	23.75	27.28	30.73	34.27
Avg.+50%	0.58	4.40	8.10	11.90	15.59	19.36	23.14	26.82	30.63	34.32	38.14

Appendix 4 a. Opportunity cost ($) per composite acre(soil type 1, farm size 1) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-11.36	-10.08	-8.87	-7.61	-6.38	-5.13	-3.88	-2.67	-1.41	-0.19	1.08
Avg.-40%	-10.06	- 8.54	-7.07	-5.55	-4.07	-2.56	-1.07	0.42	1.92	3.41	4.91
Avg.-30%	- 8.82	- 7.04	-5.33	-3.55	-1.83	-0.08	1.69	3.41	5.17	6.90	8.67
Avg.-20%	- 7.58	- 5.56	-3.59	-1.57	0.38	2.41	4.40	6.37	8.38	10.35	12.39
Avg.-10%	- 6.02	- 3.68	-1.39	0.94	3.22	5.53	7.88	10.14	12.47	14.77	17.10
Avg.	- 5.10	- 2.57	-0.10	2.43	4.88	7.41	9.90	12.36	14.89	17.35	19.88
Avg.+10%	- 3.84	- 1.07	1.64	4.42	7.12	9.89	12.65	15.36	18.15	20.84	23.64
Avg.+20%	- 2.60	0.44	3.39	6.43	9.37	12.38	15.41	18.34	21.39	24.35	27.39
Avg.+30%	- 1.37	1.91	5.10	8.40	11.60	14.87	18.12	21.31	24.60	27.81	31.10
Avg.+40%	- 0.13	3.41	6.85	10.38	13.82	17.36	20.87	24.31	27.84	31.29	34.83
Avg.+50%	1.14	4.96	8.66	12.46	16.15	19.92	23.70	27.38	31.19	34.88	38.70

Appendix 4 b. Opportunity cost ($) per composite acre(soil type 1, farm size 2) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-6.30	-5.02	-3.81	-2.55	-1.32	-0.07	1.18	2.39	3.65	4.87	6.14
Avg.-40%	-5.00	-3.48	-2.01	0.49	0.99	2.50	3.99	5.48	6.98	8.47	9.97
Avg.-30%	-3.76	-1.98	-0.27	1.51	3.23	4.98	6.75	8.47	10.23	11.96	13.73
Avg.-20%	-2.52	-0.50	1.47	3.49	5.44	7.47	9.46	11.43	13.44	15.41	17.45
Avg.-10%	-0.96	1.38	3.67	6.00	8.28	10.59	12.94	15.20	17.53	19.83	22.16
Avg.	-0.04	2.49	4.96	7.49	9.94	12.47	14.96	17.42	19.95	22.41	24.94
Avg.+10%	1.22	3.99	6.70	9.48	12.18	14.95	17.71	20.42	23.21	25.90	28.70
Avg.+20%	2.46	5.50	8.45	11.49	14.43	17.44	20.47	23.40	26.45	29.41	32.45
Avg.+30%	3.69	6.97	10.16	13.46	16.66	19.93	23.18	26.37	29.66	32.87	36.04
Avg.+40%	4.93	8.47	11.91	15.44	18.88	22.42	25.93	29.37	32.90	36.35	39.89
Avg.+50%	6.20	10.02	13.72	17.52	21.21	24.98	28.76	32.44	36.25	39.94	43.76

Appendix 4 c. Opportunity cost ($) per composite acre(soil type 1, farm size 3) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-4.28	-3.00	-1.79	-0.53	0.70	1.95	3.20	4.41	5.67	6.89	8.16
Avg.-40%	-2.98	-1.46	0.01	1.53	3.01	4.52	6.01	7.50	9.00	10.49	11.99
Avg.-30%	-1.74	0.04	1.75	3.53	5.25	7.00	8.77	10.49	12.25	13.98	15.75
Avg.-20%	-0.50	1.52	3.49	5.51	7.46	9.49	11.48	13.45	15.46	17.43	19.47
Avg.-10%	1.06	3.40	5.69	8.02	10.30	12.61	14.96	17.22	19.55	21.85	24.18
Avg.	1.98	4.51	6.98	9.51	11.96	14.49	16.98	19.44	21.97	24.43	26.96
Avg.+10%	3.24	6.01	8.72	11.50	14.20	16.97	19.73	22.44	25.23	27.92	30.72
Avg.+20%	4.48	7.52	10.47	13.51	16.45	19.46	22.49	25.42	28.47	31.43	34.47
Avg.+30%	5.71	8.99	12.18	15.48	18.68	21.95	25.20	28.39	31.68	34.89	38.18
Avg.+40%	6.95	10.49	13.93	17.46	20.90	24.44	27.95	31.39	34.92	38.37	41.91
Avg.+50%	8.22	12.04	15.74	19.54	23.23	27.00	30.78	34.46	38.27	41.96	45.78

Appendix 4 d. Opportunity cost ($) per composite acre(soil type 2, farm size 1) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-12.84	-11.56	-10.35	-9.09	-7.86	-6.61	-5.36	-4.15	-2.89	-1.67	-0.40
Avg.-40%	-11.54	-10.02	- 8.37	-7.03	-5.55	-4.04	-2.55	-1.06	0.44	1.93	3.43
Avg.-30%	-10.30	- 8.52	- 6.81	-5.03	-3.31	-1.56	0.21	1.93	3.69	5.42	7.19
Avg.-20%	- 9.06	- 7.04	- 5.07	-3.05	-1.10	0.93	2.92	4.89	6.90	8.87	10.91
Avg.-10%	- 7.50	- 5.16	- 2.87	-0.54	1.74	4.05	6.40	8.66	10.99	13.29	15.62
Avg.	- 6.58	- 4.05	- 1.58	0.95	3.40	5.93	8.42	10.88	13.41	15.87	18.40
Avg.+10%	- 5.32	- 2.55	0.16	2.94	5.64	8.41	11.17	13.88	16.67	19.36	22.16
Avg.+20%	- 4.08	- 1.04	1.91	4.95	7.89	10.99	13.93	16.86	19.91	22.87	25.91
Avg.+30%	- 2.85	0.43	3.62	6.92	10.12	13.39	16.64	19.83	23.12	26.33	29.62
Avg.+40%	- 1.61	1.93	5.37	8.90	12.34	15.88	19.39	22.83	26.36	29.81	33.35
Avg.+50%	- 0.34	3.48	7.18	10.98	14.67	18.44	22.22	25.90	29.71	33.40	37.22

Appendix 4 e. Opportunity cost ($) per composite acre(soil type 2, farm size 2) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-6.60	-5.32	-4.11	-2.85	-1.62	-0.37	0.88	2.09	3.35	4.57	5.84
Avg.-40%	-5.30	-3.78	-2.31	-0.79	0.69	2.20	3.69	5.18	6.68	8.17	9.67
Avg.-30%	-4.06	-2.28	-0.57	1.21	2.93	4.68	6.45	8.17	9.93	11.66	13.43
Avg.-20%	-2.82	-0.80	1.17	3.19	5.14	7.17	9.16	11.13	13.14	15.11	17.15
Avg.-10%	-1.26	1.08	3.37	5.70	7.98	10.29	12.64	14.90	17.23	19.53	21.86
Avg.	-0.34	2.19	4.66	7.19	9.64	12.17	14.66	17.12	19.65	22.11	24.64
Avg.+10%	0.92	3.69	6.40	9.18	11.88	14.65	17.41	20.12	22.91	25.60	28.40
Avg.+20%	2.16	5.20	8.15	11.19	14.13	17.14	20.17	23.10	26.15	29.11	32.15
Avg.+30%	3.39	6.67	9.86	13.16	16.36	19.63	22.88	26.07	29.36	32.57	35.86
Avg.+40%	4.63	8.17	11.61	15.14	18.58	22.12	25.63	29.07	32.60	36.05	39.59
Avg.+50%	5.90	9.72	13.42	17.22	20.91	24.68	28.46	32.14	35.95	39.64	43.46

Appendix 4 f. Opportunity cost ($) per composite acre(soil type 2, farm size 3) under alternate price and yield conditions.

Price	Yield										
	Avg. -50%	Avg. -40%	Avg. -30%	Avg. -20%	Avg. -10%	Avg.	Avg. +10%	Avg. +20%	Avg. +30%	Avg. +40%	Avg. +50%
Avg.-50%	-4.60	-3.32	-2.11	-0.85	0.38	1.63	2.88	4.09	5.35	6.57	7.84
Avg.-40%	-3.30	-1.78	-0.31	1.21	2.69	4.20	5.69	7.18	8.68	10.17	11.67
Avg.-30%	-2.06	-0.28	1.43	3.21	4.93	6.68	8.45	10.17	11.93	13.66	15.43
Avg.-20%	-0.82	1.20	3.17	5.19	7.14	9.17	11.16	13.13	15.14	17.11	19.15
Avg.-10%	0.74	3.08	5.37	7.70	9.98	12.29	14.64	16.90	19.23	21.53	23.86
Avg.	1.66	4.19	6.66	9.19	11.64	14.17	16.66	19.12	21.65	24.11	26.64
Avg.+10%	2.92	5.69	8.40	11.18	13.88	16.65	19.41	22.12	24.91	27.60	30.40
Avg.+20%	4.16	7.20	10.15	13.19	16.13	19.14	22.17	25.10	28.15	31.11	34.15
Avg.+30%	5.39	8.67	11.86	15.16	18.36	21.63	24.88	28.07	31.36	34.57	37.86
Avg.+40%	6.63	10.17	13.61	17.14	20.58	24.12	27.63	31.07	34.60	38.05	41.59
Avg.+50%	7.90	11.72	15.42	19.22	22.91	26.68	30.46	34.14	37.95	41.64	45.46

Appendix 5 a. Scientific names of waterfowl native to the Minnedosa pothole country.

Common name	Scientific name
mallard	Anas platyrhynchos
blue-winged teal	Anas discors
green-winged teal	Anas carolinensis
pintail	Anas acuta
gadwall	Anas strepera
American widgeon	Mareca americana
shoveler	Spatula clypeata
canvasback	Aythya valisineria
redhead	Aythya americana
lesser scaup	Aythya affinis
ruddy duck	Oxyura jamaicensis
ring-necked duck	Aythya collaris
bufflehead	Bucephala albeola
American goldeneye	Bucephala clangula
blackduck	Anas rubripes
white-winged scoter	Melanitta deglandi

Appendix 5 b. Scientific names of waterfowl predators of the central plains of North America.

Common name	Scientific name
raccoon	Procyon lotor
striped skunk	Mephitis mephitis
red fox	Vulpes fulva
badger	Taxidea taxus
mink	Mustela vison
short-tailed weasel	Mustela erminea
woodchuck	Marmota monax
Franklin's ground squirrel	Citellus franklinii
thirteen-lined ground squirrel	Citellus tridecemlineatus
crow	Corvus brachyrhynchos
magpie	Pica pica
marsh hawk	Circus cyaneus
dog	Canis familiaris