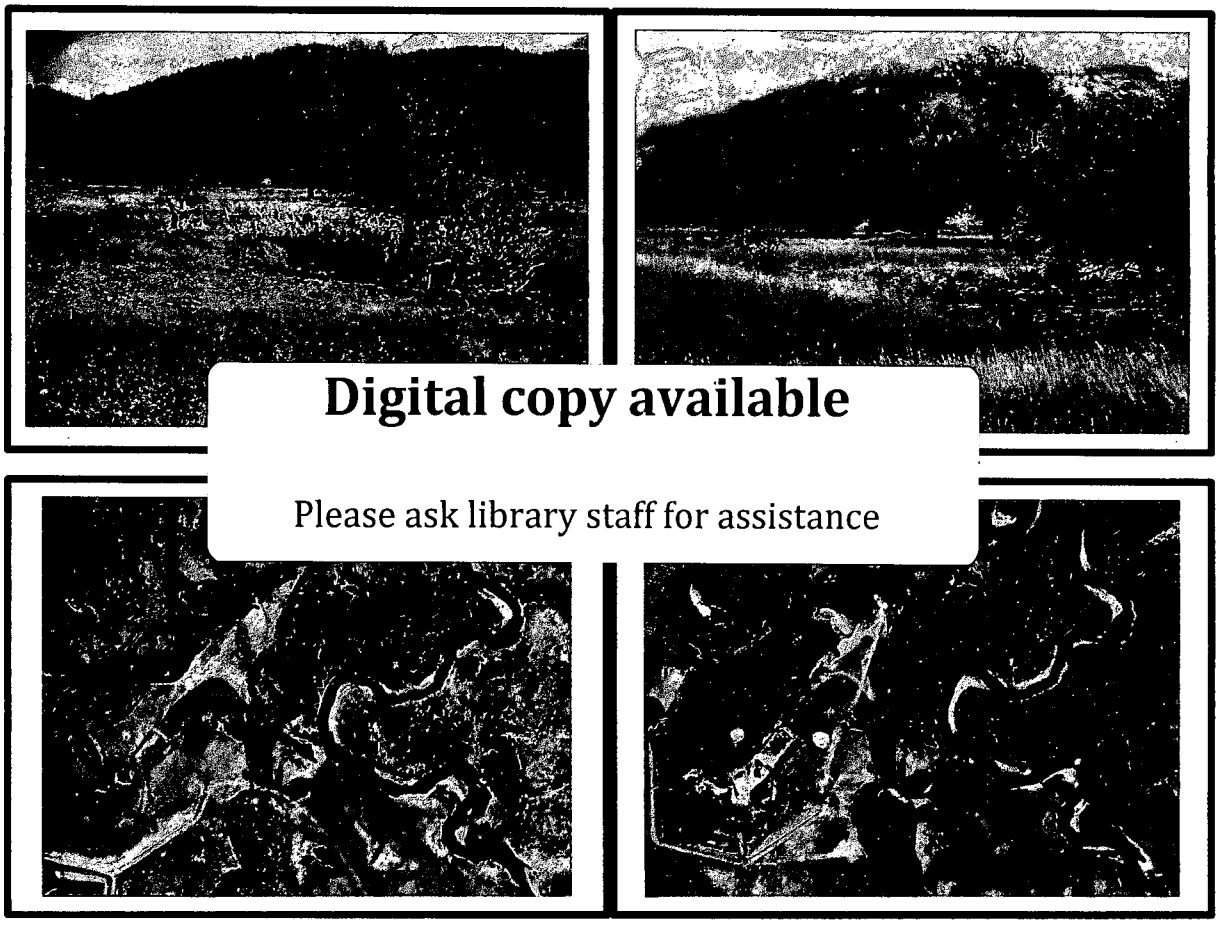
RESEARCH & MONITORING COMPONENTS OF THE INTERIOR WETLANDS PROGRAM, 1992 - 1998: A SUMMARY & SOME INTERPRETATIONS



prepared by

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for

Environment Canada
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ACKNOWLEDGMENTS

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INTRODUCTION

The Interior Wetlands Program (IWP) was a Fraser River Basin wetland conservation and stewardship initiative running from 1992 through 1998. It was established through an agreement between Environment Canada (Fraser River Action Plan) and Ducks Unlimited Canada. The program consisted of three major components: wetland-stewardship demonstration projects, project-evaluation/applied-research, and extension/education. The purpose of this report is to summarize the results of the project-evaluation/applied-research component, and to interpret those results in terms of the objectives of the IWP. Further, however, it provides recommendations for continuing studies or monitoring activities and application of the results of findings to date, giving attention to potential future programs similar to the IWP. This evaluation is based on a review of all research reports, discussions with researchers to clarify or expand upon specific points, and an inspection of photographs which had been taken to monitor changes at demonstration projects.

The objectives of the IWP were to:

- Promote land-use practices which result in:
    - robust wetland and upland vegetation for food, nesting and escape cover for waterfowl and other wildlife;
    - maintained and/or improved water quality and quantity;
    - sustained agriculture.
- Provide information required to optimize land management practices.
- Protect high-quality wildlife habitat from incompatible uses.

The primary purpose of the Research and Evaluation component of the IWP was to: "address questions related to the positive and negative impacts of various land management practices on watershed function, wildlife habitat and agricultural efficiency and sustainability." (Hennan 1993)

A list of potential research/evaluation studies identified at that time (1992) included:

- effects of winter livestock feeding on wetland vegetation;
- effects of various grazing regimes on forage production and ranching efficiencies and economics;
- effects of various grazing regimes on wetland, riparian and upland vegetation (species composition, biomass, community structure);
- effects of various grazing regimes on animal populations in the wetland/upland complex:

- waterfowl
- other birds
- small mammals
- amphibians and reptiles;

- potential for re-establishing native vegetation or habitats of preferred structure in heavily impacted riparian areas; and
- development and evaluation of monitoring procedures.

With respect to specific studies of waterfowl reproduction on grazed rangelands, it was suggested that the following might be investigated:

- density and distribution of nests of waterfowl in the areas of interest,
- nesting success,
- causes of failure to nest,
- causes of nest failure, and
- potential for improvements to nesting effort and success through modified land-use practices.

A number of the foregoing research/monitoring suggestions were addressed, at least in part, by activities subsequently conducted or supported by the IWP. The field research/monitoring activities partially or wholly funded by the IWP and documented herein include:

1. An assessment of waterbird breeding success in rangeland wetlands under a long-standing livestock grazing regime (Becher's Prairie).
2. An assessment of the response of grassland riparian habitats to livestock grazing exclusion as measured in terms of vegetation and populations of small mammals, birds, and herpetofauna (Hamilton, Lac du Bois). (A pre-cursor to long-term evaluation of the effects of specified grazing regimes on riparian habitats.)
3. An assessment of the effects of a specified grazing regime on riparian vegetation (Hamilton - Guichon).
4. An assessment of the maintenance or enhancement of stream-riparian vegetation (habitats) under controlled livestock grazing vs. grazing exclusion (Chutter Ranch). (Accompanied by an incidental wildlife inventory.)
5. An assessment of beef-cattle weight gains under a rotational grazing system designed to enhance a wetland landscape (130-Mile Ranch).
6. Evaluation of IWP demonstration projects (the application of a variety of wetland stewardship techniques) through aerial and/or ground photography used to assess changes in plant communities.

In addition to the foregoing field studies, four information-gathering /analysis projects were sponsored by the IWP:

7. "Preliminary Assessment of the Responses of Waterfowl Populations to Habitat Initiatives undertaken under the Interior Wetlands Program", by André Breault and Peter Watts.
8. "Economic Analysis of Investments in Range Improvements", by G. Cornelius van Kooten and Brad Stennes.
9. "Impacts of the Interior Wetlands Program: Report on a Survey of B.C. Ranchers", by Dovetail Consulting Inc.
10. "From a Bird's Eye View: an overview of selective Policy and Legislation to Identify Conservation Opportunities for Waterbirds in B.C.'s Wetlands and Associated Uplands", by Dovetail Consulting.

During the period of the IWP, 1992-1998, it was acknowledged that much of the information acquired would be baseline in nature. It was understood that, at demonstration projects, changes in land-use or land-management may or may not result in demonstrable changes to vegetation composition and structure during the 1 to 7 years of project existence. Similarly, some of the research studies only provided a "before" or early "post-management" picture of habitats, wildlife populations, or economic effects of land-management changes. Project monitoring activities and research studies were intended to be long-term in application to ensure ecologically meaningful conclusions. This report consists of a summary and interpretation of the findings to date; future observations should yield more significant insights into the relationships of land management practices, vegetation/habitat changes, wildlife responses, and economic benefits.

In the following sections, each research / monitoring project is interpreted, where appropriate, in terms of one or more of the following "questions":

- wildlife / habitat interrelationships (esp. waterbirds);
- methods of maintaining or restoring preferred wetland / riparian vegetation and habitats.;
- livestock grazing / range management and wetland, riparian and upland vegetation (species composition, biomass, structure);
- livestock grazing / range management and wildlife populations;
- livestock grazing / range management and forage production;
- livestock grazing / range management and rangeland health;
- livestock grazing / range management and the economics of ranching; and
- methods of monitoring the effects of wetland stewardship projects.

Table 1 shows which issues or questions were addressed by the studies conducted within the IWP.

Table 1. Questions addressed by the studies conducted by the IWP. (P indicates a primary issue addressed by the study; S indicates a secondary issue).

	STUDY*					
QUESTION	1	2	3	4	5	6
Habitat/wildlife relationships	**P**	**P**		S		
Wetland/riparian restoration	S	**P**	S	**P**		**P**
Range management/wetland-riparian vegetation	S	**P**	**P**	**P**		**P**
Range management/wildlife populations	S	**P**		S		
Range management/forage production		S	S	S	**P**	S
Range management/rangeland health		S	S	S	S	**P**
Range management/ranch economics				S	**P**	
Monitoring methods	S	S	S	S	S	S

*1 - Becher's Prairie; 2 - Hamilton; 3 - Guichon; 4 - Chutter; 5 - 130-Mile; 6 - Photos.

Although the major study results and conclusions (see "Major Findings to Date") are listed in the following sections by way of referencing subsequent interpretations, the reader is referred to the original reports for details of study sites, methodology, and results.

RESEARCH / MONITORING STUDIES

An assessment of waterbird habitat use and breeding success in rangeland wetlands under a long-standing livestock grazing regime (Becher's Prairie)

Purpose

This study was a component of a larger, ongoing, 10-year, research program designed "to investigate a complex of [forest, grassland and wetland] habitats with a diverse avifauna," ... to carry out "detailed studies of representative species, particularly concentrating on how they are affected by environmental (and particularly anthropogenic) change," ...to "understand the effects of humans on the biodiversity of the region" (Cooke *et al* 1997).

IWP support was based on the objectives of:

- documenting the use of the complex of ponds, lakes and surrounding grasslands and open forest areas by waterfowl during the pre-nesting, nesting and post-nesting periods;
- assessing reproductive success, survival, and dispersal patterns of representative waterfowl species;
- correlating bird habitat use and reproductive success with habitat variables, especially anthropogenically-induced habitat changes;
- determining the cause-effect relationships between habitat changes and bird use and reproductive success through controlled habitat manipulations.

Researcher

Dr. Fred Cooke, Wildlife Ecology Chair, Dept. of Biological Sciences, Simon Fraser University (SFU) was the general project manager. Researchers for various components of the project included:

Uli Steiner.....	Green-winged Teal
Barbara Pohl	Lesser Scaup
Sean Cullen	Eared Grebes
Saul Schneider	Barrow's Goldeneye

However, several others were involved in other related study components: Kari Nelson, Jonathan Thompson, Dr. John Eadie, Dr. Kathy Martin, and Dr. David Lank.

Funding

The IWP provided $40,000 in grants over two years (1995/6 and 1996/7). This not only enabled the IWP to direct a portion of the studies towards issues of relevance to its program objectives, but also served as a catalyst for the researchers to acquire 5-year funding from Forest Renewal BC for the larger biodiversity program.

Period of Study

1995 - 1996, and ongoing. Aspects of the research of ongoing interest to wetland conservation are being conducted, and reports have been prepared.

Major Findings to Date

The following is a summary of observations and conclusions drawn from research reports produced by the Wildlife Ecology Chair at SFU.

1995:

- Waterfowl pair counts were reliable in estimating nesting populations and can be correlated with the "cooperative waterfowl breeding pair surveys" for the region. Put another way, breeding waterfowl population trends for the area were adequately reflected in the replicated surveys of the 15 study ponds on Becher's Prairie.

- Most nests of ground-nesting ducks were found within 150 m of water, but some ducks nest at greater distances from water than anticipated.

- There was little correlation between numbers or species of broods seen and numbers of nests found (Table 2).

Table 2. Numbers of broods observed and nests found at study ponds at Riske Creek in 1996.

SPECIES	NESTS	BROODS
Mallard	1	4
Teal	10	1
American Wigeon	1	4
Northern Shoveler	1	0
Gadwall	2	3
Redhead	0	2
Canvasback	0	1
Scaup/Ringneck	4	2

- Nest success was very low.

- Ravens, black bears and coyotes were significant predators.

- Cattle seriously impacted emergent vegetation, but it was not determined that that impact influenced bird use of the wetland habitat.

- Researcher activities in emergent vegetation delayed nesting by eared grebes and affected pond use by other waterfowl.

- The presence of large numbers of coots reduced production by other waterfowl on a pond.

- Monitoring of grazing impacts on riparian and emergent vegetation is essential to assessing waterfowl / habitat relationships. Documentation of military activity in the area is essential if various land-use factors are to be appropriately related to waterbird use of the habitat.

- Cattle foraging and trampling destroyed up to 60% of wetland nesting habitat (emergent/riparian).

- Nest searches on five fenced ponds revealed that this method would not yield sufficient nest data for a meaningful comparison of fenced and unfenced ponds.

- The high failure rate (100%) for nesting green-winged teal may have been due to high predator pressure and/or poor vegetation cover. "Cattle grazing might result in shorter grass vegetation and therefore reduce potential nest sites or impair the nest site quality."

- Nests of 19 ground-nesting ducks were found in a search area of 670 ha (0.03 nests/ha). The nest density within 150 m of pond edges was 0.1 nests/ha.

- Almost all ring-necked duck and lesser scaup nests were found in taller grassland vegetation within fenced areas.

- The highest numbers of nests were found in areas with comparatively more sedge but little cattle impact.

1996/97:

In 1996, along with continued study of ground-nesting waterfowl, there was increased attention on cavity-nesting waterfowl and the nest cavity "nest web". Two of the seven redefined overall objectives for the waterbird studies were: (1) "making management suggestions regarding the exceptionally rich waterfowl community of this area, and" (2) "providing information useful in assessing the biological impact of discretionary forest vs. range land use of this region." The following points are taken directly from "Summary of Major Findings and Activities" (Cooke *et al* 1997).

- "The rich cavity nesting fauna in the Williams Lake area of the Cariboo-Chilcotin region includes 8 species of primary cavity nesters (all woodpeckers), 4 species of weakly excavating cavity nesters (nuthatch, chickadees), 20 secondary cavity nesting bird species (ducks, passerines and birds of prey), and 11 species of cavity-nesting mammals.

- Trembling aspen hosts 95% of the cavities used by hole-nesting birds on study plots in this region.

- Few cavities were excavated in Lodgepole Pine, the most abundant tree on our plots, or in other conifers.

- Two woodpecker species, flickers and red-naped sapsuckers, are "keystone" primary excavating species, providing 70% of the nest holes for other species.

- The abundances of primary and secondary cavity nester species were positively correlated among plots.

- Primary and secondary cavity nesting species were more abundant in more fragmented sites, and secondary cavity nesters more abundant in plots with a higher proportion of deciduous trees.

- A "nest web", analogous to a food web, operates and may be an important factor structuring forest bird communities.

- The rich waterfowl community using the Becher's Prairie/Riske Creek area generally has been stable for the past 17 years. However, surveys with sufficient power to detect trends as small as 5%/year show significant changes in seven of 18 species tallied, with increases in four and decreases in three species.

- In contrast to most of the cavity-nesting species, Barrow's goldeneye depends primarily on sparsely distributed pileated woodpeckers for natural nest sites.

- Barrow's goldeneye populations declined by ca. 5%/year. This change is probably directly attributable to earlier researchers' enhancement of the area through the provision of nest boxes, a lack of maintenance of those boxes after the completion of that study, and the collection of breeding females by another researcher towards the end of the census period, rather than reflecting changes in the availability of natural cavity nest sites.

- To gather information on individual movements, as an aid to interpreting population patterns, we captured and individually marked Barrow's goldeneye, bufflehead, lesser scaup, green-winged teal, and eared grebes, with combinations of nasal tags and radio transmitters. Except for documenting long-distance dispersal, nasal tags have proved to be the most useful and cost effective tool.

- Barrow's goldeneye females have a high rate of natal philopatry.

- Recruitment rates of goldeneyes appear to depend on duckling growth rates, which may be a function of pond productivity.

- Bufflehead, a secondary cavity nesting species, are ubiquitous, found in nearly all ponds at the study site.

- More scaup occur on larger, deeper, and more open ponds, but neither density nor brood number showed strong correlation with the degree of forest edge or other measured wetland properties.

- Green-winged teal prefer forested nest sites, and may have higher hatching success on ponds with forest-edges.

- In our first attempt to determine avian population structures in the Riske Creek area, we conclude that the eared grebe population is mobile within the region, and that it is not appropriate to treat each colony or pond as a separate population. This finding directly affects recommendations for management of the area with respect to waterfowl populations."

Interpretations Relative to IWP Objectives

1. Confirmation that the cooperative waterfowl breeding bird surveys do, in fact, reflect population trends on the study area, and vice-versa, indicates that, if methods remain consistent, either survey data set may be used to detect changes in waterfowl populations. Note, however, that because of "significant seasonal movements of waterfowl through the area throughout the season", ... "these data could produce quite noisy results if considered as reflective of breeding populations, especially in years with unusual phenology or nest predation regimes" (Cooke *et al* 1997). Conducting both levels of survey in any given year could help detect population shifts and their causes at the local level; that is, shifts which ***may*** be a consequence of changes in land management practices. For example, if regional populations are statistically unchanged between 2 years, but several of the study area ponds show increases in numbers, researchers would be led to examine habitat changes at those sites to determine whether a cause-effect relationship existed. The two levels of surveys should be continued in conjunction with other waterfowl-habitat/land-use research. They will be an important component in the experimental assessment of modified land-management practices such as grazing regimes and prescribed burning. Those surveys, should, however, be complemented by other monitoring procedures, such as nest searches, marked hens, and brood surveys, but only if those techniques prove successful. Waterfowl breeding-bird surveys at Becher's Prairie were best conducted between mid-May and early June. For long-term population assessment and detecting change, "it is important to always conduct the same number of surveys during the same period of time and the same time intervals."

Surveys used to detect population change do not necessarily reveal the causes for change, but they can trigger investigations to determine the causes. Declining populations can be related to off-site mortality as well as local recruitment failure resulting from poor habitat conditions, severe weather, or high predation. Recruitment failure can be manifested through failure to nest, nest failure, hen predation, and/or brood mortality.

2. American coot populations have increased at a rate of 31%/year in the Riske Creek area (Cooke *et al* 1997). Coots nest overwater on floating nests of aquatic plant material. Coots are strongly territorial and aggressive and can drive off other water birds, thereby reducing their local recruitment.

3. While some ground-nesting ducks, and some individual hens of other duck species used nesting sites at considerable distance from study ponds, most nests were within 150 m of water. That observation is consistent with general knowledge of waterfowl behaviour. In conjunction with the observation that nest success was very low in the study area, that information can be interpreted to suggest that:
    - if reasonably good habitat is available close to wetlands, ducks will tend to use it before going further into the uplands;
    - at time of nesting, the habitat was of adequate "quality" to attract breeders of those species, but inadequate to ensure their success;
    - there was a high density of waterfowl nest predators.

    At this point we do not know if "better-quality" habitat would have attracted more nesters and/or provided for higher nesting success. For some species (mallard, wigeon) brood observations indicated that either nests were not being found in the areas searched or that those species were nesting somewhere outside the search area (and, therefore, at very considerable distance from water).

    Green-winged teal, on the other hand, did nest in the forest understorey some distance from water, but experienced high predation loss: the ratio of nests to broods was 10:1.

4. Regional duck populations have been more-or-less stable over the past 17 years. "The community appears to be basically in equilibrium with current land use practices, with most species maintaining their populations at stable levels" (Cooke *et al* 1997). That suggests that the measures of nest success used to date may not be reflective of the true situation; i.e. the observed nest success implies a declining population. Green-winged teal were an exception to that interpretation: surveys have indicated a declining population while the nest and brood studies have revealed a low nesting success. Overall, however, a need for more accurate measures of nesting effort and success is implied.

5. The direct impact of cattle-trampling of emergent vegetation was obvious; however, assessment of bird use of ponds did not provide for detection of a link between the loss of

emergents and bird use. We do know, however, that the preferred nesting habitat for some species of waterfowl (e.g. canvasback, redhead, ruddy duck) is emergent vegetation, and that emergent vegetation is important in providing safe cover, especially for broods and moulting ducks. Therefore, it is probable that trampling of emergents would have reduced waterfowl nesting and recruitment. On the other hand, trampling of emergents could favour use by territorial males of some species of ducks, by resting ducks (seeking "loafing sites"), and by shorebirds. If increased diversity of habitats and wildlife species were an objective of management, then some cattle impact on emergent vegetation might be desirable.

6. In a comparison of 2 selected ponds, it was determined that cattle use (intensity and distribution) was very different from one pond to the other, and that different parts of the shoreline of a given pond received different levels of use. Cattle tended to concentrate on certain parts of the shoreline and avoid others (e.g. steep slopes).

7. The researchers suggest that properly documented and sufficient observations of breeding waterfowl on ponds could be used to determine the potential for impacts of disturbance (as by people or cattle) in terms of nest abandonment or increased nest predation. Cattle use of the areas in and around wetlands should be monitored in conjunction with waterfowl studies, as was done during the reported period. However, the distribution and intensity of site use by cattle should be related to the overall grazing strategy for the area (timing, duration, and numbers). It may eventually be determined that different grazing regimes (e.g. spring grazing or fall grazing only) result in different cattle distribution, habitat structure, and waterfowl recruitment.

8. Waterbird life-cycle activities are closely related to the phenological development of their habitats (i.e. stage of plant growth). Researchers detected that research activities (nest searches) delayed nesting of eared grebes by about one week. Since the timing of nesting, hatching and moulting relative to habitat phenology was altered by disturbance, it may be safe to assume that recruitment of eared grebes was reduced. Other waterbird species -- while not nesting colonially or in numbers sufficient to allow for detection of impacts -- may have been similarly impacted. "Intrusive nest searches should be avoided, since breeding later in the season might cause a decreased rate of brood survival due to changing weather conditions, food availability, etc." Other consequences of researcher activity may be alteration of habitat structure and increased predation. Where research answers can be obtained by less intrusive means, such as observing marked hens, the latter methods would be preferred.

9. To meet IWP research objectives, the relationships between grazing regimes, various types of human activities (military, research, recreation), habitat structure, and waterfowl population dynamics must be clearly identified. From the information available, it is not clear that the grazing regime, the military activity, recreational activity, and the habitat structure

components are being adequately identified and documented. Weather data might also require closer examination when interpreting population dynamics. To date, only very general interpretations can be made from the data collected for ground-nesting waterfowl. For example:

- the highest number of nests were found in areas with comparatively more sedge, but with little cattle impact;
- almost all ring-necked ducks and lesser scaup nests were found in taller grassland vegetation within fenced (ungrazed) areas;
- there is a difference in the types of ponds used by breeding versus non-breeding scaup.

10. Nest searches at 5 fenced ponds revealed that there were insufficient nests (or that the search method yielded insufficient nests) for a meaningful comparison of fenced and unfenced ponds (35 being required). That conclusion is based on nests of all species combined; therefore, there would be an even greater insufficiency for any one species. That data insufficiency implies that in order to make comparisons of grazed and ungrazed wetland habitats, in terms of waterfowl nesting and recruitment, we must:
    - speculate on the basis of non-statistical data;
    - infuse sufficient resources (assuming enough comparative habitat is available) to increase the sample size; or
    - use a different methodology, such as behavioural studies involving marked birds.

11. The 100% nest failure for green-winged teal may have been due to high predator pressure and/or poor vegetative cover in the areas searched. "Cattle grazing might result in shorter grass vegetation and therefore reduce potential nest sites or impair the nest quality." These interpretations simply reflect the underlying premise for supporting research into rangeland management vis-à-vis waterfowl habitat and waterfowl recruitment. If we confirm that relationship between grazing practices and waterfowl recruitment, and establish means to enhance habitat and recruitment while simultaneously enhancing forage production, the program will have achieved at least that research goal. The current research should be designed to ensure that we can accept or reject that hypothesis, and allow us to predict land management benefits in terms of waterfowl and range health.

    If, as the data indicate, green-winged teal prefer forested nest sites, they may be "particularly sensitive to changes in forested habitat" (Cooke *et al* 1997). However, this apparent preference may be a consequence of the condition of grasslands in the immediate vicinity of study ponds. In fact, this author suspects that this apparent preference may be true of other ground-nesting dabblers as well. The fact that there are considerable numbers of broods observed on grassland ponds which have little cover in the immediate vicinity suggests that ducks are finding safe nest sites further away from wetlands in places too well concealed for predators (and researchers) to detect. At the same time, that interpretation still begs the

question: what waterfowl production could be achieved over large tracts of grassland where ground cover is relatively tall and dense (i.e. offering nest security)?

12. The prolonged pair-bond of green-winged teal during the nesting period implies a strong propensity to renest in response to poor first-nest success.

13. The decline in Barrow's goldeneye numbers (ca 5%/year over the past 17 years) at Becher's Prairie may be attributable to attrition of nest boxes since regular maintenance has ceased. That has obvious implications for the maintenance of Barrow's goldeneye populations throughout BC in light of:
    - other nest box initiatives,
    - timber harvesting guidelines,
    - range management practices, and
    - guidelines for protection and restoration of riparian habitats.

    The erection of nest boxes for restoring, maintaining, or increasing goldeneye populations should be well-considered at the outset and accompanied by a plan and commitment for long-term nest box maintenance. As Cooke *et al* (1997) point out, "the simple presence of birds in an area is not sufficient evidence that they are thriving. ...Both Barrow's goldeneye and bufflehead utilize ponds varying widely in their adjacent vegetation, ranging from fully forested to completely open. This range of occupancy is facilitated, especially for goldeneye, because a well established network of nest boxes decouples pond usage from the pattern of natural cavity availability, which would normally be determined by the distribution of riparian vegetation." However, to obviate both nest box erection and maintenance, it would be more prudent to maintain habitats -- deciduous, coniferous, and mixed-wood forests and riparian areas -- attractive to pileated woodpeckers. The study has shown that the "nest web" is a naturally-evolved ecological strategy, which, for the goldeneye, begins with the presence of pileated woodpeckers associated with such habitats. Further nest-web studies should help refine guidelines for maintaining the biologically complex nest web.

14. Data collected by MS student, Matt Evans, in 1997 suggests that Douglas fir figures highly in providing natural cavities for goldeneyes (25-30% of natural nest sites). Nest success was higher at natural sites than at boxes, although clutches were smaller (D. Lank, pers comm).

15. The 1995 / 96 data indicated that recruitment rates of goldeneyes may depend on duckling growth rates, which in turn, depend on wetland productivity. More recent results (Lank, pers comm) confirm that "duckling growth rate correlates positively with return rates, thus presumably juvenile survival rate, for goldeneye. It also looks as if we can link growth rate to measures of invertebrate abundance. ...it is clear that for goldeneye, some ponds will produce

'better' (faster growing and more likely to survive) ducklings than others" (Cooke *et al* 1997). Given the strong territoriality of goldeneyes, both intraspecific agonism and food supplies are factors to consider when trying to increase goldeneye production as by erecting nest boxes and/or increasing the amount of mature aspen in riparian areas.

16. The fact that eared grebes -- which appear to be much less mobile than many other waterfowl species -- do, in fact, utilize a "community" of ponds during the breeding season, reinforces the idea that a community of wetlands (perhaps with each providing different important habitat functions) is greater than the sum of its pond components in terms of waterfowl recruitment. In other words, isolated wetlands are not as productive as wetlands within complexes.

17. Systematic observation and recording of predators should be included in ongoing studies at Becher's Prairie.

18. Problems were experienced in attempts to use radio tags (telemetry) to track breeding goldeneye, bufflehead, and scaup to assess their use of the habitat. In many cases, radios were either quickly removed by the birds or the birds emigrated from the site. Nasal tags proved to be a much more effective tracking technique.

19. Forthcoming related reports/papers from the Riske Creek Research Station / SFU:

- Lougheed, L.A., A. Breault and D.B. Lank. Submitted Dec., 1997. Long-term population monitoring of waterfowl at Riske Creek. J. Wildlife Management.
- Martin, K. and J.M. Eadie. Accepted. Nest webs: a community wide approach to the management and conservation of cavity-nesting forest birds. Forest Ecology and Management.
- Cullen, S. MS. Habitat, local movements, and philopatry of eared grebes..
- Habitat, local movements, and philopatry of scaup and teal.
- Gurd, B. Habitat change through forest management: effects on waterfowl population dynamics at Chilco Ranch and Bald Mountain. This study, begun in 1997, is designed to yield background data on waterfowl populations vis-à-vis the habitat parameters of wetland hydrology and invertebrates, against which to assess impacts of logging practices.

Grazing impacts on the biodiversity of grassland riparian ecosystems (Hamilton Commonage/Lac du Bois)

Purpose

This study was designed to assess, first, the response of grassland riparian ecosystems to livestock grazing exclusion, and, at some future point, the response to prescribed grazing regimes. Response is to be measured in terms of vegetation, birds, small mammals, amphibians, and reptiles. The long-term goal is to be able to "delineate integrated management strategies [for livestock grazing] sustainable for indigenous riparian ecosystems" (van Woudenberg, 1997).

The purpose of this study was strongly aligned with the objectives of the IWP: providing information which promotes land-use practices which result in robust wetland and upland vegetation for food, nesting and escape cover for waterfowl and other wildlife; maintained and/or improved water quality and quantity; and sustained agriculture.

The data acquired in this study may be complemented by results of upland vegetation monitoring begun in 1996 by the Ministry of Forests (MOF) at nearby sites.

Researcher

The principal researcher was Astrid M. van Woudenberg. Initial direction for the study came from Dave Low, biologist with the Ministry of Environment, Lands and Parks (MELP), Kamloops. The research program was administered by the BC Conservation Foundation.

Funding

Initial funding came from the MELP, Habitat Conservation Trust Foundation. The IWP provided $154,400 over three years, 1993 to 1995. Further funding was provided by the Green Plan for Agriculture.

Period of Study

This was designed as a long-term study of 20 years or more. The 1992 - 1996 portion was Phase I. The study design and locations were determined in 1992. Study site layout and pre-treatment inventories were conducted during 1993 through 1995. Standardized sampling techniques were established by 1995, and riparian livestock exclosures were completed by 1995.

The researcher recommended repeat sampling within 5 years of Phase I, preferably beginning 1999, for 2 consecutive years, with subsequent sampling at approximately 5-year

intervals (van Woudenberg, pers comm). The purpose of repeat sampling is to monitor riparian community structure and determine when an indigenous community has become established; that is, when the rate of change of species composition (vegetation and fauna) levels off. It is understood that caution must be exercised in that determination; the indigenous community may be attained in stages as vegetative communities reach plateaus and faunal populations subsequently immigrate and become established.

Major Findings to Date

The following points are drawn from the Phase I report (van Woudenberg 1997). These are ***pre-treatment*** observations, that is, descriptions of plant and animal communities of the grassland riparian study sites under current grazing regimes.

- The condition of vegetation in the riparian areas at Hamilton Commonage and Lac du Bois study sites indicated that current grazing practices are ecologically unsustainable. Historically, an indigenous riparian shrub component was likely present at most study ponds but was not sustainable under historical grazing practices. Current grazing practices do not seem to be allowing for shrub regeneration. Most vegetation communities were dominated by a few (often "weedy") species of plants, and shrubs were restricted to a few small patches with little evidence of regeneration. At Lac du Bois, for example, baltic rush (*Juncus balticus*), thistle (*Cirsium sp*), scratchgrass *(Muhlenbergia asperifolia*), foxtail barley (*Hordeum jubatum*), and cheatgrass (*Bromus tectorum*) were indicative of overgrazing and/or disturbance in the riparian zone, while gooseberry (*Ribes lacustre*) and silverweed (*Potentilla anserina*) suggested less impact. "For long-term sustainability, management strategies should switch to prescriptions from pasture systems. Management prescriptions will consider plant physiology, terrain, and integrated resource management objectives." Wildlife objectives require careful attention to the timing of grazing.

- The following species were listed (van Woudenberg, 1997: 67-68) as indicators of grassland riparian condition (Table 3). These observations complement information available in Delesalle (1998).

Table 3. Some plants which serve as indicators of grassland riparian condition (after van Woudenberg, 1997).

COMMON NAME	SCIENTIFIC NAME	INDICATIONS
Early blue violet	*Viola adunca*	Disturbance
Canada thistle	*Cirsium arvense*	Disturbance
Yarrow	*Archillea millefolium*	Disturbance
Kentucky bluegrass	*Poa pratensis*	Overgrazing
Pussytoes	*Antennaria neglecta*	Overgrazing
Purple-leaved willowherb	*Epilobium ciliatum*	Disturbance/fluctuating water levels
Small bedstraw	*Galium triflorum*	Overgrazing
Beaked sedge	*Carex rostrata*	Moderate grazing
American brooklime	*Veronica americana*	Dense colonies indicate no trampling impact
Fleabanes & Daisies	*Erigeron spp*	Overgrazing
Baltic rush	*Juncus balticus*	*May* indicate heavy grazing
Foxtail barley	*Hordeum jubatum*	Moderate to heavy grazing
Water smartweed	*Polygonum amphibium*	*May* indicate disturbance

- Terrain surrounding ponds has considerable influence on livestock distribution throughout the riparian zone, and livestock distribution, in turn, influences soils, water movement, and vegetation. Cattle avoided steep slopes and wet riparian soils, tending to concentrate on gentler slopes and firm soils. "Trailing" on moderate to gentle slopes in riparian zones "likely resulted in significant soil compaction that altered the structure and composition of plant species and narrowed the riparian zone." Shrub-aspen complexes were more vulnerable to damage from trampling, grazing and rubbing when they were located in riparian areas versus elsewhere in the landscape.

- "The results suggest that at all ponds, cattle will likely prefer the riparian zone to the upland zone by midsummer when most upland forage species become unpalatable and micro-climates are more favourable in riparian zones. ...Disproportionate utilization of riparian habitats from midsummer until fall may account for the reduced abundance of shrub and aspen regeneration components that were detected and the high abundance of coarse woody debris accumulations. ...Mechanical damage to young trees and shoots of regenerating shrubs by congregating cattle can result in mortality (Kauffman and Krueger 1984). Furthermore, browsing new buds of growing, young trees and shrubs can be particularly inhibiting to height and girth development, reducing vigour (Skovlin 1984). Young shrubs and trees with few branches available for photosynthesis are likely less tolerant of browsing. Wildlife and cattle can both be responsible for browsing young shrubs and trees and the exclosures should provide information to delineate the sources of impact."

- Wildlife species diversity in riparian areas appears to be more dependent on vegetation structure than the species of plants present. Greater animal species diversity, but not necessarily animal abundance, was associated with the presence of a aspen-shrub component.

- Most species of birds and small mammals used riparian habitats more than uplands to meet their overall life requisites.

- For small mammals that exhibited a preference for riparian areas, when vegetation in those areas was relatively robust, animals were heavier than those trapped in upland sites.

- Birds were considered to be "generalists" if they were detected in a number of habitat types, or "specialists" if they tended to be detected in a single habitat type. Notably, there were some specialists (e.g. warblers and flycatchers) which were detected only in aspen-shrub complexes. Generalist species were less abundant in habitat patches occupied by specialists.

- At Lac du Bois, bird inventories indicated that species composition of bird communities may have changed during recent decades as a result in changes in vegetation. The implication is that forest encroachment, probably induced by fire suppression and modified grazing systems, has attracted forest-edge species that are not indigenous to grassland habitats. Expanding urbanization and increasing recreational activity are further confounding factors at Lac du Bois.

- Due to the large sampling effort required and the numbers of small mammals present, "individual ponds are likely not large enough to provide meaningful population numbers and trends." Rather, the sampling has provided "an inventory of small mammal species that occurred at ponds in each study site overall."

- Impacts of cattle trampling on pitfall traps, and cold spring weather (eliminating an effective auditory survey) precluded acquisition of good inventory data for herpetiles. The study efforts yielded presence/absence information only.

Interpretations Relative to IWP Objectives

1. The reported results are reflective of only the pre-treatment condition of grassland riparian areas. However, some very important conclusions have been drawn. The most significant of those is that, for grassland sites, at least some past grazing practices have been unsustainable; that is, they did not sustain the plant and animal communities that were indigenous to those sites. Further, under current, ongoing grazing systems, it does not appear that those sites can regenerate a full complement of indigenous plant and animal species. Exclosures, over time, may result in the re-establishment of a shrub-tree-grass-forb community with a more diverse fauna than currently exists.

2. Confirmation of the nature of livestock impacts on riparian areas affirms the need for extension/education programs such as that carried out within the IWP. However, we have yet to discover what to expect when those grassland riparian areas are relieved of livestock grazing pressure, what our options are for ***restoring*** indigenous communities (e.g. total exclosure, modified grazing systems, plantings, weed control, etc), and how to manage grazing to ***maintain*** revitalized riparian ecosystems. As these studies proceed (presuming they will), ecosystem objectives should be defined, and management prescribed to most effectively meet those objectives.

3. Management prescriptions must be site specific. The Douglas Lake Cattle Co. component of the study area at Hamilton Commonage was subject to continuous, season-long grazing by horses and cattle. However, because the pasture was large and livestock numbers sufficiently small, and because the pasture contained "several patches of deciduous, coniferous, and deciduous-coniferous mixed stands, providing livestock with plenty of thermal regulating opportunities during the dry, hot summer period", ponds in that area experienced the least (but not necessarily ecologically sustainable) impact from livestock.

   Timing will be a critical component of any grazing system. Where riparian communities are in good condition, moderate spring grazing may be an appropriate practice because upland forage may be at its best and keep grazing pressure off the riparian areas. On the other hand, where riparian areas have been heavily impacted, it may be necessary to totally rest a pasture through one or more growing seasons so allow for plant re-establishment and animal re-colonization. Again, where riparian habitats are robust, light to moderate fall grazing, leaving a "good" supply of residual vegetation, may serve to maintain a properly functioning riparian ecosystem. In the arid Interior, it is unlikely that grasslands can sustain more than light

summer (July - September) grazing without causing deterioration of riparian plant and animal communities.

4. Not only is there a greater diversity of wildlife in healthy riparian areas, it appears that individual animals fare better (are heavier and have a higher survival rate) when that habitat is in good condition. That observation parallels conclusions drawn about goldeneye ducks at Becher's Prairie: survival is higher for ducklings raised on ponds with abundant food. While that relationship might seem axiomatic, we do need to be reminded to consider all aspects of the wetland landscape in order to meet the life requisites of a given species.

5. Good inventories of small mammals and herpetiles are obviously difficult to obtain, but necessary if we are eventually to have a comprehensive ecological picture of grassland riparian ecosystems. The experiences of the researchers in trying to obtain such data should be used to develop more effective inventory methods.

6. As was noted for Becher's Prairie, researchers should undertake systematic observations and recording of non-target wildlife species (e.g. grazing ungulates, mammalian predators, etc) in conjunction with their specific population studies.

7. While some interesting observations and interpretations have been drawn from Phase I of this study, its greatest values are yet to be realized -- in the periodic monitoring that lies ahead and the experimental grazing regimes that are to follow the establishment of persistent plant/animal communities within the exclosures.

8. It would be valuable, but perhaps inappropriate from a researcher-impact perspective, to conduct waterfowl recruitment studies at the Hamilton/Lac du Bois sites, paralleling those at Becher's Prairie. No waterfowl nests were found in the Hamilton/Lac du Bois study plots. It would be of considerable interest to see if ducks start to nest in the exclosures and to assess their nesting success.

An assessment of the effects of a specified grazing regime on riparian vegetation (Hamilton - Guichon)

Purpose

In renewing its grazing license in 1993 for the Hamilton Range Unit, the Gerard Guichon Ranch proposed a "new" grazing system of relatively short-duration/high intensity based on Holistic Resource Management principles (Savory 1988). The Merritt District office of MOF-Range, with input from the MELP, approved the proposed system on the condition that grazing impacts on range condition would be monitored by the licensee, that biodiversity would be maintained, and that the vegetation would progress toward good to excellent range condition (later

understood to imply "the desired plant community"). It was determined that 3 monitoring sites would be appropriate, representative of ecosystems common to the Range Unit: grasslands, aspen copses, and riparian areas.

Among numerous specified conditions of the license were the following:

- "livestock must be managed away from riparian areas";
- "not more than 10% of the current years shoots will be removed from shrubs by domestic livestock. ...aspen regeneration within existing aspen groves must not be impaired"; and
- "spring grazing of known ground nesting bird species must be avoided."

The first two conditions are common to all range use plans; the third is common to all grassland range use plans.

Gerard Guichon Ranch solicited input from several agencies and organizations to develop monitoring methods that could be undertaken annually by ranch personnel within a very short time frame (4 days/yr) and which could bear public and scientific scrutiny (appropriate methodology given constraints of resources and logistics). The proposed monitoring/assessment of a specific grazing system meshed well with the IWP objective of promoting ecologically sustainable land-use practices; therefore, the Program participated in the cooperative development of riparian monitoring procedures. However, since wetland condition is a reflection of activities across the landscape, results from all 3 monitoring sites will be of great interest and potential application.

Researcher

Personnel from MOF, MAFF (Ministry of Agriculture, Fisheries and Food), MELP, DUC, and Gerard Guichon Ranch had input to establishing the monitoring procedures. The Merritt District office of MOF-Range is responsible for administration of the grazing license and for ensuring the data are collected and interpreted. Gerard Guichon Ranch is responsible for collecting the data according to the prescribed methods.

Funding

The IWP's contribution was to provide staff time (through DUC) to work with other agencies and Gerard Guichon Ranch, during 1993-1994, to develop and test the riparian monitoring procedures.

Major Findings to Date

Formal reports of results have not been prepared. The MOF, Merritt office, maintains a file of all data collected along with copies of all photographs, which are part of the monitoring process.

- Glenn Heyes, District Range Resource Officer, MOF, Merritt, provided a table (Table 4) which summarizes the measures of height/density (Robel Pole readings) of vegetation along wetland-riparian-upland transects at the riparian monitoring site on Hamilton Commonage. The readings are the averages of 4 transects at one pond. The "bands" are visually-differentiated plant communities which were labeled:

  Band 1 - upland

  Band 2 - transition (riparian)

  Band 3 - Juncus (wetland)

  Band 4 - Carex (wetland)

  Band 5 - Bulrush (wetland)

Table 4. Mean Robel Pole measurements of height and density of vegetation at 4 riparian transects on the Hamilton Range Unit

YEAR	ROBEL POLE MEASUREMENTS OF HEIGHT/DENSITY (dm)				
	Band 1	**Band 2**	**Band 3**	**Band 4**	**Band 5**
1994	0.28	0.31	1.78	0	2.42
1995	0.86	1.36	3.47	2.18	5.76
1996	1.07	1.04	2.09	0.35	4.42
1997	2.42	--	2.61		

- Based on a simple comparison of averages, it appears that vegetation in all bands increased in height and density, with highest readings in 1995. The Band 4 reading for 1996 is an anomaly which one might speculate represented a specific grazing phenomenon; however, a footnote to the table pointed out that Bands 4 and 5 were excluded from the transects in 1997 because

they were taking too much time and because cattle were ***not*** utilizing them. A more detailed assessment of the raw data, including anecdotal notes regarding grazing activities, would be required to fully interpret the results.

- In addition to the height/density measurements, dominant plant species were recorded for each band in each transect. Those data require examination to determine if there have been any shifts in species composition or relative abundance. [Further data analysis was not within the scope of this report.]

Interpretations Relative to IWP Objectives

1. The type of height/density measurements acquired in this monitoring program, if complemented by appropriate information regarding weather, plant phenology, and grazing timing and intensity, can be very valuable in assessing the impacts of grazing systems. However, while vegetation community structure is a very important factor in determining overall biodiversity values, its measurement must be complemented (as has been done in this instance) by species composition information because of the specific requirements of indigenous wildlife populations. For example, a dense stand of alfalfa or stinging nettle could provide excellent nesting cover for waterfowl, but those stands might preclude development of a diverse native riparian flora which contributes food and cover for a wide range of birds, small mammals, and herpetiles, ***as well as*** duck nesting cover.

2. Measurements in Bands 4 and 5 (Carex and bulrush) were terminated after 1996 because of the heavy time requirement for obtaining that aquatic vegetation data and because it appeared that cattle were not utilizing those bands. At time of writing it appears that resources are lacking to provide for continued collection of that data. However, it would be preferable to continue measurement of those bands so that, should water levels decline, and those bands become more accessible to cattle, the impacts could be assessed.

An assessment of maintenance and enhancement of stream-riparian vegetation (habitats) under controlled livestock grazing vs grazing-exclusion (Chutter Ranch)

Purpose

The Nicola River Corridor Project included, among several land-management components, the fencing of 14 km of the river corridor between Nicola Lake and the City of Merritt. The fencing, located on three privately-owned ranches, was designed to limit livestock access to the river and its riparian zone, thereby promoting development of riparian vegetation for erosion protection and fish and wildlife habitat. For economy of fencing, the fences did not always follow the

bends of the river, but rather cut across the meanders, meaning that considerable productive forage land was excluded from the ranches' grazing systems. If the practice of riverine riparian fencing were to prove successful in significantly enhancing the functioning condition of the river corridor, it could have wide application in BC, and significantly impact forage resources wherever applied. Therefore, the question arose: can riparian vegetation (and wildlife) communities be maintained or restored while grazing continues under a managed regime? The purpose of this study was to compare the vegetative development of ungrazed riparian areas with riparian pastures that were grazed "lightly" and "moderately". Further, one of the sites was in a relatively degraded state, having very little shrub and tree cover and exhibiting bank erosion, while the other site was in relatively stable condition with good shrub/tree cover. The first site was selected to determine if the riparian zone could be ***improved*** under a grazing regime, while the second was selected to determine if the riparian zone could be ***maintained*** under a grazing regime. At each site, one riparian pasture was to receive light grazing while the other received moderately heavy grazing. "We will ... be seeking to find a grazing system that allows for maintenance or improvement of streambank stability and which allows the riparian vegetation to develop or be maintained in a state similar to the exclosures, or some other defined condition, and which is in keeping with how the rancher might logistically manage his cattle."[1]

The study was complemented by vegetation community mapping derived from aerial photography and ground truthing (see *"Evaluation of IWP demonstration projects through aerial and/or ground photography used to assess changes in plant communities"*).

As one indicator of the potential effects of the treatments on wildlife, an inventory of birds within the study sites was also undertaken.

Researcher

The principal researcher was Astrid van Woudenberg who undertook this work in conjunction with the riparian biodiversity study at Hamilton Commonage / Lac du Bois. The project contract was administered by the BC Conservation Foundation. Other organizations were invited to monitor other potential effects of the riparian fencing (e.g. fish habitat, forage production) but those were not undertaken. The federal Department of fisheries and Oceans (DFO) did undertake some initial river morphometry measurements as benchmarks to assess change, but those have not been repeated. Chutter Ranch offered to maintain records of cattle use of the treatment pastures and to manage their herds in accordance with the qualitative criteria for forage utilization described above (i.e. light and moderate use).

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[1] Schedule A of contract #0053-4 between BC Conservation Foundation and Ducks unlimited Canada, 1995.

Funding

The contract for this study included ground-truthing of the aforementioned vegetation maps for the entire Nicola River Corridor Project. The IWP provided $38,170 for the two components combined.

Period of Study

Pre-project aerial photography and vegetation community mapping was completed in 1994. Fencing at the study sites was completed by spring of 1995. Vegetation ground-truthing for the project corridor, and detailed vegetation monitoring of the study sites were completed in 1995 (i.e. pre-treatment detailed vegetation description for the study plots was not acquired). Van Woudenberg submitted her report early in 1996. International Remote Sensing Surveys Ltd. produced a GIS-generated vegetation map of the corridor early in 1997 (based on the 1994 aerial photography and 1995 ground-truthing).

No definite re-monitoring date was established. Ideally, however, the study sites would have been monitored annually , at least for the first three to five years or until the rate of change in the vegetation communities in controls and treatment pastures had leveled off. The original work will have been wasted if not repeated and interpreted in terms of pasture management in riparian zones.

Major Findings to Date

See also, *"Evaluation of IWP demonstration projects through aerial and/or ground photography used to assess changes in plant communities."*

- Table 5 is a summary of cattle management within the study units and adjacent pastures. Some of the records are incomplete because field notes were lost. Chutter Ranch provided their estimate of what happened in those situations. The data do not tell us how many head of cattle actually used the treatment sites, only how many had access to them (gates were open). Timing of removal of cattle from the treatment units was based on subjective assessment of the level of use of the pastures.

Table 5. Chutter Ranch livestock management of Nicola River Corridor Project study sites, 1995.

SITE	TREATMENT	LIVESTOCK PRESENT IN ADJACENT PASTURE	DATE	PERIOD OF POTENTIAL USE [1]	COMMENTS
Low Impact	T1 - Light [2] T2 - Moderate	? [3]	May 16	?	Believe there was no use because of high water.
		?	July ?	?	Believe there was no use.
		147 yrlg heifers; 12 cow/calf pairs	Oct 20 - 24	3.5 days	Ca 100 left the pasture by swimming river.
		Ca 100	Oct 24 - 31	7 days	
High Impact	T3 - Light	238 yrlg heifers; 15 cow/calf pairs	May 7	0.5 day	
		"	July ?	0.5 day	Estimated; records lost.
	T4 - Moderate	"	May 7 - 8	2 days	
		"	July ?	2 days	Estimated; records lost.
	T - 4 - Moderate	"	Sept 21 - 24	4 days	

[1] These data do not tell us how many head used the treatment pastures, only how many had access to them (gates open). Removal timing was based on subjective assessment of forage utilization.

[2] T1 and T2 were exposed the same amount of time which implies that no more than light use was experienced.

[3] Field notes were lost.

- The raw data for the vegetation inventory of the study sites has not been analyzed. However, the following observation was made: "Overall, the Control and Treatment sites in the low impact area had a greater diversity of birds and the vertical structure of the vegetation was

higher and more complex. The high impact sites lacked the abundance of shrub species, and therefore had low structural diversity and more grassy openings."

- The bird inventory, which involved two surveys, revealed that the sites with previously low grazing impact had more species of birds and higher numbers overall than the high-impact sites (Table 6). "The vertical structure of the shrub and tree strata likely provided more suitable habitat for birds than the predominant lower strata of grasses and forbs that were available in the moderate-high impact sites." Further, those high-impact sites that were adjacent to riparian stands of cottonwood, aspen, and willow across the river (Treatments 3 and 4), had higher densities of birds than the high-impact control site (Control 2) which lacked the adjacent tree/shrub riparian areas.

Table 6. Bird densities in study sites of the Nicola River Corridor Project (Van Woudenberg 1996).

SITE	AREA (ha)	# OF SPECIES	BIRDS / METER	BIRDS / 40 ha
Low Impact				
Control 1	1.03	23	24.8	990.3
Treatment 1	1.5	24	22.7	906.7
Treatment 2	1.8	21	18.9	755.6
High Impact				
Control 2	2.3	11	5	200
Treatment 3	1.9	18	9.2	368.4
Treatment 4	2.6	24	11.2	446.2

- Bird community eveness (a measure combining number of species with relative abundance of individuals of each species) was higher in high-impact sites (except Treatment 2) suggesting "a more equitable use of resources and available niches among species". While "community structure in the low impact sites tends to be dominated by a single species", (yellow warblers

in Control 1 and rock doves in Treatment 1), the remainder of the community exhibits "greater eveness, indicating community stability".

Interpretations Relative to IWP Objectives

1. While the study was established to monitor and assess riparian change, comparing no livestock use with 2 levels of grazing impact, no surveys have been carried out since the original surveys of 1995 when the prescribed grazing management was implemented. Therefore, nothing can be concluded relative to the main study objectives at this time. However, because the sites were chosen to show the potential for improvement (or maintenance) of both a highly impacted riparian site and a low-impact site, opportunity was provided to speculate on what "improvement" might mean to the more heavily impacted site. **(The 2 sites are <2 km apart on the same river, and can be expected to have similar potential** natural communities.)

2. The vegetation at the low-impact site strongly indicates that a regeneration of shrubs and trees at the high-impact control site (Control 2) is possible, although that regeneration might be impeded by dense grass cover. "Many of the grass species were introduced and/or invasive species such as quackgrass (*Agropyron repens*) and smooth brome (*Bromus inermis*)". Also, because some grazing has occurred historically on the low-impact sites, yet they have an abundance of trees and shrubs, we might expect to see tree and shrub regeneration occurring at least in the lightly-grazed treatment area of the high-impact site, and possibly the moderately-grazed treatment area as well.

3. If the bird community can be considered indicative of biodiversity and animal abundance, then with the regeneration of trees and shrubs, we can expect greater biodiversity and animal abundance generally.

4. There is much potential for producing informative results by continuing the monitoring of vegetation and birds at the study sites, and properly analyzing the changes. However, there were parameters that were not included in describing baseline conditions:

    - forage production,
    - water quality (especially turbidity and temperature),
    - fish populations and habitat use (however, data collected by Bob Vadas of SFU might be relevant and repeatable),
    - other wildlife populations and habitat use.

Monitoring of those variables along with weather and river hydrology, plus a repeat of DFO river morphometry measurements, would provide valuable information, although the value would be diminished where baseline data are lacking. In addition, if logistically possible, it would be preferable to have livestock use of the treatment areas monitored more precisely; i.e. numbers of animals using the treatment pastures during the period of their accessibility to those pastures.

An assessment of beef-cattle weight gains under a rotational grazing system designed to enhance a wetland landscape (130 Mile Ranch)

Purpose

The IWP demonstration projects were designed to promote sustainable agriculture as well as properly functioning wetland ecosystems. At 130 Mile Ranch, a rotational grazing system was implemented by developing several pastures complete with improved livestock watering facilities. Several productive wetlands within those pastures were further protected by fencing to exclude livestock. The rotational grazing system was promoted with the belief that such a system would yield a healthier and more diverse vegetative community, more diverse and abundant wildlife populations, and improved forage for livestock (see Ducks Unlimited's Project Sheet for details). The purpose of the proposed study was to assess the effectiveness of the proposed livestock/pasture management scheme by weighing calves entering and leaving the system and determining their weight gains.

Researcher

Ken Awmack, District Agriculturist, MAFF, Williams Lake, offered to provide weigh scales and oversight for obtaining weights of calves being raised on the project pastures. The data was to be collected by the ranchers, Lee Hoium and Wendy Braim.

Funding

No specific funds were allocated to the collection of these data. Mr Awmack helped to design the rotation and undertook to set up monitoring procedures for cattle weights. This was done as part of Mr. Awmack's duties as District Agriculturist.

Period of Study

The pasture developments were complete by the end of 1996, and the proposed grazing system was implemented in 1997. Unfortunately, the weigh scales were not available and the study did not proceed.

Assessment

The data regarding weight gains of cattle would have been of great value (assuming positive results) in promoting an intensively managed grazing system incorporating wetland stewardship practices. Further, it is also desirable to obtain concurrent data regarding the benefits of the system to vegetation community structure and wildlife populations (as discussed for the Chutter Ranch study). Ideally, a baseline of information regarding beef production and plant and wildlife communities would have been acquired prior to implementation of the new system; however, that was not possible. At minimum, the ranchers should be interviewed to determine their satisfaction with the system; their impressions of forage and beef production under the new system; modifications they may have made, or plan to make, to livestock and pasture management; and general efficiency of the operation. If funding were available, it would still be worthwhile to conduct the weight-gain measurements and compare the data with norms for the industry in that area where cattle are turned out on crown range for the summer. Photo monitoring (both ground and aerial) begun during the IWP, should be continued to provide evidence of changes in plant community structure.

See also, *" 'Economic Analysis of Investments in Range Improvements': a review of a paper by G. Cornelius van Kooten and Brad Stennes, 1998."*

Evaluation of IWP demonstration projects through aerial and/or ground photography used to assess changes in plant communities.

Purpose

The IWP chose to monitor vegetation change as the principal means of assessing ecological impacts of the IWP demonstration projects. Vegetation, that is, plant community composition and structure, is relatively easy to monitor compared to wildlife or fish populations, and is a good indicator of ecosystem health. Photo stations for ground-based photographs were established for each project and aerial oblique photos were acquired for several projects in 1996. Vertical aerial photography and vegetation-community maps were produced for 6 demonstration projects (Table 7).

Table 7. Interior wetlands program: project photo-monitoring status

DEMONSTRATION PROJECT	PROJECT NUMBER	YEAR COMPLETED	PRE-1995 PHOTO DATES	1995	1996	1997	AERIAL OBLIQUE	AERIAL VERTICAL
130-Mile Ranch	2121	96	81-10, 84-05-23, 93-09-01	95-04-19	96-06-06	97-06-03	81-04-06 82-05-21	96-08-23
137-Mile Ranch	2812	95	94-07-21 94-10-05	95-07-10	96-06-06	97-06-03		
6-Mile Ranch	2818			95-08-18	96-06-11	97-06-12		96-08-23
Buckskin Marshes	2797	94	94-07-20 94-10-04	95-09-05	96-06-05			
Chilcotin Marshes	2535	93	94-05-06 94-07-21	95-09-05		97-06-04		
Duck Meadow	2593	92	92-07-17	95-05-31	96-06-03	97-06-06	96-08-23	
Fallis Pond	2791	95	87-11	95-05-31	96-06-03	97-06-04		
Frost Creek	2651	94	90-09-17 94-05-06	95-05-11	96-06-05	97-06-17		
Hall Lake	2820	95		95-07-14	96-06-06	97-06-03		
Hart Lakes	2816	95		95-07-11	96-06-06			
Jug Lake	2381	97						96-08-23
Lazy L Ranch	2821	95	94-10-19		96-04-17	97-06-09	96-08-23	
Ludwig's Pond	2811	95	94-06-20	95-07-12				
McDonald Creek	2230	94			96-06-04	97-06-09	96-08-23	
Nicola River Corridor	2778	96		95-03-16	96-05-16	97-06-19	93-10-29	94-09-18 96-08-23
Peterhope Lake	2814	95			96-05-15	97-06-05	96-08-23	
Rush Lake	2265	94	94-05-05	95-05-09	96-04-11 96-06-06			

DEMONSTRATION PROJECT	PROJECT NUMBER	YEAR COMPLETED	PRE-1995 PHOTO DATES	1995	1996	1997	AERIAL OBLIQUE	AERIAL VERTICAL
S. Thompson Riparian	2790	96	94-03-24	95-06-01	96-06-03	97-06-06	96-08-23	
Salmon Arm Indian Lands	2753	93				97-06-09		90-? 96-08-23
Siwash Lake	2526	95			96-06-04		96-08-23	
T'Kumlups Marshes	2798	94		95-06-02	96-06-03	97-05-31	85-01-02 96-08-23	
Tunkwa Range	2677			95-06-09	96-06-10	97-06-03, 05, 13, 19		96-08-23
Wild Horse Meadow	2813	96	94-10-05		96-06-05	97-06-05		

Researcher

The ground photo stations were established by E. Hennan in 1994 through 1996, and were subsequently repeated by either E. Hennan or other Ducks Unlimited staff. A few of the projects had been photographed prior to the IWP by DU staff; those photographs were included in the monitoring files. The aerial obliques and verticals were taken by Kent Watson of International Remote Sensing Surveys Ltd. The assessment of changes, based on the photographs listed in Table 7, was conducted by this author as part of preparation of this report.

Funding

The photography was conducted under the research and monitoring budget of the IWP.

Period of Study

Photographic monitoring was begun in 1994 and carried on through 1997. Once photo stations were established, an effort was made to repeat the photography annually on or near the same date and/or similar phenological conditions. This was a guideline which could not always be followed for logistical reasons.

Major Findings

The following (Table 8) are observations and interpretations based on an examination of photographic series of selected photo stations from each IWP Project:

Table 8. Assessment of plant community/habitat changes at IWP demonstration projects based on photographs acquired for that purpose.

PROJECT NAME	*YEAR COMPLETED*	*RESPONSE PERIOD ASSESSED (yrs)*	*PRE-DEVELOPMENT CONDITIONS*	*PROJECT EXPECTATIONS*	*EVIDENCE OF CHANGE*
130-Mile	1996	<1	Water level (WL) variable; heavy cattle impacts in riparian areas of all ponds, but emergents ± intact; uplands heavily grazed.	Much improved upland cover; much improved riparian cover - vigour and diversity in exclosures; maintenance of emergent cover.	Some riparian vegetation response and reduced shoreline trampling evident in exclosures in '97. WL up in '96 and again in '97.
137-Mile	1995	2	San Jose R. fluctuates with annual runoff and subsequent drawdown; cattle use of riparian area light; good riparian cover; annual haying upslope of riparian area; good emergent cover.	Maintained or enhanced riparian and emergent vegetation	Emergent and immediate riparian vegetation maintained; upslope cover within exclosure - increased height and density relative to adjacent haylands.
6-Mile	Not Completed		WLs variable. High proportion of shorelines heavily grazed, but limited evidence of trampling; good emergent cover; riparian shrubbery probably reduced by past grazing.	Stabilized water levels. Improved upland and riparian cover.	Not available.
Buckskin Marshes	1994	2	WLs fluctuated widely with irrigation drawdowns; moderate to heavy grazing on grassed shorelines; wet meadow vegetation only lightly grazed if at all.	Improved water regime (less fluctuation) for all basins, especially Upper Buckskin Lake; improved upland and riparian cover within exclosures.	Movement of floating cattail beds in Buckskin Lake; more stable water level in Upper Buckskin L.; some evidence of improved upland cover and regeneration of aspen within exclosure at Upper Buckskin L.
Chilcotin Marshes (Spade Marsh)	1993	3	Flooded in spring, and drawn down in summer for haying; therefore, a large shallow basin of open water in the spring, limited emergent vegetation; very limited water-based habitat in fall; uplands heavily grazed.	Permanent marsh with good interspersion of emergent veg'n and open water; increase in height, density and diversity of riparian and upland vegetation (within fenced exclosure).	Good development of emergent vegetation (notably bulrush) with permanent flooding, however, the emergents have not increased in distribution and density, possibly due to the water regime (increase may have been more pronounced if WL had been increased in stages). Upland and riparian vegetation not noticeably changed except perhaps at some of the more inaccessible portions of shoreline. Livestock have been within the exclosure at times since the fencing was completed.

PROJECT NAME	*YEAR COMPLETED*	*RESPONSE PERIOD ASSESSED (yrs)*	*PRE-DEVELOPMENT CONDITIONS*	*PROJECT EXPECTATIONS*	*EVIDENCE OF CHANGE*
Duck Meadow	1992	3	Backflooded and drawn down annually to produce a grass-sedge hay crop; provided excellent spring-migrant habitat for waterfowl; Monte Creek flowed through meadow following drawdown (mid- to late-summer); little water-based habitat in fall. Some cattle-grazing in meadow following haying.	Permanent marsh with good interspersion of emergent cover and open water, with potential to become overgrown, primarily with cattail; development of excellent riparian and upland cover following termination of haying.	Development of emergent and upland vegetation has been rapid and favourable; some signs of increasing density, and change in composition from sedge-grass to sedge-cattail; excellent cover-water interspersion, but could become too dense from waterfowl-habitat perspective. Aerial oblique photos (or verticals) help in assessing that interspersion.
Fallis Pond	1995	2	WLs variable; severe trampling of riparian zone and emergent vegetation at margins; uplands heavily grazed. Emergent vegetation (amount and density) varied with WLs (the latter based on personal observations, not photos).	WLs will still fluctuate with precipitation, runoff and watershed conditions. Development of broad band of emergents around perimeter; increase in height, density and diversity of riparian vegetation within fenced exclosure. Reduced turbidity.	Upland to north, across road, has been logged; WLs have been consistently high; emergent vegetation has not developed as expected (although some is present), possibly due to high WLs; riparian vegetation has increased favourably in height and density. Periods of very dense blooms of algae, very likely due to intensive livestock use of pond immediately upstream, along with effects of logging above north shore.
Frost Creek	1994	3	Uplands and riparian zones very heavily grazed; logging occurring in adjacent forestland; Colpitt dam removed exposing upper contours of basin; good peripheral stands of emergent vegetation on Colpitt and Axe Lakes.	Stable WL on Colpitt L; maintenance of emergent vegetation on Colpitt and Axe L; increase in height, density and diversity of riparian vegetation within fenced exclosure. Some improvement in upland range condition (i.e. forage production).	By 1997, there appears to be slight increases in height and density of riparian and upland vegetation in exclosures; evidence of past shoreline trampling is being obscured by plant growth; emergents have been maintained on Colpitt and Axe L. Grazing on uplands still apparently very heavy.
Hall Lake	1995	2	Uplands and riparian zone heavily grazed on north side; dense forest growth on south; narrow margin of cattail around perimeter; dam condemned.	WL secured through licensed dam; improved height and density of riparian and upland vegetation through livestock management.	Negligible evidence of change.

PROJECT NAME	*YEAR COMPLETED*	*RESPONSE PERIOD ASSESSED (yrs)*	*PRE-DEVELOPMENT CONDITIONS*	*PROJECT EXPECTATIONS*	*EVIDENCE OF CHANGE*
Hart Lakes	1995	<1	Hart L subject to irrigation drawdowns and shoreline grazing. LeBlanc Marsh drained with attempts to hay; WL variable; uplands hayed.	Hart Lake - stabilized marsh habitat; increased height and density of riparian vegetation within exclosure. LeBlanc Marsh - development of permanent marsh with increased height, density and diversity of riparian zone.	Hart Lake - increased height of riparian grasses within exclosure relative to adjacent grazed uplands. LeBlanc Marsh - South uplands logged between '95 and '96. High water level in '96 flooded exclusion fence and former riparian zone.
Jug Lake	1997	0	Portion of adjacent uplands hayed; remainder forestland. Emergent band (cattail) adjacent to hayland.	Maintenance of WL, emergent vegetation, and a 30 m riparian "buffer".	
Lazy L Ranch	1995	2	WLs variable; some upland areas very heavily grazed; ponds in those areas have strongly impacted riparian zones; areas used for hay production develop excellent riparian and upland cover, at least for late-nesting waterfowl.	More stable WLs; increase in height and density of emergent and riparian vegetation within exclosures.	Marked increase in height and density of riparian vegetation in exclosures relative to grazed pastures.
Ludwig's Pond	1995	<1	Extreme grazing pressure on riparian zones and immediately adjacent uplands; even emergent-wet meadow veg'n being grazed.	Increased height and density (and possibly diversity) of wetland, riparian and upland vegetation, at least during the waterfowl breeding season.	Not available.
McDonald Creek	1994	2	Annual drawdowns for haying on Top Meadow and Home Meadow -maintained fen or wet meadow habitat (traditionally hayed).	WLs on Top and Home Meadows stabilized (no mid-summer drawdowns); dev'mnt of permanent marsh habitat. Improved upland haylands satisfy landowners' hay req'mnts and provide additional waterfowl nesting habitat.	WLs providing very good marsh habitat, although "emergent" vegetation still predominantly sedge/grass. Newly developed upland hayland appears to be productive.
Nicola River Corridor	1996 (some riparian fencing completed by '94)	3	Riparian zone of much of the river subject to grazing and trampling; severe degradation of riparian vegetative cover; haying further upslope; severe erosion in some reaches; declining number of mature cottonwoods.	Increased height, density and diversity of riparian vegetation; maintenance of mature cottonwoods plus ingrowth of second-growth trees; reduced lateral erosion and river turbidity. Improved habitat complexity in "Mush Bowl"	A more quantifiable interpretation could be derived through a comparison of GIS-derived plant community data from 1994 and 1996 (analysis of digitized data). Marked response of grass component of riparian zone, especially evident in the (formerly) more intensively grazed

PROJECT NAME	*YEAR COMPLETED*	*RESPONSE PERIOD ASSESSED (yrs)*	*PRE-DEVELOPMENT CONDITIONS*	*PROJECT EXPECTATIONS*	*EVIDENCE OF CHANGE*
				through level ditching.	areas; assessment of tree/shrub response requires more detailed site examination. (See van Woudenberg 1996.)
Peterhope Lake	1995	2	Annual irrigation drawdowns of Peter Hope Lake subjected peripheral marshy habitats to extreme fluctuations and impacted lake fishery. Grazing impacted emergents and riparian zones, notably at N end of lake.	Stable lake WLs; maintenance or improvement of emergent vegetation. Increase in height and density of riparian and immediately adjacent upland vegetation within fenced exclosure.	No photo-detectable evidence of change. Aerial oblique photo will provide best image for that assessment. No photos of fenced riparian zone to make comparisons.
Rush Lake	1994	2	WL variable with precipitation and runoff conditions. Riparian zone and adjacent grassed uplands very heavily grazed. No riparian shrubbery except along south side and in meadow on the southeast.	Increase in height, density and diversity of riparian and adjacent upland vegetation within fenced exclosure; heavy impacts around water holes developed outside of the fence on the east side.	Moderate increases in height and density of riparian and adjacent upland vegetation within exclosure. Expect continued improvements along with additions to plant community.
Salmon Arm Indian Lands	1993	0 (except aerials - 6 yrs)	Up to 3 m WL fluctuations on Shuswap Lake yield extensive mudflats that become inundated by early summer; upper contours are wet meadows or marsh, flooded for extended periods; Old river channel in project area subject to annual desiccation; meadows along Salmon River delta subject to heavy grazing limiting regeneration of riparian trees and shrubs and reducing stands of wet-meadow grasses .	WLs continue to fluctuate; water retained in old river channel by an outlet weir (part of project); wetland and riparian vegetation maintained or increased in height and increased in diversity through regeneration of shrubs and cottonwoods.	A more quantifiable interpretation could be derived through a comparison of GIS-derived plant community data from 1990 and 1996. Aerial photos from those dates show a substantial increase in height (and possibly, density) of grasses within fenced exclosures surrounding the old river channel and along the west side of the Salmon River. Assessment of tree/shrub component requires field investigation.
Siwash Lake	1995	<1	Heavily grazed uplands and degraded riparian and emergent zones. WLs variable. (See 1988 photos on file at DU office, Kamloops; note low WL).	Increased height, density and diversity of riparian vegetation within exclosure; increase in emergent vegetation; improved range condition in uplands.	
South Thompson Riparian	1996	2	Riparian zone heavily grazed and trampled. Stobart Creek heavily trampled and eroded; very turbid. Enlarging, unvegetated alluvial fan at outlet of Stobart Cr.	Increased height, density and diversity of riparian vegetation; reduced erosion on lower Stobart Creek.	Substantial increase in height and density of riparian vegetation, notably the ground cover of grasses and forbs; very noticeable revegetation of lower Stobart Creek, above Shuswap Rd, but

PROJECT NAME	*YEAR COMPLETED*	*RESPONSE PERIOD ASSESSED (yrs)*	*PRE-DEVELOPMENT CONDITIONS*	*PROJECT EXPECTATIONS*	*EVIDENCE OF CHANGE*
					continued erosion below Shuswap Rd.
T'Kumlups Marshes	1994	3	WLs fluctuate widely, often very low by late summer; east pond no longer functioning as sewage pond. Emergent vegetation changes with water levels; sometimes abundant. Upland vegetation moderately dense but very weedy. Some riparian shrubbery on east pond.	Stable, controlled water levels conducive to development of emergent vegetation and increase in height and diversity of riparian vegetation.	East Pond: WL low in '95; good in '96 and emergent cover abundant; dry in '97 with abundant cattail, bulrush and annual "weeds"; riparian grasses/forbs tall and dense. West Pond: WL low in '95 with substantial band of cattail; moderately high in '96 with good emergent cover; very high WL in '97; cattail band reduced; water up into former "weedy" riparian zone; adjacent "upland" vegetation moderately tall and dense.
Tunkwa Range	Not Complete. (Portion of fencing complete by '97).	1	WLs variable with precipitation, runoff and irrigation demands. Uplands and riparian areas very heavily grazed; wet meadows, fens, and emergent zones not heavily impacted; limited amount of severe shoreline trampling	Increase in height, density and diversity of riparian and upland vegetation; possibly more shrubs in riparian zones.	No obvious changes between '96 and '97.
Wild Horse Meadow	1996	1	WLs variable with precipitation and runoff. Uplands and riparian zones very heavily grazed and some sections of shoreline trampled.	Continued variable WLs, but increase in height, density and diversity of riparian vegetation within fenced exclosures. Some improvement in range condition of uplands. Livestock watering access has changed and may lead to a change in grazing patterns (distribution on the pasture).	Little evidence of change; too little time has elapsed.

Summary Comments

Table 9 summarizes the interpreted effects of the demonstration projects in terms of photo-detectable effects from three project components: fenced livestock exclosures, modified grazing regimes, and water level management.

In most cases fenced exclosure had some degree of impact on riparian vegetation in terms of increasing height and density. In some cases there appeared to be some increase in plant height in ungrazed uplands as well. It is generally too early to tell if there is a significant change in plant composition although there is some evidence of regeneration of aspen adjacent to Upper Buckskin.

There has been insufficient time elapsed to determine whether modified grazing regimes have resulted in photo-detectable changes to either riparian or upland vegetation.

The influence of water level management or water level changes could be detected at several projects. In some cases water management has yielded permanent marshes (Chilcotin, Upper Buckskin, Hart Lake, Duck Meadow) and improved cover-water interspersion (Duck Meadow). In other cases, the result was maintenance of existing emergent vegetation (Buckskin, Frost Creek, Peterhope, Siwash). In others, the results are inconclusive (Chilcotin, T'Kumlups).

Table 9. Summary of photo-detectable changes in vegetation in IWP demonstration projects based on three project components: fenced livestock-exclosure, modified grazing regimes, and water-level management.

PROJECT COMPONENT	PROJECTS TO WHICH COMPONENT APPLIES	ASSESSMENT OF EFFECTS
Fenced Exclosure	130 Mile	Positive
	Buckskin	Positive
	Chilcotin	No Change
	Duck Meadow	Positive
	Fallis Pond	Positive
	Frost Creek	Positive
	Hart Lake	Positive

PROJECT COMPONENT	PROJECTS TO WHICH COMPONENT APPLIES	ASSESSMENT OF EFFECTS
	Lazy L Ranch	Positive
	Nicola River	Positive
	Rush Lake	Positive
	Salmon Arm Indian Lands	Not Enough Data
	South Thompson Riparian	Positive
	Tunkwa Range	Not Enough Elapsed Time
	Wild Horse Meadow	Not Enough Elapsed Time
Modified Grazing Regime	130 Mile	Not Enough Elapsed Time
	6 Mile	Not Enough Elapsed Time
	Hall Lake	Not Enough Elapsed Time
	Nicola River	Note Enough Elapsed Time/Data
	Salmon Arm Indian Lands	?
	Siwash	Not Enough Elapsed Time
	Tunkwa Range	Not Enough Elapsed Time
	Wild Horse Meadow	Not Enough Elapsed Time
Water Level Management	Buckskin	Positive
	Chilcotin	Positive, but not conclusive
	Duck Meadow	Positive
	Frost Creek	Positive
	Hart Lake	Positive
	Lazy L Ranch	Not Enough Data
	McDonald Creek	Not Enough Elapsed Time

PROJECT COMPONENT	PROJECTS TO WHICH COMPONENT APPLIES	ASSESSMENT OF EFFECTS
	Peterhope Lake	Not Enough Elapsed Time
	Siwash	Not Enough Data
	T'Kumlups Marshes	Positive, but not conclusive

Some Recommendations Regarding Future Photo Monitoring:

The following are a few suggestions regarding the acquisition and filing of future photos:

- Each photo should have a unique identifying number, such as 2331 - 97 - 06, where 2331 is the project number, 97 is the year, and o6 is a specific photo from a specific site (only the year would change in a series of comparable photos). These numbers would correspond with photo sites on a sketch map of the project.
- Prints and slides (or prints and negatives, if print film was used) should be stored in separate locations.
- Photo stations must be the same each year.
- The camera lens should be a consistent focal length (e.g. 55 mm).
- As much as possible, the picture should be taken during the same phenological period each year.
- If possible, photos should be taken during the same period of the day each year (i.e. am or pm).
- If possible, photos should be taken under similar light conditions, usually moderate to bright sunlight, facing away from the sun.
- Resources permitting, ground photos should periodically be augmented by oblique aerial photography.

"Preliminary Assessment of the Responses of Waterfowl Populations to Habitat Initiatives undertaken under the Interior Wetlands Program": a review of the paper by André Breault and Peter Watts, 1998.

Purpose

This was an *a posteriori* analysis of breeding waterfowl survey data collected between 1987 and 1996 (the B.C. Cooperative Waterfowl Pair Survey). The purpose of the analysis was to determine if and how waterfowl population trends might be related to the land management and wetland enhancement activities of the IWP. Only the subset of data related to the Kamloops region (176 wetlands) was used in the analysis because that was the area of greatest activity under the IWP.

Researcher

The analysis was conducted by André Breault, Waterfowl Biologist, Canadian Wildlife Service, and Peter Watts, consultant.

Funding

The report was produced as an internal document of the CWS.

Period of Study

The Cooperative Breeding Waterfowl Survey data used in the analysis was collected between 1987 and 1996, a database of over 100,000 bird sightings. The IWP was active from 1992 to 1997. The analysis was completed in January, 1998.

Major Findings

The observations and conclusions that appeared most relevant to the objectives of the IWP were the following (see the original report for an important discussion of the limitations of the data and analysis):

- Wetlands in the Bunchgrass (BG) bio-geoclimatic zone supported 5 times as many breeding pairs of ducks per wetland as wetlands of the Interior Douglas Fir (IDF) zone, and 4 times as many total ducks.

- According to the BC Watershed Atlas, there are relatively more wetlands (20:1) and more wetland hectares (10:1) in the IDF zone than in the BG zone in the Southern Interior ecoprovince.

- Up to 22 species of waterfowl use wetlands of the IDF zone; up to 18 species of waterfowl use wetlands of the BG zone.

- During the 1989 to 1996 period, 60% of the upland margins around wetlands were impacted by grazing. The % of impacted margins varied among survey areas, implying different grazing regimes.

- Fenced or partially-fenced wetlands had lower waterfowl species diversity, but higher duck numbers, than unfenced wetlands (but fenced wetlands were usually smaller than unfenced wetlands). However, there was .... "no evidence that fencing was associated with an increase in the number of breeding pairs on the short term, probably because of the length of time it takes for both marsh and upland vegetation to regenerate."

- There was no detectable change in average grazing pressure over the time period 1989 to 1996.

- There was no detectable difference in breeding-bird species diversity or waterfowl abundance in relation to grazing pressure.

- Permanent wetlands supported more waterfowl species, more breeding pairs and more total birds than seasonal wetlands.

Interpretations Relative to IWP Objectives

1. An analysis of the waterfowl survey data by wetland size class and bird density (breeding pairs / ha) might prove meaningful in providing direction for habitat enhancement programs such as fenced exclosures.

2. The remarkably higher numbers of both breeding pairs and total ducks per wetland in the BG zone suggest a much higher primary productivity in those wetlands relative to those in the IDF. Further, since there is much less BG-wetland habitat available, the security and quality of that habitat would appear to be critical. At the same time, since the evidence shows that those habitats have been degraded, and degraded for some time (60% of wetland margins impacted throughout the 1989-1997 period), the implication is that there is much potential for increase in waterfowl production from those wetlands if those degraded habitats can be restored.

3. The foregoing does not mean that BG wetlands should necessarily receive exclusive attention in habitat restoration initiatives. There are 20 times more wetlands and 10 times more wetland hectares in the IDF than in the BG zone. Their greater structural diversity (more trees) is quite likely the reason for greater waterfowl species diversity. Like BG wetland margins, those of the IDF zone were also impacted by grazing. Thus, while breeding waterfowl numbers per wetland were lower in the IDF zone, there is much more of that habitat, habitat which would also benefit from improved stewardship.

4. A closer examination of where and why lower levels of grazing pressure occurred within the survey area might provide insight into stewardship possibilities. It might also mean only that some areas were more resilient than others to grazing impacts.

5. There appear to be too many variables to properly assess the effects of fenced exclosures on waterfowl use of wetlands, via the Cooperative Breeding Waterfowl Surveys. The surveys were not designed to address that question and only targeted a certain segment of the waterfowl breeding population (early nesters). If that kind of information were required, it would probably be best derived from a study directed specifically at that question (see Hamilton Commonage and Becher's Prairie research studies). Such studies may tell us what we can expect from wetlands where the wetland margins are enhanced, but it is highly unlikely that the resulting recommendation would be the fencing of great numbers of wetlands.

6. By taking into account the nature of the Cooperative Breeding Waterfowl Surveys, or adding certain elements to those surveys, it may be possible to use those data to address specific questions regarding the effects of changing land-use practices or wetland-landscape projects arising out of future conservation programs.

"Economic Analysis of Investments in Range Improvements": a review of a paper by G. Cornelius van Kooten and Brad Stennes, 1998.

Purpose

The IWP promoted wetland-habitat improvements and land-use/land management practices that were believed to be at least neutral, and preferably beneficial from an agricultural standpoint. Some of the "improvements" that were promoted on the basis of mutual wildlife and agricultural benefits included the development of alternative stockwatering facilities, fencing to accommodate modified grazing regimes, more intensive herding, removal of salt blocks from riparian sites, and restriction of cattle access to erodable riparian areas. It was the intent of the

IWP to use demonstration projects and extension materials and activities to encourage landowners, particularly ranchers, to implement similar projects on their own accord because they saw such practices as economically profitable as well as socially responsible. However, there has been very little documented evidence quantifying the relationship between such practices and their agricultural values, the closest perhaps being recent evidence of enhanced weight gains of cattle having access to clean water versus direct access to "unclean" sources such as dugouts (Willms et al 1994). Therefore, the IWP contracted economists at the UBC to examine the economics of range improvements.

The purposes of the investigation were :

- "to provide a synopsis of available literature related to the economics of improved range condition;
- to provide a detailed review paper;
- to identify information gaps for BC and Western Canada; and
- to make recommendations for the co-operative opportunities for the agriculture-wildlife habitat interface."

Researcher

The analysis was conducted by Professor G. Cornelius van Kooten and Ph.D. candidate, Brad Stennes from the Forest Economics and Policy Analysis Research Unit of the University of BC.

Funding

The $ 13,400 study was funded by the IWP.

Period of Study

1998.

Major Findings

The following, quoted from the research paper, are deemed to be some of the more significant and relevant statements with respect to the IWP and future comparable programs.

- "Resolving conflicts in a way that maximizes the social benefits received for the range resource is the principle task of range economics and management."

- "Simple budget analyses that have been the "bread and butter" of most range managers cannot be relied upon to determine the economic viability of public investments in range improvements."

- "... there is no effective and comprehensive inventory of provincial range resources; and monitoring of resources is lacking..."

- "... forage production on forestland is substantially higher than on open range, perhaps as high as 10 times (Quigley and Bartell 1990, p 2)."

- "Open range in BC tends to be most degraded, with much of the range in fair to poor condition. Forest and logged range, as well as meadow range, tend to be in good to excellent range condition (BC Ministry of Forests 1980)."

- "Rather, conflict takes place in the BC Interior, where estimated forage supply amounts to 980,000 AUMs annually, but annual demand by livestock and wildlife amounts to 1,564,000 AUMs. ... it would appear that the shortfall between demand and supply is made up by overgrazing. In any event, the estimates indicate that, unless society is willing to accept fewer wildlife or reduce livestock AUMs, investing in range improvements is important for future survival of the ranch sector in BC."

- "It is important to identify range improvements that are efficient from society's point of view, weeding out projects that do not enhance the overall well being of society while encouraging those that do. This may require subsidies in the case where projects can be justified on the basis of their nonmarket and spillover (environmental or external) benefits."

- "Pope and McBryde (1984) ... found that profit was higher if the range was systematically overstocked, with appropriate range treatments applied periodically to improve range quality."

- "They [Hu, Ready and Pagoulatus (1997)] ... applied their model to a region in Mongolia, concluding that economically optimal grazing may not lead to sustainable grazing. This conclusion was based on assumptions from limited data, a recurring theme in the analysis of the economics of range improvements."

- "While the economic surpluses associated with domestic forage consumption can readily be calculated, the same is not true of wildlife resources. Yet the latter need to be taken into account in making decisions about how the range is to be utilised and managed for multiple resource use."

- "An example of environmental costs is the damage caused by cattle to riparian areas (and wetlands more generally), damage that reduces habitat for waterfowl and aquatic life."

- "Range improvements that protect riparian areas enhance fish and waterfowl habitat, thereby contributing to consumptive (fishing, hunting) and non-consumptive (wildlife viewing) use values. ... On the other hand, whenever those participating in recreation (wildlife viewing, hunting, hiking or camping) encounter cattle or sheep, their recreational experience likely suffers, but, as far as we are aware, there exist no estimates of the economic costs of these negative amenities.... . Creation of wetlands or preventing their demise also adds to viewing and hunting values."

- "As van Kooten and Bulte (1998, pp. 166-68) show, the contribution [to non-use value] of added protection of land is almost negligible at the margin."

- "While total or average nonmarket benefits of range may be substantial, the contribution of range improvements to nonmarket value needs to be considered at the margin. At the margin, such values are small or negligible."

- " ...there are a variety of different approaches to dynamic modeling ... Each of these methods has its limitations and advantages. In the end, however, the method that is adopted is as much determined by the particular problem (particular range improvement) to be analysed as anything else."

- "One area that has not been adequately taken into account in range economics has been the incorporation of nonmarket values. It is necessary to take into account the benefits accruing to society at large, rather than only a small subset of ranchers, when evaluating range improvements. Thus, appropriate models for evaluating range improvements need to integrate this component."

- "Along with ecological 'rules of thumb,' budget analysis remains the 'bread and butter' of range management. However, such an approach tells an incomplete story and could lead to erroneous conclusions about the social desirability of investments in range improvements."

Interpretation Relative to IWP Objectives

1. Van Kooten and Stennes provided an extensive analysis of methods of evaluating range improvements in terms of ranch, range, and social values. Their insights are very important to planning any range improvement program, but especially where program focus is on one aspect of the range such as forage or wetlands or timber production while the full spectrum of range resources must be considered. That full spectrum may be recognized as biodiversity or ecological sustainability or bioeconomics. While van Kooten and Stennes discussed ***how*** such

values may be derived (in particular, the bioeconomic model of dynamic optimization), they did not address the specifics of evaluating IWP-sponsored range improvements in terms of ranch economics in particular or social values in general. Thus, the tools are provided, but the job, in terms of IWP needs, has not been done. If the projects undertaken by the IWP are to be "extended", or other similar programs are to ensue, then it remains to:

- assess IWP-sponsored range improvements via the recommended methodologies for assessing ranch and social values;
- review the literature on range improvements in accordance with the recommended methodologies; and / or
- design further studies of range improvement projects incorporating the recommended economic analysis procedures.

2. While it is theoretically appropriate, and socially responsible, that government resource agencies should apply the best economic methods to range-improvement decisions on public lands, range improvements on private ranchlands (with potential spillover on to public lands) are likely to be based on less altruistic criteria. Therefore, as much as possible, the range improvements promoted as part of environmental stewardship programs, must address the specific question of ranch economics in terms acceptable to the individual ranch enterprise. The rancher may wish to be environmentally or socially responsible, but can only do so if his or her enterprise survives the next fiscal year. We return to the same basic question: will range improvements geared toward environmental stewardship, even on private land, require public subsidies (such as government or non-government conservation programs) to ensure extensive and ongoing implementation? It is quite possible that, even with the more economically compelling range improvements, ranchers will require initial assistance with capital costs in order to implement change. This would be especially true in times, such as the present, when profit margins are low and the economic climate is generally poor.

3. Van Kooten and Stennes recommend ... "permitting grazing fees to increase and compensating producers for forage left for other users, or tree seedlings left untrampled" ... in order to increase economic efficiency. At the same time, they recommend that other range users should "contribute to the administrative costs and improvements of range resources" with compensatory payments to livestock producers through an offsetting fee system. On Crown or public lands, the evidence seems to be that the costs of range improvements must be borne by more than the ranching sector -- by all direct users of the range resources (e.g. recreationists), but also by all society because we must acknowledge an ***existence*** value of vegetation and wildlife. It follows that the contributing public would have more of a say in how the range is managed.

4. The recommendation, by van Kooten and Stennes, that economists be involved in range research at the design stage, is one that should definitely be followed in future programs modeled on the IWP. Appropriately derived evidence of the ranch, range, and social economic values of wetland-stewardship activities will be critical to their extensive implementation on the landscape.

"Impacts of the Interior Wetlands Program: report on a survey of B.C. ranchers": review of a paper by Dovetail Consulting Inc., 1998.

Purpose

This survey-based evaluation was designed "to assess the Interior Wetlands Program in terms of its uptake by the core of its target audience: ranchers in the lower and mid-elevation grasslands and open forest range lands of the interior Fraser River Basin." The results of this survey are complementary to economic analyses such as that discussed in the prefious section: the uptake of stewardship activities by ranchers is a reflection of their perceptions of the economic viability of those activities.

The results and interpretations reported by Dovetail are based on 256 returns of questionnaires sent to 1649 members of the BC Cattlemen's Association. The fundamental questions posed in the questionnaire were:

- What proportion of the target audience did the IWP reach?
- What proportion of the target audience learned from the IWP?
- What proportion of the target audience took actions to protect wetlands as a result of the IWP?

Researcher

Dovetail Consulting Inc., Vancouver, BC.

Funding

The $ 15,000 survey was funded by the IWP.

Period of Study

The survey was conducted during 1998.

Major Findings

The qualified results of the survey indicated that at least 80% of the target audience were aware of some aspects of the IWP. More than 30% acquired new knowledge or understanding of issues addressed by the IWP because of their exposure to the program. More than 30% modified their land-use practices during the IWP because of the new knowledge and understanding being acquired.

The report states: "Although ranchers adopt alternative management practices as a result of a range of influences, the results of this analysis show that the IWP does have a significant influence unto itself. One indicator of this is the high correlation between reported levels of influence of the program and the extent to which alternative practices have been implemented. When we estimated the number of ranchers who would have changed their practices without the IWP, and netted down the influence of the program accordingly, the program still showed a 20% or greater influence for 4 out of the 8 practices, and it is likely that our calculations underestimate the effect of the program in this analysis."

"Those who report a strong program influence on their understanding of IWP themes also tend to report a strong likelihood of adopting alternative land management practices in the future."

"Program influence on activities was noticeable only with respect to general exposure to the program and not in connection with individual materials or activities."

Interpretations Relative to IWP Objectives

The conclusions derived from the results of the survey already constitute an interpretation relative to the IWP. Therefore, the following is simply an expansion upon Dovetail's discussion.

1. The fact that the program appeared to be more influential in raising economic awareness than ecological awareness may mean that the audience was more "tuned in" to economic issues than ecological ones. Again, the inclination towards solvency is probably stronger than altruism. If a new practice has demonstrable economic benefits as well as ecological benefits, the uptake can be expected to be more rapid and extensive. This is an important consideration in the design of future conservation/stewardship programs. If those who earn their livelihood from their own land are being asked to modify ***how*** they use their land -- for the betterment of society -- there should be an economic incentive ***to accompany*** the ecological rationale. Also,

as discussed in the review of the previous document by van Kooten and Stennes, the economic argument must be clear and validated.

2. Further, as the survey revealed, landowners are probably more receptive to hearing an ecological message from other landowners than from environmental-conservation personnel. Therefore, the message should be strategically delivered to ensure the greatest ripple effect.

3. Any conservation/stewardship program should acknowledge its role as one of many factors influencing land-use practices and seek to complement those other factors. There is doubtless a need for the following types of programs/activities in ensuring sustainable land use:

    - regulatory,
    - incentive (subsidies, rewards, relief),
    - advisory,
    - extension/ education,
    - planning,
    - demonstration,
    - monitoring, and
    - policy review.

The IWP focused primarily on demonstration, monitoring, and extension; but its success was part of the combined success of many concurrent programs and activities.

"From a Bird's Eye View: An Overview of Selective Policy and Legislation to Identify Conservation Opportunities for Waterbirds in B.C.'s Wetlands and Associated Uplands": review of a paper by Dovetail Consulting Inc., 1998

Purpose

Federal and provincial government legislation, policies, regulations, and practices relating to land and resource use often influence aspects of the environment other than the target land use or resource, and do so in ways that are not always immediately apparent. For example, well-

intended legislation which gives tax relief to rural landowners who produce more than some minimum value in agricultural produce may have the effect of encouraging use of land that is unsuitable for that purpose and which results in ecological degradation, and ultimately, a social cost. This review was undertaken "to identify opportunities [within existing legislation and policies] for non-governmental organizations and agencies to promote conservation of waterbirds and waterbird habitat in wetlands and associated uplands in British Columbia." The purpose was also stated as: "to identify programming options for Ducks Unlimited and Environment Canada to support improved range practices and habitat conservation in light of the current and emerging legislation and policy environment in British Columbia." It is important to note what the review does ***not*** do. It does not:

- "evaluate legislation and policies themselves ...";
- "evaluate detailed range and wetland management practices and procedures ...;"
- "evaluate current conservation initiatives of conservation organizations or agencies; or
- establish priorities for conservation efforts from among the opportunities identified."

The authors also note that their review is only a "snapshot" of policies and legislation which are in the process of undergoing considerable change.

The report identifies and examines 3 trends in policy and legislation in BC that "provide increased opportunities for the protection of waterbirds and their habitats":

- greater emphasis on the protection of water, fish, and riparian habitats;
- increased land-use planning requirements; and
- "new provisions for the protection and management of species at risk".

Researcher

Dovetail Consulting Inc., Vancouver, BC.

Funding

This $ 11,000 review was funded by the IWP.

Period of Study

The review was completed in the first quarter of 1998.

Major Findings

The authors recommended that conservation organizations / agencies participate in a number of processes to avail themselves of opportunities presented by the legislation and policies they reviewed. Those processes were:

- water management planning,
- local government land-use planning and management (e.g. referrals and Regional Growth Strategies),
- regional land-use planning (e.g. Land and Resource Management Plans or LRMPs),
- development of Landscape Unit Objectives,
- Range Use Plans,
- the Identified Wildlife Management Strategy (Wildlife Habitat Area designation, General Wildlife Measures), and
- endangered species designation (under the Fish Protection Act, with potential Wildlife Management Area designation under the Wildlife Act).

Primarily, that participation would involve:

- building appropriate linkages with planning agencies and multi-stakeholder groups;
- providing inventory and mapping information;
- providing technical expertise regarding wetlands, riparian areas, and wetland-dependent wildlife;
- identifying and classifying important wetland and riparian habitats;
- assisting in land-use planning exercises;
- providing extension / education materials and forums;
- promoting financial incentives for sustainable land-use practices; and
- direct involvement in the preparation of land-use plans (e.g. Range Use Plans).

Interpretations Relative to IWP Objectives

The above recommendations already constitute an interpretation relative to the IWP. Therefore, the following is simply an expansion upon Dovetail's findings.

1. Aside from the ongoing development of ecological awareness, understanding, and sensitivity within the public consciousness, government legislation, policies, regulations, and programs, at all levels, constitute the realm of greatest influence on environmental sustainability.

2. A number of the conservation opportunities identified are already being addressed by conservation organizations. Ducks Unlimited, for example, has engaged in the establishment of liaison with planning groups, provision of inventory and mapping information, participation in planning processes, contribution of extension materials (through the IWP), and contribution of technical expertise. However, those activities may be partly a response to opportunities, and only partly the result of long-range planning. A more dedicated approach may be necessary to fully take advantage of the opportunities identified. Acquiring the appropriate staff and resources to engage in the preparation of Range Use Plans or Regional Growth Strategies, for example, may prove to be a most effective means of ensuring the sustainability of wetland ecosystems under the current set of statutes and policies.

3. The purpose of the review was "to identify opportunities" within selected policy and legislation; it was not to identify potential ways in which a wide range of existing legislation, policies, regulations, and practices might inadvertently be at odds with wetland conservation (e.g. is the pricing of irrigation water at odds with wetland conservation?). Sandborn (1996) suggested we need to "synthesize and improve the existing legislation, policies, programs and actions that already contribute to wetland conservation", and "adjust provincial legislation, policies, programs, and activities that are at cross-purposes to wetland conservation." The latter is a task which bears attention ***from the perspective of those specifically concerned with wetland and wetland wildlife conservation.*** Dovetail's review addressed 15 statutes, 2 major wetland policies, 6 wetland-related strategies, and some 8 planning processes. Possibly many more of BC's 494 statutes (extant in 1996), along with numerous related policies and programs, would bear scrutiny with respect to cross-compliance, in an ecological sense, with wetland conservation initiatives. Recent amendments to the Municipal Act and revisions of the Water Act, both stemming from the Fish Protection Act, are evidence of the need for this type of scrutiny.

4. Nolan and Jeffries (1996) examine wetland law and policy from the perspective of using those as tools for wetland protection, but they also make a number of recommendations for modifying existing legislation and policies. Review of new government legislation, policies, regulations, and programs should be an ongoing component of conservation organization / agency activities.

OVERVIEW OF IWP RESEARCH / MONITORING

Table 10 is an assessment of the effectiveness of the IWP research and monitoring studies in addressing relevant issues or questions. Table 11 lists those studies which should be continued in order to more completely address those questions and to provide information of value to future programs modeled after the IWP.

Table 10. An assessment of the effectiveness of studies, conducted by the IWP, in addressing primary IWP questions (see Table 1).

QUESTION	STUDIES WHERE QUESTION WAS PRIMARY	USEFUL INFORMATION PROVIDED BY END OF 1998	POTENTIAL FOR ACQUIRING USEFUL INFORMATION THROUGH ONGOING STUDY
Habitat/wildlife relationships	1*	Yes	Yes
	2	Yes	Yes
Wetland/riparian restoration	2	No	Yes
	4	Yes	Yes
	6	Yes	Yes
Range management/wetland-riparian vegetation	2	Yes	Yes
	3	Yes	Yes
	4	Yes	Yes
	6	No	Yes
Range management/wildlife populations	2	Yes	Yes
Range management/forage production	5	No	Yes
Range management/rangeland health	6	No	Yes
Range management/ranch economics	5	No	Yes

*1 - Becher's Prairie; 2 - Hamilton; 3 - Guichon; 4 - Chutter; 5 - 130-Mile; 6 - Photos.

Table 11. IWP-supported studies recommended for continuation, to more completely address questions of relevance to future IWP-like programs.

QUESTION	STUDIES* RECOMMENDED FOR CONTINUATION IN SUPPORT OT FUTURE IWP-LIKE PROGRAMS
Habitat/wildlife relationships	1, 2
Wetland/riparian restoration	1, 2, 4, 6
Range management/wetland-riparian vegetation	1, 2, 4, 5, 6
Range management/wildlife populations	1, 2, 4
Range management/forage production	4, 5, 6
Range management/rangeland health	1, 2, 3, 5, 6
Range management/ranch economics	4, 5

*1 - Becher's Prairie; 2 - Hamilton; 3 - Guichon; 4 - Chutter; 5 - 130-Mile; 6 - Photos.

REFERENCES

Breault, A. and P. Watts. 1998. Preliminary assessment of the responses of waterfowl populations to habitat initiatives undertaken under the Interior Wetlands Program. Internal report, CWS. 28 p.

Cooke, F., K. Martin, and S. Boyd. 1997. Effects of Forest Management on Biodiversity of Riparian Ecosystems in Interior Forests of the Cariboo-Chilcotin. 1996/97 final report. Forest Renewal BC Research Program. 23 p.

Cooke, F., K. Martin, S. Boyd, and D.B. Lank. 1998. Effects of Forest Management on Biodiversity of Riparian Ecosystems in Interior Forests of the Cariboo-Chilcotin. SCBC #FR-96/97-044 (2); FRBC Research Award # CC96029-RE. 1997 Interim Report. Forest Renewal BC Research Program. 10 p.

Dovetail Consulting Inc. 1998. From a bird's eye view: an overview of selective policy and legislation to identify conservation opportunities for waterbirds in B.C.'s wetlands and associated uplands. Final draft. Ducks Unlimited Canada, Kamloops. 24 p.

Dovetail Consulting Inc. 1998. Impacts of the Interior Wetlands Program: report on a survey of B.C. ranchers. Ducks Unlimited Canada, Kamloops. 40 p.

Hennan, E.G. 1993. Waterfowl nesting in rangelands of the British Columbia Interior Fraser River Basin: research and evaluation proposal. Internal planning document, Ducks Unlimited Canada, Kamloops. 3 p.

Nowlan, L. and B. Jeffries. 1996. Protecting British Columbia's wetlands: a citizen's guide. West Coast Environmental Law Research Foundation, and British Columbia Wetlands Network. (from: http://freenet.vancouver.bc.ca/local/wcel/wcelpub/1996/11580/welcome.html)

Pohl, B., F. Cooke, and S. Cullen. 1996. Waterfowl in Becher's Prairie: waterbirds, grazing and disturbance. SFU, Burnaby. 41 p.

Sandborn, C. 1996. Towards a British Columbia wetlands policy (Draft).

Savory, A. 1988. Holistic Resource Management. Island Press, Washington, D.C. 563 p.

Van Kooten, G.C. and B. Stennes. 1998. Economic analysis of investments in range improvements. Draft, Sept. 2, 1998. Forest Econ & Policy Res. Unit, UBC, Vancouver. 54 p.

Van Woudenberg, A.M. 1996. Nicola Corridor Demonstration Project: terrestrial monitoring component. Ducks Unlimited Canada. 25 p.

Van Woudenberg, A.M. 1997. Grazing impacts on the biodiversity of grassland ecosystems: Project Phase I. MELP, Kamloops. 87 p + appendices.

Van Woudenberg, A.M. and D.A. Haag. 1996. Grazing impacts on the biodiversity of grassland riparian ecosystems. 1995 Summary Report. 10 p.

Willms, W., D. Colwell and O.Kenzie. 1994. Water from dugouts can reduce livestock performance. Prairie Water News, Vol 4(1).