REMOTE SENSING IN OPERATIONAL RANGE MANAGEMENT PROGRAMS IN WESTERN CANADA

M.D. THOMPSON
Intera Environmental Consultants Ltd.
Calgary, Alberta

ABSTRACT

During 1976, a pilot program was carried out in Western Canada to test remote sensing under semi-operational conditions and display its applicability to operational range management programs. Four agencies were involved in the program - two in Alberta and two in Manitoba. Each had different objectives and needs for remote sensing within their range management programs, and each was generally unfamiliar with remote sensing techniques and their applications. Personnel with experience and expertise in the remote sensing and range management fields worked with the agency personnel through every phase of the pilot program - planning, data acquisition, training and interpretation of remote sensing imagery (mainly false colour infrared photography at three different scales, plus Landsat imagery), evaluation of results, and preparation of recommendations for implementation into their own agency programs. Provision of pertinent inventory and monitoring data and cost-effectiveness were considered primary factors. Results indicate that these agencies have found remote sensing to be a cost-effective tool and will begin to utilize remote sensing in their operational work during ensuing seasons.

1. INTRODUCTION

The rangelands of Canada cover a wide geographical area and constitute a valuable resource in terms of livestock and wildlife, timber, recreation, fossil fuel and other resources. Increasing demand on such resources necessitates intensification of management which will maximize productivity and allocate multiple use of rangelands, as most range managers are now aware. They are challenged with more intensive management of lands under their current jurisdiction, as well as wtih inventory of new lands, and provision of accurate and detailed information for multi-use policy decisions in rangeland areas.

Remote sensing can assist the range manager by maximizing efficiency, expanding area of coverage, reducing intervals of range monitoring, and permitting economical inventory of remote areas. Management agencies should thus be developing management plans and strategy to include up-to-date remote sensing techniques. Such a development has in the past been unduly delayed since these agencies, with limited manpower, budgets and exposure to remote sensing, had to generate such expertise from within themselves. The pilot program approach has been proposed as a means of transferring remote sensing from research into operational spheres; each interested agency is exposed to the techniques of remote sensing, and to the potential benefits for their individual range management programs, while developing expertise in application of remote sensing within their own agency over a relatively short time period. This approach was tested during 1976 when the Canada Centre for Remote Sensing sponsored a pilot program under the management of INTERA Environmental Consultants Ltd., involving four range management agencies in western Canada.

A pilot program is a necessary intermediary stage between research-oriented, feasibility studies and fully operational applications of remote sensing. During this program, remote sensing technology is tested under semi-operational conditions and the results display its applicability to the operational programs of range management agencies, allowing each agency to assess the value of remote sensing with respect to their own needs.

Four of the eleven major range management agencies in western Canada participated in the 1976 project (their areas of jurisdiction are seen in Figure 1). These were (1) the Forest Land Use Branch, Alberta Forest Service, Department of Energy and Natural Resources (Edmonton); (2) the Lands Division, Alberta Department of Energy and Natural Resources (Lethbridge); (3) the Crown Lands Division, Manitoba Department of Agriculture; and (4) the Renewable Resources Division (Wildlife), Manitoba Department of Renewable Resources and Transportation Services. The latter two agencies were considered together as they shared the same study area and remote sensing imagery. Thus, there were three separate pilot programs conducted under this contract.

The range agencies were directly involved in the planning of the pilot program, the data acquisition (both in the air and on the ground), the interpretation of the imagery, and the subsequent implementation into their individual management systems. Since range managers often are not experienced in these areas, and require assistance in carrying out such a program so that the results would be useful and directly applicable to their work, INTERA coordinated the program for each agency, ensuring efficient and meaningful data acquisition, interpreter training, and provision of assistance in making recommendations for future operational programs.

2. STRUCTURE OF 1976 PILOT PROGRAMS

A basic four-stage pilot program was designed which allowed for flexibility in application to the different agencies involved: (1) program planning, (2) data acquisition, (3) training and interpretation, and (4) program evaluation. The first stage consisted of establishing the objectives, current programs and needs of each agency with respect to inventory and monitoring the rangelands under their jurisdiction, and based on that information, planning a pilot program. This included choosing a study area, planning the ground surveys, discussing remote sensing imagery types and scales, and all other details. INTERA worked with the agency personnel in an advisory capacity, their level of involvement differing with the experience of the agency personnel and the needs of that agency program. The choice of remote sensing imagery, the scales and times of year for data acquisition were based on the recommendations of a 1975 feasibility study (Intera, 1975) although changes were made according to agency preference and need. Thus, the remote sensing included false colour infrared (FCIR) photography at large, medium and small scales, Landsat imagery (Bands 5 and 7), and in one case small format colour and colour infrared photographs.

The second stage involved the airborne and ground data acquisition. INTERA participated in the ground surveys to ensure proper data collection and supervised the processing of the data. Most of the FCIR photography for the three programs was flown by the first week of August, although some was obtained later in the season as requested by the agency involved. The ground surveys were timed with the remote sensing overflights where possible.

For the third stage, INTERA prepared a three-day training course as an introduction to remote sensing and its application to rangeland management. The level of training was gauged to the varying experience of the range managers with remote sensing. The interpretation of the remote sensing imagery was carried out by the agency personnel with assistance from INTERA when necessary (this varied from agency to agency according to their needs). In the final stage, program evaluation, meetings were held with all of the personnel involved to discuss the pilot program in all its aspects, the results of the interpretation

of the remote sensing imagery and its application to operational range management programs, and to make recommendations for future use of remote sensing by the agency. A report was then compiled for each agency, documenting each stage of the program, its results, conclusions and recommendations (Thompson & Yule, 1977; Thompson & Klumph, 1977, Thompson et al, 1977).

3. DESCRIPTION OF THE THREE AGENCY PILOT PROGRAMS

Table 1 provides a summary of the three agency pilot programs carried out during 1976, including details on their study areas, remote sensing imagery, ground survey data, and methods of remote sensing interpretation. Their individual agency objectives for participation in the program were varied, thus emphasizing the need for flexibility in the basic pilot program. The Alberta Forest Service (Edmonton) wanted to use remote sensing to partially replace time-consuming ground surveys and thus reduce the 15-year interval of monitoring their grazing allotments (there are about 90 allotments in the Alberta Rocky Mountain Forest Reserve covering 3650 square kilometers). Using remote sensing imagery for inventory and monitoring of range species and range condition, existing allotment management plans could be modified according to current status of the range, and management thus intensified.

The Alberta Lands Division (Lethbridge) was primarily interested in estimating range productivity during the grazing season, on their 24,000 square kilometers of grazing leases in the short and mid-grass prairie areas of southern Alberta. Their goals included using remote sensing for more intensive and more frequent inspections of their grazing lands to ensure proper management.

Within the Manitoba pilot program, the Department of Agriculture (Crown Lands) is currently establishing a range management program, and wanted to use remote sensing for inventory and monitoring of Crown grazing lands under their jurisdiction. The Renewable Resources (Wildlife) agency, on the other hand, was interested in inventory and monitoring of wildlife habitat on public lands.

4. EXECUTION OF 1976 PILOT PROGRAMS

The actual execution of the three 1976 pilot projects is discussed under the four stages of the program (program planning, data acquisition, training and interpretation, and evaluation).

Program Planning Stage (July 1976)

In this important stage all of the decisions regarding objectives, choice of a study area (see Figure 1 for locations), remote sensing and ground survey data acquisition, and levels of participation are made. Although a period of two months had originally been proposed for this stage (i.e. beginning about April 1976), holdups delayed authorization until July, almost halfway through the grazing season. This unfortunately shortened the planning stage of the pilot projects to one or two weeks, since the data acquisition had to be completed by the first week of August at the very latest, and eliminated early season remote sensing. For the Alberta Forest Service, the pilot program was easily adapted to their existing summer field program; choosing a suitable study area and carrying out the ground surveys were relatively easily accomplished. The Alberta Lands Division was also relatively accommodating of this pilot project, although it required choosing a new study area and adjustment of summer field programs. The Manitoba group suffered most because of this short planning stage. The Agriculture personnel are still in the process of developing their range management program, which made designing a remote sensing program to complement current and proposed activities more complicated and time consuming. Generally unfamiliar with remote sensing and its application to range management, the Agriculture group required more time to carefully consider their objectives, but unfortunately the data acquisition could not be delayed and required rapid decisions.

Data Acquisition Stage (July - October 1976)

Because of the lateness of the season and the necessity of obtaining the remote sensing imagery quickly and correctly, INTERA ordered the Landsat imagery and obtained the FCIR photographs using their own aircraft and an RC-8 camera (loaned by the Canada Centre for Remote Sensing). The ground data collection was varied to suit the objectives of each pilot program but included species inventory, assessment of range conditions and clipping for productivity estimation (Table 1). In Manitoba, where they had very limited experience in ground survey methods normally used for range management, INTERA sent a range biologist, wildlife ecologist and a remote sensing specialist for the ground surveys, to assist in collecting ground information for the remote sensing. In the two Alberta projects, where range management field programs are already well established, only minor changes and additions were necessary and most of the ground work was carried out by agency personnel and their summer field staff, counselled by INTERA.

Training and Interpretation Stage (September 1976 to January 1977)

INTERA's approach to the training of the participants was to present a general overview of remote sensing and detailed material on the interaction of radiation and the target (mostly vegetation), false colour infrared film characteristics and Landsat imagery, and to provide hands-on experience with the remote sensing imagery obtained for each agency's study area as well as all the interpretation equipment. In fact, the training program was delayed in all three cases until the remote sensing imagery for the study area was available, so that it could be used as an integral part of the training. This proved to be a good approach, as it related the remote sensing theory to actual hands-on practice with photographs of a familiar area. Each participant then was to interpret the remote sensing imagery (with assistance as required from INTERA) in order to evaluate potential uses and applications to his agency's field of interest and objectives. To allow adequate time to study the imagery and formulate conclusions, regular field and office schedules had to be rearranged in most cases.

In the interpretation of the remote sensing imagery, emphasis was placed on basic techniques, primarily visual analysis using hand lenses and stereoscopes. Such easily obtained equipment can be used in future operational work right in the agency offices, a matter of practical importance. Good use was also made of a multispectral viewer for the Landsat imagery analysis in the case of the Alberta Lands Division pilot project (a densitometer was also used for this project). The participants appreciated this practical side to the pilot project, as their limited budgets do not easily allow for purchase of extra equipment.

By the end of the time allowed for interpretation (end of January) most participants felt at ease with the remote sensing imagery and wished to continue with the interpretation, since more information could be derived from the imagery and checked in the field during the next grazing season. Thus, although reports were produced for each of the agencies, further work will be done in most cases and more conclusive results attained. After the 1977 field checking, each interpreter will have more confidence in his ability, and will be better able to interpret and evaluate remote sensing applications in his range management program.

Every participant in the three projects, amazed at the resolution, ground detail and overall quality of the FCIR transparencies, felt that they were well worth the extra cost over standard panchromatic prints. Almost all agreed that the most useful photo scale for their work was a medium scale of about 1:20,000. The large scale photographs (1:2000) contained much more detail than they needed or wanted (this was confusing), and for two of the projects, the small scale (1:46,000) photographs were not detailed enough. This points out the necessity in a program of this type of suiting the photo scale not only to the data need, but also to the experience of the interpreter. In the case of this program, where almost every participant was new to the task of interpreting FCIR photo-

graphs, a scale which shows recognizable and familiar ground detail will produce the best results. As their experience in interpretation increases, then smaller scales (for inventory and monitoring at lower costs and with increased areal coverage) and larger scales (to solve more detailed problems) can be utilized effectively. It is important in the initial stages of a program such as this to minimize logistical and practical problems so that the focus is on interpretation. Choice of a photo scale from which maps showing meaningful units can be made, solves one of these important practical problems.

Evaluation Stage (February 1977)

The evaluation of the pilot projects was carried out in February 1977 (in order to meet contract deadlines), and the results of the remote sensing interpretation were considered preliminary since more work is yet to be done. Nevertheless, evaluation of the three pilot projects showed that each was successful in terms of its objectives to a different degree. Based on final meetings with the participants, material written by them on the pilot project, questionnaires (prepared by INTERA to obtain specific answers on project details from all participants), and INTERA's observations during the course of the pilot projects, the agency reports were prepared (see Reference Section).

Table 2 presents a summary of the results of the pilot programs for the four range management agencies in terms of areas of jurisdiction, current programs, objectives for use of remote sensing and future operational work using remote sensing. The objectives of the Alberta Forest Service pilot project were to use remote sensing to identify and map range types and range condition, and to use this information to modify the system of range use through changes in grazing allotment management plans. Through interpretation of the remote sensing imagery, they were able to improve on the quality and quantity of the data for mapping obtained by means of intensive ground surveys. Thus, they were satisfied with their results, and plan immediate implementation of remote sensing into their operational range management program. In future, they will save on man-time in the field and double their annual area of coverage of previous years under their current budget; this will improve both the frequency of rangeland monitoring and the data base upon which management decisions are made. This pilot program may thus be considered a success.

The Alberta Lands Division wanted to use remote sensing for evaluation of range condition, not through vegetation inventory, but rather through estimation of productivity (biomass). Their results were positive in that they were able to assess range condition, utilization and productivity at varying levels of detail from FCIR photography, from Landsat Imagery, and from 35mm colour infrared slides. They identified operational uses for each of these remote sensing tools, and the means of implementing each into their operational program, depending on budget and available mantime. However, they also identified a number of problems which they feel require further investigation before remote sensing can fill all of the proposed operational niches, and they plan to continue with such investigations. Using the remote sensing techniques tested in the pilot program, they will be able to improve the monitoring capability of the agency both in frequency and in quality and quantity of data on which to base management decisions.

The Agriculture-Crown Lands agency in Manitoba wanted to identify carrying capacities through inventory of vegetation types and range condition, so that the remote sensing could be applied to their five-year inventory program. They did not carry their investigations quite to this point; however, they were successful in developing a preliminary legend for their inventory, and in mapping vegetation and range conditions using this legend. They are planning to refine the legend for their range inventory program and to further develop their interpretation abilities. They consider this pilot program to be successful in that they learned ground survey techniques, were made aware of the applications of remote sensing to range management programs, and developed interpretation skills. The Manitoba Wildlife group wanted to utilize remote sensing for inventory and assessment of three main types of wildlife habitat (that of white-

tailed deer, grouse, and waterfowl). They were successful at only one of these (assessment of waterfowl habitat) and plan to utilize FCIR photography for this purpose in their operational management programs next year, while continuing evaluation of the other two.

5. SUMMARY AND CONCLUSIONS

The results of these three 1976 pilot projects have confirmed the original assumption that remote sensing can play an effective role in operational range management programs in western Canada. Remote sensing tools can be implemented within the limits of present budgets, and can still provide a more detailed and efficient data base for management decisions than other methods. Investigations into the application of remote sensing to range management must still be continued, however, if not by the range management agencies themselves, then by other investigators, as the problems of imagery interpretation and methodology have not yet all been solved.

Detailed recommendations for the implementation of remote sensing into the operational range management programs of each agency made in the final report on the project (INTERA, 1977) are summarized in Table 2. Their positive results indicate that other range management agencies in western Canada should become involved in such work. Most of the involved agencies were satisfied that they can improve their management programs through implementation of remote sensing without major budgetary increases (which seems to be one main reason for not getting involved with remote sensing in the past). By making manpower changes, and lightening the field work load, an agency can allow for the costs of remote sensing data acquisition. Small budgetary increases, if granted, then can only serve to further improve the management program by allowing even more frequent inventory and monitoring of the area under their jurisdiction, an objective of every range management agency. Before becoming involved in a pilot project of this type, however, they should have an established operational program and clearly defined objectives for the implementation of remote sensing. Otherwise, the pilot project is not utilized efficiently and the objectives are not realized to their full extent.

The importance of this pilot program lies not only in the individual results obtained from the remote sensing imagery by each range manager/interpreter, since these are relatively basic and probably overly obvious to anyone involved in remote sensing research in rangeland managment, but also in the success of the program in transferring remote sensing technology from research to operational management programs. Not only in range management, but in many other fields, remote sensing can be successfully implemented into operational programs; facilitated with respect to time and efficiency by making use of an "expert" (whether a consultant, a government scientist or a knowledgeable person from the range agency) to guide the agency, this pilot program approach provides a mechanism for such a transfer.

ACKNOWLEDGMENT

This project, entitled "Rangeland Remote Sensing-1976 Pilot Project", was supported by the Canada Centre for Remote Sensing, Department of Energy, Mines & Resources (Ottawa, Canada) under DSS Contract OSZ76-00183, as a result of an unsolicited proposal. The Alberta Remote Sensing Centre and the Manitoba Remote Sensing Centre made their facilities available for part of the interpretation of the remote sensing imagery.

REFERENCES

INTERA Environmental Consultants Ltd., 1975, Remote Sensing of Rangelands in Western Canada, unpublished report prepared for Canada Department of Agriculture (DSS Contract OSZ4-0413), Calgary, Alberta, 104 pp.

_____, 1977, Final Report, Rangeland Remote Sensing 1976 Pilot Project, unpublished report prepared for Canada Centre for Remote Sensing (DSS Contract OSZ76-00183), Calgary, Alberta, 53 pp.

Thompson, M.D. and S.G. Klumph, 1977, Remote Sensing of Rangelands-1976 Pilot Program in Southern Alberta, Final Report submitted to Lands Division, Alberta Department of Energy and Natural Resources, Edmonton, Alberta, 67 pp.

_____, and D.A. Yule, 1977, Remote Sensing of Rangelands-1976 Pilot Project in Alberta's Rocky Mountain Forest Reserve, Final Report to Alberta Forest Service, Department of Energy & Natural Resources, Edmonton, Alberta, 22 pp.

_____, et al, 1977, Remote Sensing of Rangelands-1976 Pilot Project with Range Management Agencies in Manitoba, Final Report submitted to Manitoba Departments of Agriculture, and Renewable Resources and Transportation Services, Winnipeg, Manitoba, 41 pp.

TABLE 1
SUMMARY OF 1976 AGENCY PILOT PROGRAMS

	ALBERTA FOREST SERVICE	ALBERTA LANDS DIVISION	MANITOBA
Study Area	Todd Creek-Rock Connelly (2 grazing allotments - 84 km^2)	Rowley-Jakes Butte (2 grazing association leases - 50 km^2)	Narcisse (200 km^2)
Range Type	Foothills	Midgrass Prairie	Parkland
	1. Grasslands (Festuca scabrella, Danthonia parryi) 2. Browse (Salix spp., Amelanchier alnifolia) 3. Conifers (Pinus spp., Picea glauca, Pseudotsuga menziesii) 4. Deciduous (Populus tremuloides)	(Festuca scabrella, Stipa comata, Bouteloua gracilis, Agropyron spp.)	1. Grassland (Stipa comata, Danthonia, Poa spp.) 2. Wooded areas (Populus tremuloides, Quercus, Picea glauca, Cornus stolonifera)
Airborne Remote Sensing			
Type	FCIR Photographs 23 cm roll transparencies	FCIR photographs 23 cm roll transparencies	FCIR Photographs 23 cm roll transparencies
Scales	1:40,000 1:16,000 1:2,000	1:46,000 1:20,000 1:2,000	1:46,000 1:24,000 1:2,000
Dates	July 26, 1976 October 1, 1976	July 23, 1976 August 13, 1976	August 3, 1976
Landsat Imagery			
Bands	5,7	5,7	----
Dates	May 9 & 10, 1976 July 2 & 20, 1976 Sept. 13, 1976	July 2, 1976	----
Other	-----	35 mm colour and colour IR slides	----
Ground Data	1. range types (species) 2. range condition 3. range developments 4. forage production	1. forage production from 80 sample sites 2. general description of range	1. range types (species) 2. range condition 3. range developments 4. forage production 5. wildlife habitat assessment
Method of Interpretation (Major)	1. Mirror stereoscope 2. Hand Lens 3. Multispectral viewer (Landsat)	1. Mirror stereoscope 2. Hand Lens 3. Multispectral viewer 4. Densitometer	1. Mirror stereoscope 2. Interpretoscope

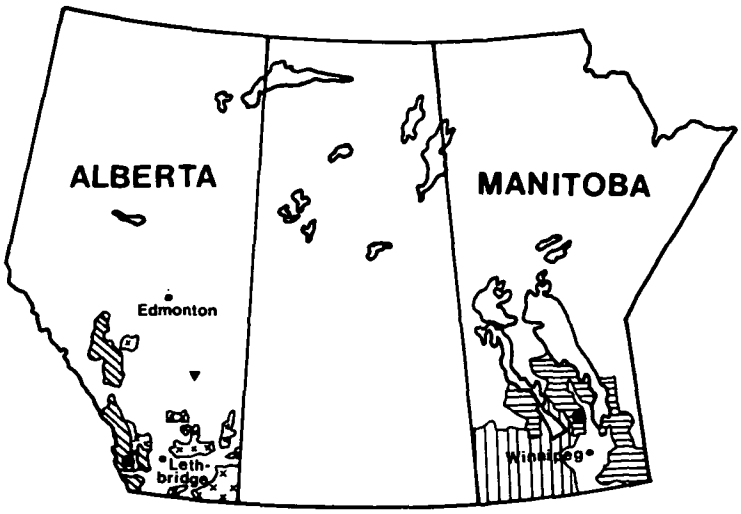
TABLE 2
SUMMARY OF OPERATIONAL REMOTE SENSING OF
RANGELAND PROGRAMS IN ALBERTA AND MANITOBA

	ALBERTA FOREST SERVICE	ALBERTA LANDS DIVISION			MANITOBA	
					AGRICULTURE	WILDLIFE
AREA OF JURISDICTION	365,000 ha. (3650 square km) in Forest Reserve (plus northern Alberta Green area)	2,430,000 ha. (24,300 square km) in S. and Central Alberta			810,000 ha. (8100 sq. km)	Not available
TYPE OF RANGELAND	Mainly foothills grasslands and bushlands range (plus northern boreal areas)	short- and mid-grass prairie			grasslands to parklands	grasslands, parklands and boreal forest, and wetlands
CURRENT MANAGEMENT PROGRAM	regular inventory (15 year interval) for update of management plans for 90 grazing allotments	monitoring range productivity and condition on grazing leases			beginning inventory of all leases to establish carrying capacity over 5-year period	evaluation of wildlife habitat especially for deer, grouse and waterfowl
OBJECTIVES FOR USE OF REMOTE SENSING	reduce inventory interval thru remote sensing interp. for better data base (range type, condition, trend, utilization)	estimation of biomass (productivity) on grazing leases and permits			inventory of grazing leases (species assoc., condition, utilization)	inventory and evaluation of waterfowl habitat, to be used in planning and development
REMOTE SENSING FOR OPERATIONAL WORK						
TYPE(S)	FCIR photography	Landsat	FCIR photog.	35mm	FCIR photography	FCIR photography
TIME OF YEAR	September	all season	June (end)	June July Sept.	spring, July	July
SCALE	1:16,000	-	1:46,000	1:20,000	1:20,000	1:10,000 (approx.)
METHOD OF INTERPRETATION	visual (hand lens & stereoscope)	multi-spectral viewer	visual (stereoscope)	visual (hand lens)	visual (stereoscope)	visual (stereoscope)

FIGURE 1

RANGELANDS IN ALBERTA AND MANITOBA

AND LOCATION OF STUDY AREAS FOR 1976 PILOT PROJECTS



ALBERTA

- Alberta Forest Service Grazing Allotments
- ■ Rock Connelly Study Area
- Alberta Lands Division Grazing Permits & Leases
- ▼ Rowley/Jakes Butte Study Area

MANITOBA

- Crown rangelands in most of area
- Scattered grazing leases on Crown Lands
- ● Narcisse Study Area