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Kootenay National Park

Fire History and Management Study

Summary Report for Year 2: 1989/90

By

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Kootenay National Park

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1. INTRODUCTION

This report summarizes the work completed during Year 2 of the Kootenay National Park Fire History and Management Study. The purpose of this study (O&M Project 95298) is to collect and analyze all the required information to prepare a comprehensive fire management plan for the Park. Year 1 (1988/89) focused on the fire history of the Park (see "Forest Fire History of Kootenay National Park" by the same author). Several smaller projects were completed in Year 2 (1989/90), which are detailed below. Tasks for Year 3 of the study (1990/91) will include preparation of the final plan and initial work on implementing the final plan.

The purpose of this report is to:

- serve as a summary, rather than a comprehensive 'step by step' accounting of time, materials, and methods;
- document the purpose, objectives, and results of each of the sub-projects; and
- indicate which sub-projects require further work.

Each sub-project is described (including some results) and the reader is directed to additional reports or information as required. Some sub-projects rely on geographic and other databases; these are described in the text for each section. Figures and tables are included only to demonstrate the outcome of the sub-projects and should be considered only a partial record of each undertaking.

2. PROJECTS

2.1 USE OF SPANS GEOGRAPHIC INFORMATION SYSTEM

2.1.1 ECOLOGICAL LAND CLASSIFICATION

With the acquisition of SPANS (SPatial ANalysis System by Tydac Technologies of Ottawa) geographic information system in Year 1 of the study, a priority was placed on developing the databases required for effective use of the system. The KNP Ecological Land Classification (ELC) maps of ecosites had been successfully transferred from CanSIS Arc/Info to SPANS in Year 1, but a comprehensive database of the extended legend information for the ELC was lacking. This database would make for easier reclassification of various themes present in the ELC legend. The ELC map for KNP comprised approximately 1400 polygons averaging 1 km each. These 1400+ polygons were classified according to 88 different ecosites and landforms in the ELC documents.

A dBase III+ database of the extended legend was created and entered by G. Hendry of KNP. This file is found within the KNP ELC universe in SPANS as KNPELC.DBF. Documentation for the file is in Appendix 2. The .dbf file contains most of the individual characteristics found in the legend (ie. ecoregion, ecosection, ecosite, dominant vegetation, dominant soil type, wildlife information, etc.) plus additional fields for the SPANS class number (for the ecosite) and a blank field to use for classifications. For example, if one wanted to produce a classification of the ecosite map to show a map of marten habitat, the following dbase commands might be used:

. replace all reclass with 1 for marten = "L"
. replace all reclass with 2 for marten = "M"
. <etc. for H and VH use classes>

This reclassification information can then be written to an ASCII file for use as a reclassification file in SPANS. SPANS needs the class number of the 'old class' (the ecosite number from 1 - 88 which includes all ecosites and land forms) and a number for the 'new class' (in this case, the marten use class):

. copy fields ecosite_#, reclass to marten.gen type sdf

The above command would create an ASCII file called marten.gen (.gen is used for 'general' reclassification file) that can be used in SPANS to create a marten habitat map for KNP. The 'old class' would be column 1 and the 'new class' would be column 2 in the file.

SPANS uses a strict format file for reclassifications called an .rcl file. A blank template for these types of files is created from within SPANS and includes a title for the file, the short legend name for each class number, the class number for each class, and a 0 for a potential 'new class' number. For relatively simple reclassifications, this format is quite useful as the ecosite information is retained and no special knowledge of dbase processing is required. A requirement for thematic maps of grizzly bear habitat by a Park Warden with little computing knowledge made good use of these files. A blank .rcl file was provided on a diskette with a text editing program that the Park Warden could edit on a portable computer back at his remote station, using the books he required to make the proper class definitions. When it was completed (at his pace), the file was copied back into the SPANS ELC universe and used to create the thematic maps required. A copy of each map was printed (along with a 2 map cross-tab area analysis showing the area of each habitat class in each of KNP's main valleys) and delivered back to the Park Warden within a few hours.

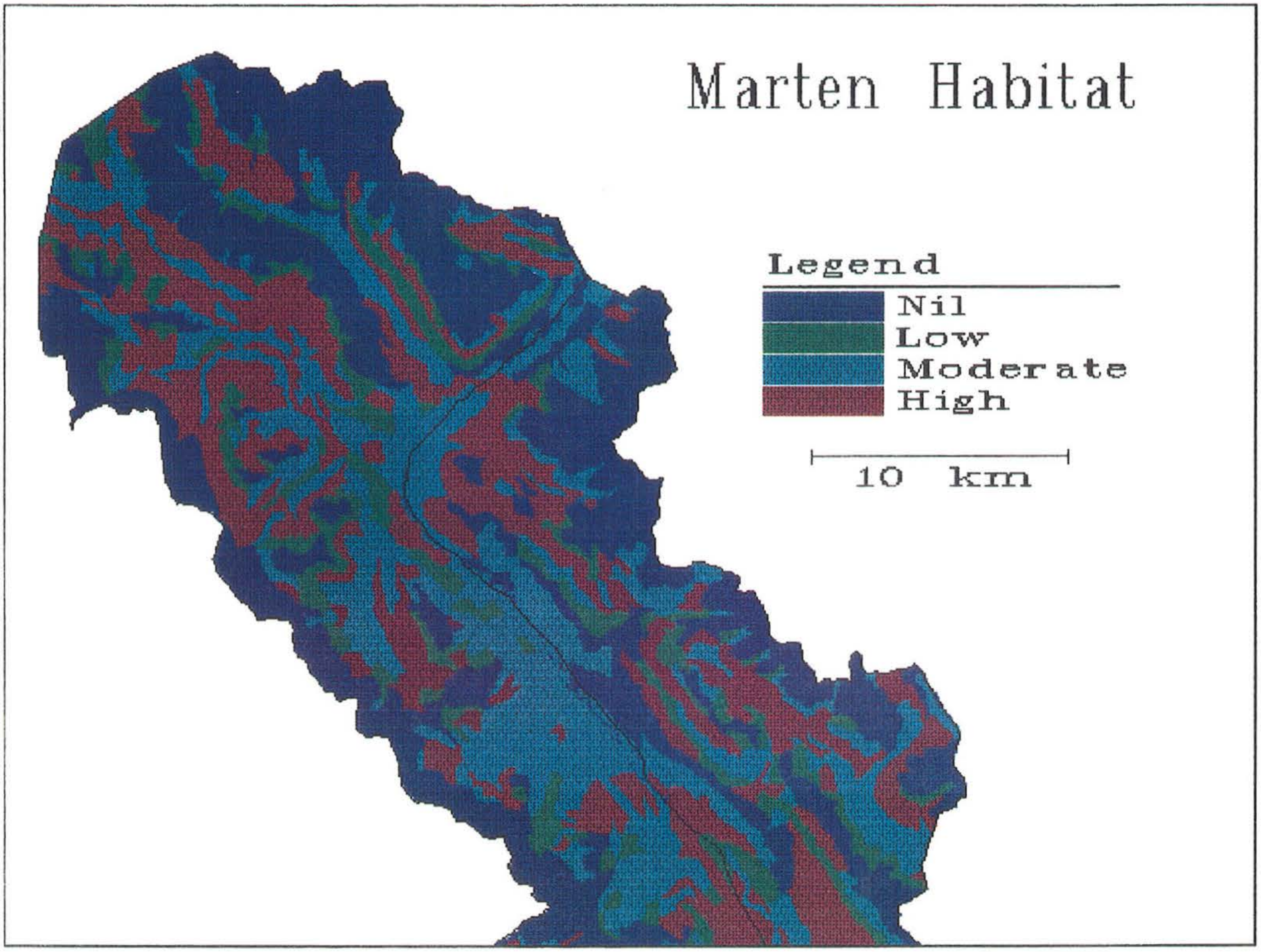
Using the .rcl file showed some distinct advantages. A disk could be provided for the requester of the information to edit on their own time on another computer, thus freeing the SPANS workstation (and it's operator) for other work. The .rcl file format is very simple, and the responsibility for accurate class translation is left to the person editing the file. The editor is simple to use, and no special knowledge of the inner workings of SPANS is required. The comprehensive database file will still be required for more sophisticated multi-combinations of various themes, but the simple one-map, one-scheme method of reclassifications using the .rcl file will go a long way for most uses. To date, numerous reclassifications of ELC data have been performed (eg. grizzly and black bear habitat in support of the grizzly bear research study, elk winter use habitat for an EARP and the modelling project, fuel types from vegetation types for the fire study, ecoregion and ecosection maps, etc.).

The Park's hiking trails were digitized and 100m corridor maps were produced using the 'Arc to Corridor' function of SPANS. In an example application shown on the GIS display posters (see section 2.9), the corridor map of trails was overlayed with each of the grizzly habitat maps (by month, April to November) to determine the area by habitat class that each trail traverses. Though more complex modelling could be applied, a simple class mean procedure was used to rank each trail by month by mean habitat value (eg. 0 = nil, 1 = Low, ... , 5 = Very High). In the example, it was suggested that this form of ranking could be used to allow visitors to select which trails they (do not) wish to hike on, or Park management could close certain trails at certain times to avoid potential conflicts. It is likely that additional criteria will have to be used for these decisions, but the ecological land classification and grizzly habitat research information can now be used in a quantitative manner.

Figures:

- Reclassified ecosite map to show pine marten habitat. An .rcl file was created using the ELC database and reclassified in SPANS.

- Table of grizzly bear habitat values for each of KNP's hiking trails by month. This table was created by overlaying each monthly habitat map with the 100m corridor map of hiking trails and printing a mean class values report. These mean values were then classified and summarized. A different modelling scheme could be used to reflect other concerns (such as proximity to campgrounds, trail lengths, variable influence corridors, etc.). Note that only certain trails have mean values greater than the overall average (ie. values of 3 or greater) and that these occurrences are only after mid-late summer. All values of 3 and 4, for example, could identify the trail for warnings or closures.


Marten Habitat
Legend
Nil
Low
Moderate
High
10 km

Grizzly bear use values by trail and month
for Kootenay National Park.

Legend: Low - 1, Moderate - 2, High - 3, Very High - 4

Trail Name	Apr	May	Jun	Jul	Aug	Sep	Oct	Avg
Aquacourt Trails	2	2	2	2	2	3	3	2
Cobb Lake	2	2	2	2	3	3	3	2
Daer Fire L/o	2	2	2	3	3	4	3	3
Dog Lake	2	1	1	2	3	3	3	2
East Kootenay Fire Road	2	1	1	3	3	3	3	2
Floe Creek	1	1	1	2	2	2	2	2
Goodsir	1	1	1	1	1	1	1	1
Hawk Creek	2	1	1	2	2	2	2	2
Helmut Creek	2	2	2	2	2	2	2	2
Juniper Trail	2	2	2	2	3	3	3	2
Kimpton Creek	2	2	2	2	3	3	3	2
Kindersly Creek	2	2	2	2	2	2	2	2
Luxor Pass	2	2	2	2	2	2	2	2
Mt. Shanks L/O	2	1	1	2	2	2	2	2
Nixon Creek	1	1	1	3	4	3	3	2
Numa Creek	1	1	1	1	2	2	1	1
Ochre Creek	2	2	2	2	2	2	2	2
Ottertail	2	2	2	2	2	2	2	2
Pitts Creek	2	2	2	3	3	3	3	3
Redstreak Creek	2	2	2	2	3	3	3	2
Rockwall Pass	1	1	1	1	1	1	1	1
Simpson River	2	2	2	2	3	3	3	2
Sinclair Creek	2	2	2	2	2	2	2	2
Stanley Glacier	2	2	2	2	2	2	2	2
Tokumm Creek	2	1	1	2	2	2	2	2
Tumbling Creek	1	1	1	1	1	1	1	1
Verendrye Creek	2	2	2	2	2	2	2	2
Verdant/Honeymoon	2	1	1	2	2	2	2	2
Wardle	1	1	1	2	2	2	2	2
West Kootenay Fire Road	2	2	2	3	3	3	3	3
Wolverine	1	1	1	1	1	1	1	1
Average	2	2	2	2	2	2	2	2

Overall distribution of class occurrence:

Class	#	%
1	54	25
2	123	57
3	38	18
4	2	1
	217	100

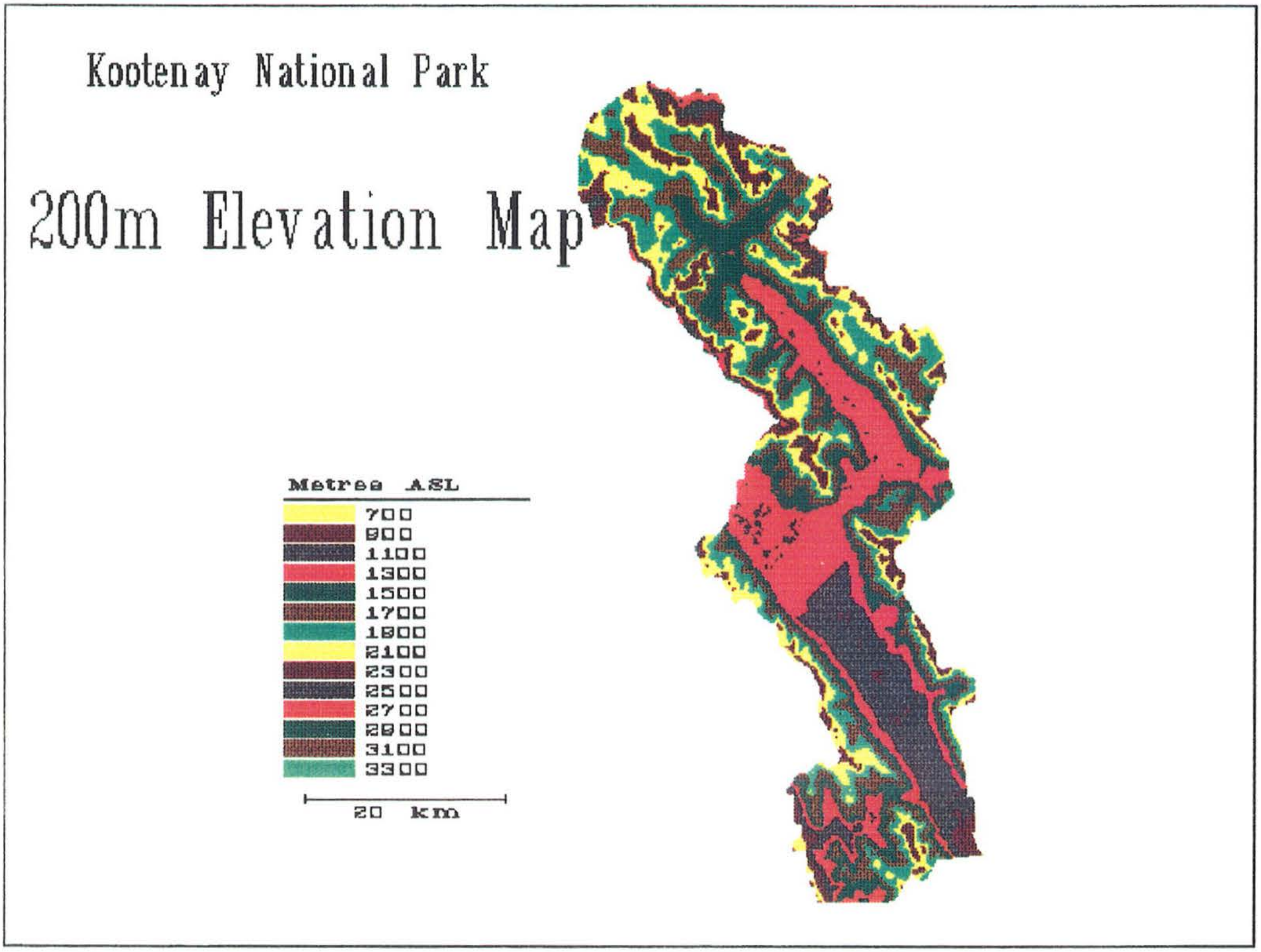
2.1.2 TERRAIN MAPS

In addition to digitizing the stand origin maps from the fire history study in Year 1 of this project, terrain maps of the Park were developed using SPANS. Over 3200 spot elevations were digitized from topographic maps and were contoured in SPANS to produce maps of elevation, slope, and aspect (the compass direction of a slope). Because of limitations in SPANS Ver 4.02 and earlier, only 1500 points could be contoured at one time. This required some tedious file separation to ensure enough overlap to perform the contouring on two subsets for the Park. Newer versions of SPANS are said to be able to use shadow memory available on 80386 computers to be able to contour up to 5000 points at one time (this has not yet been demonstrated as true in KNP).

The topographic map used to obtain the elevation points was the 1:200000 scale map of BNP, YNP, and KNP produced by Environment Canada. This map was found to be of poorer cartographic quality than the published ELC maps as control points were found to be approximately 200-300m in error. Contour interval was 200m. Digitizing of the spot elevations along contour lines took approximately 3 days with an additional 3-5 days for dividing the data into subsets and performing the contouring operations. (Contouring is extremely computation intensive and very slow even on a 20Mhz 80386 computer.) This process was laborious, but the maps of slope, elevation, and aspect are essential for any rigorous use of GIS in mountainous terrain. (See discussion on SIF Data Project in Section 2.11)

Figures:

- 200m Elevation map of KNP. This map was generated using the contour function of SPANS from 3197 spot elevation points digitized from a 1:200,000 scale topographic map. The data was subdivided near the 51 st. parallel and north and south halves contoured separately because of software limitations. These sheets were then joined together. Due to a small overlap, the area of join is not visible. The same data was used to produce slope and aspect maps.



Kootenay National Park
200m Elevation Map
Metres ASL
700
900
1100
1300
1500
1700
1900
2100
2300
2500
2700
2900
3100
3300
20 km

2.1.3 IDRISI

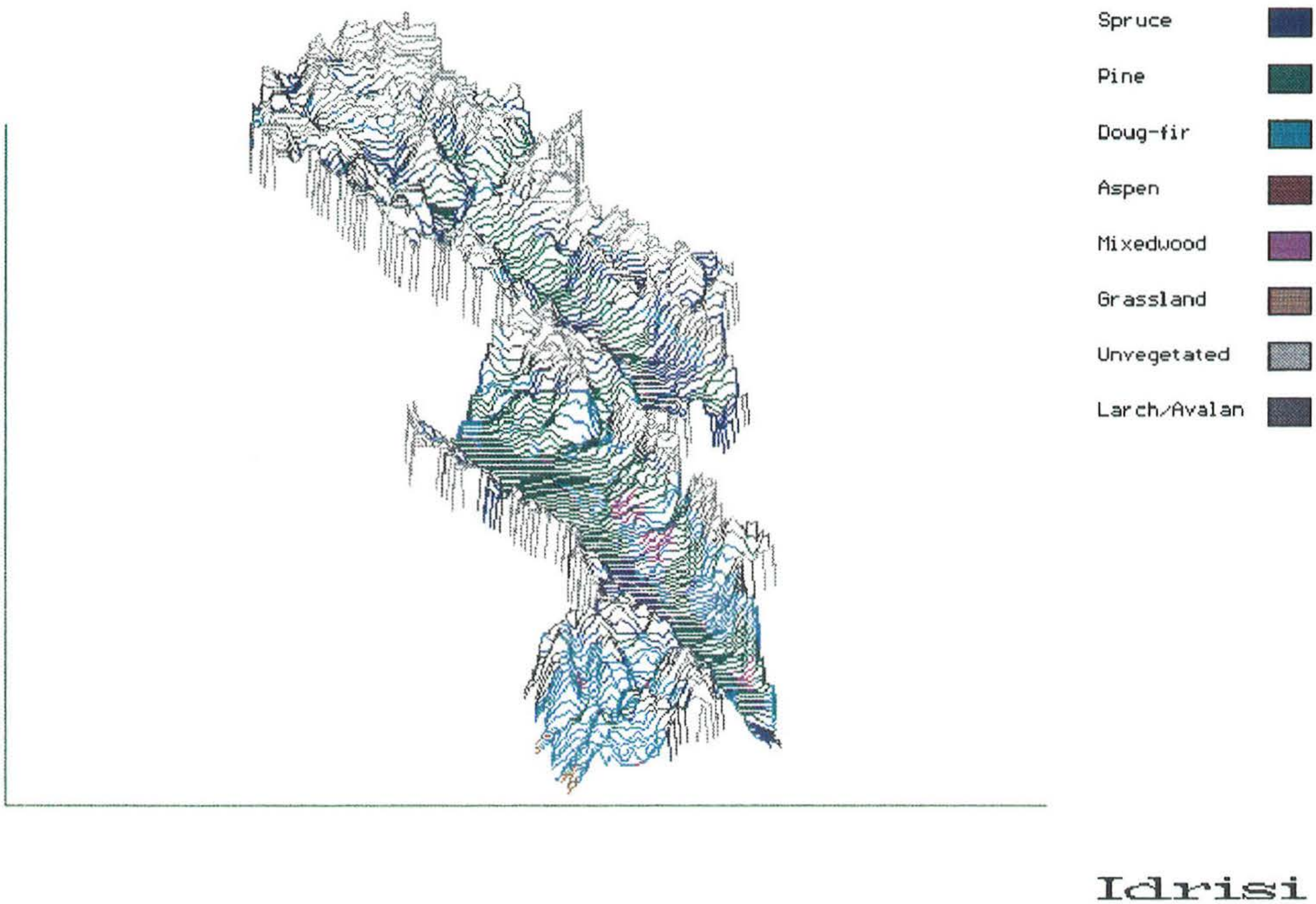
Another GIS program was used through the course of this study: Idrisi. This program was purchased before SPANS and includes functions not found SPANS: orthographic presentation (3-D) of elevation data, draping of thematic information on top of orthographic presentations, filtering and smoothing, maximum likelihood classification, visible area maps, watershed delineation, Moran's I value for autocorellation, etc. Idrisi lacks the full functionality of SPANS for raster and vector interfaces (limited support), integrated colour printer support, universal digitizing support, overlay modelling language, point sampling, etc. Idrisi is used by various universities (ie. University of Calgary and soon University of Alberta) to teach GIS to geography students, primarily because of price (US$50 for students, $100 for research/academic, and $300 for other). Idrisi is ideal for small research projects, and because the file formats are simple (raster, versus the complex - but efficient - quadtree structure of SPANS) users can access the data directly using other commercial and user developed software. SPANS raster maps (.rnl files) can be read directly by Idrisi with minor modifications. A copy of the KNP ELC, terrain, and fire study maps has been provided to the Geography Department of the UofC for use in their education programmes using Idrisi.

Figures:

- Othographic view of KNP, with fuel type overlay. Raster files exported from SPANS (.rnl and .rnh pair) can be read directly by Idrisi by renaming the .rnl file to an Idrisi .img file and creating a .doc documentation file using the information in the SPANS .rnh file. The elevation and fuels maps in SPANS were exported using the same quad level and were then overlayed orthographically using the ORTHO module in Idrisi. Ortho allows the user to specify orientation, viewing angle, and vertical exaggeration factors. This form of presentation quickly shows topographic limitations for certain vegetation types. A similar routine will be available in future releases of SPANS.

fuel

Superimposed upon : Elevation



WARDEN SERVICE

2.2 ROSMAPS: FIRE RATE OF SPREAD MODEL USING SPANS

The Canadian Forest Fire Danger Rating System (CFFDRS) is comprised of 3 subsystems: the Fire Weather Index (FWI) system, the Fire Behaviour Prediction (FBP) system, and the Fire Occurrence Prediction (FOP) system (under development). The FWI system provides general fire behaviour indices for a standard fuel type (Lodgepole or jack pine) consisting of fuel moisture codes, rate of spread and buildup indexes, and a final FWI value which is a measure of frontal fire intensity. The FBP system uses some of these FWI values to produce estimates of front and back fire rates of spread (in m/min), fire size calculations, and intensity for various broad fuel types. A certain rate of spread (ROS) value is required to initiate the transition from a ground or surface fire to a crown forest fire, which is very difficult to control. This ROS value is a function of the fuel type, slope, wind speed, wind direction relative to the aspect of the slope, and fine fuel moisture (revisions to the FBP system, to be published spring of 1990, will include buildup and other effects).

Before SPANS, fire management personnel in KNP could only estimate ROS values for certain individual situations and could not appreciate the variability or location of critical ROS values on a daily basis for the whole park, because of the complexity of the problem. Therefore, a set of modelling equations was written in SPANS to perform the necessary overlays and calculations to produce ROS calculations for the whole Park for use in research, teaching, and daily fire preparedness decisions. This set of command files and equations was called ROSMAPS. The system is run by entering the ROSMAPS universe, entering command mode, and typing:

```
exec f=rosmaps
```

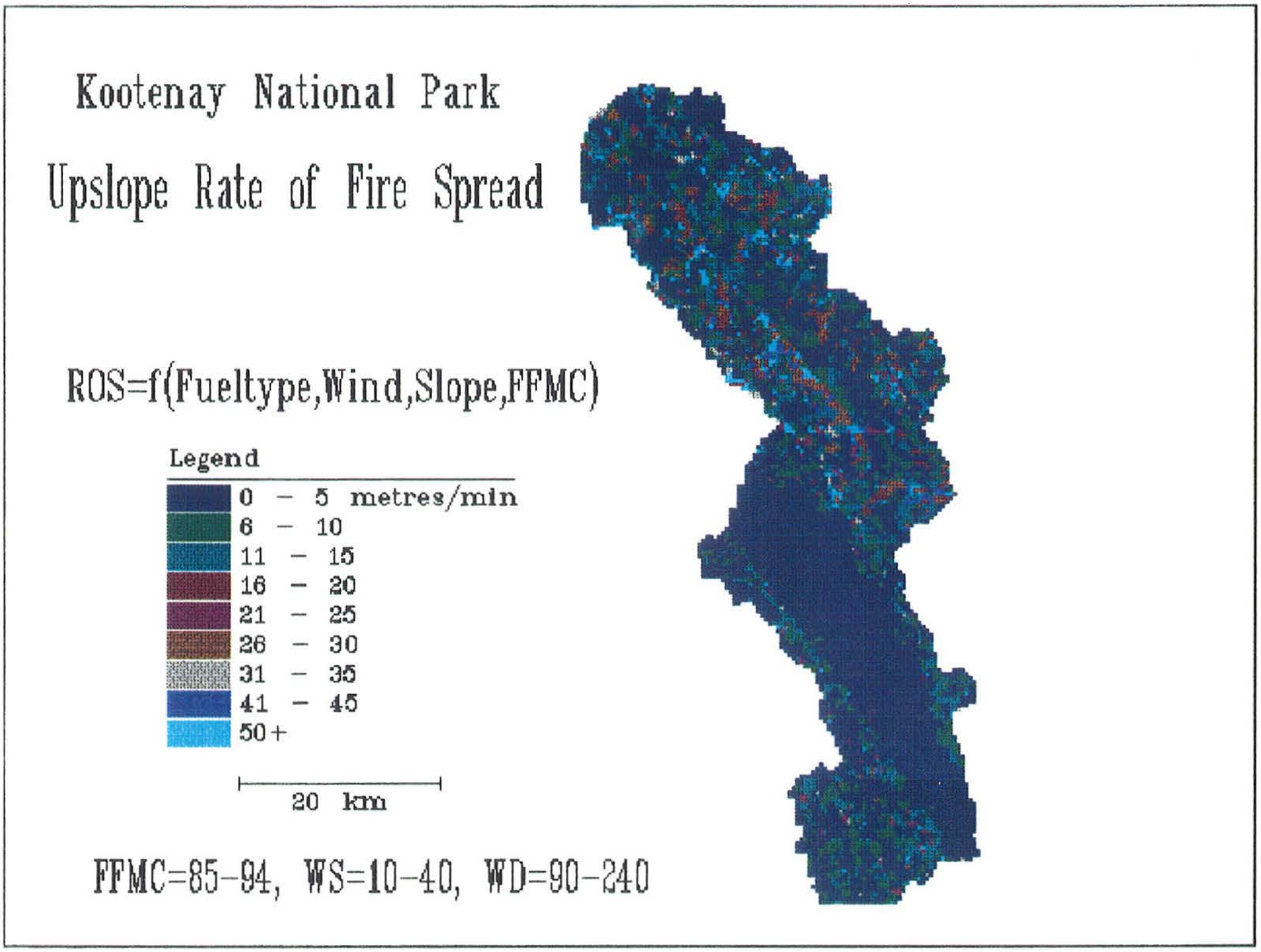
Each of the maps required to run ROSMAPS (fuel type, aspect, slope, fire weather zone) was re-quadded to use minimum quad (raster) sizes of approximately 200m to shorten execution speed. This level of resolution was thought to be adequate for ROS purposes. (The maps were re-quadded from 12m raster sizes by exporting raster - .rnl - maps and re-importing them using a lower quadding value.) The user is prompted for the Fine Fuel Moisture Code (FFMC) and wind speed for each of the Park's 3 weather zones (Vermilion, Kootenay, and Sinclair). These values are then assigned to each of the 3 valleys, for lack of more detailed weather information or weather models. ROS values are calculated on a cell by cell basis referring to the fuel map for the fuel type in each cell and then choosing the correct equation based on fuel type and Initial Spread Index (ISI) value as calculated from FFMC and wind speed. This ROS value is also adjusted for slope from the cell values from the slope map, assuming upslope fire spread with wind. A second map of ROS is generated using FFMC, fuel type, slope, and ISI without wind. The 3rd and final map of ROS that is produced compares the stated wind direction (obtained from the user) with the aspect of the slope (from the aspect map) and assigns a ROS value from the two previous ROS maps depending whether the wind is flowing up or down slope (ie. According to the FBP system at present, if wind and fire are spreading upslope use ROS adjusted for wind and slope; if wind is downslope and fire spreading upslope, use ROS for no wind).

The final map produced shows corrected ROS values for the whole park for fire spreading up-hill. An area analysis, showing the area in each spread class by valley, is also generated. The ROSMAPS files also include equations for calculating fire sizes and maps of crown fire potential based on fuel type and crown fire thresholds.

A complete scenario takes about 10-15 minutes to run using maps of 200m cell sizes (quad level 9) and >30 minutes using maps of <50m cell sizes (quad level >12 for this universe). Software developed specifically for this purpose by commercial vendors and other government agencies would perform this task in under 2-3 minutes. The disparity in execution speeds is a functionality/performance trade-off; while SPANS provides the user with the utmost in flexibility, execution speeds for overlay modelling is much longer. Flexibility and slow execution is acceptable for research (eg. overlaying ROS maps with vegetation types and performing frequency analyses) but it is likely that for daily fire operational preparedness another (faster) system would be preferred (see Section 2.10).

Figures:

- ROS map for KNP using data from July 29, 1989 (wind adjusted). Note the higher rates of spread values in the Vermilion and Sinclair Valleys as compared to the Kootenay Valley because of higher fine fuel moisture codes (FFMC). Because FFMC and wind values were lower in the Kootenay Valley this particular day, the highest ROS values occurred only on the steep slopes of the valley walls of the Kootenay river valley. An area analysis of this map is produced by the ROSMAPS equations which allows for %coverage comparisons. Fire control effort would have to be allocated quickly to the Vermilion to control any fires.


Kootenay National Park
Upslope Rate of Fire Spread
ROS=f(Fueltype,Wind,Slope,FFMC)
Legend
0 – 5 metres/min
6 – 10
11 – 15
16 – 20
21 – 25
26 – 30
31 – 35
41 – 45
50+
20 km
FFMC=85-94, WS=10-40, WD=90-240

2.3 SPATIAL WIND PREDICTION USING WNDCOM

This section describes in brief the process of developing a spatial implementation of W.C. Ryan's WNDCOM model for surface wind prediction in mountainous terrain. Complete details, references, model algorithms, and copies of the program can be obtained from Kootenay National Park. A separate report entitled 'Spatial wind prediction in mountainous terrain for forest fire management' by the same author can also be obtained from KNP. The program diskette for KNP contains a README file which provides full details and references.

WNDCOM is a wind speed and direction prediction model developed by the US Forest Service to assist in diagnosing and predicting surface winds in mountainous terrain. A user's guide for the model was produced that detailed the many complex calculations required. S.G. Pickford of the University of Washington, during a period as a Visiting Scientist at the Northern Forestry Centre of Forestry Canada in 1987/88, implemented WNDCOM in a IBM PC compatible program called WCM. This program greatly enhanced the ability to observe how WNDCOM works but was designed to work only on one point at a time. Wind information was required in KNP for two reasons: 1) to use in the ROSMAPS application for fire rate of spread calculations in SPANS, rather than just assigning one weather station's values to a large area, and 2) to explore the spatial variation in wind speed and direction as a function of terrain and other parameters for the purpose of investigating these effects on the fire history of the park. It was proposed to develop a set of programs to collect all the information about the terrain required by WNDCOM and then batch calculate WNDCOM estimates for a sample grid of points. Using contouring or voronoi display, these points would be used to show a map of wind speed and directions (ie. a wind field).

WNDCOM requires for each point the slope to the horizon (in percent) for each of 24 - 15 degree increments around the compass and the aspect of the facing terrain on each of the 24 arcs. Also required is the elevation, slope, aspect, and up-valley direction at each point. A computer program was written to overlay elevation, slope, and aspect maps of KNP and to search out from each point to find the necessary horizon information and then write the data for each point out to a file (the program is called WCMTERRA and is written in Turbo Pascal Version 5.5). Initially, Idrisi was used to develop the terrain maps using point elevation data digitized from topographic maps. However once the terrain maps had been developed in SPANS, a different procedure was used which involved creating a 1 km^2 sample grid and then using points modelling to sample the elevation, slope, and aspect maps. The UTM coordinates for these sample points were created with a custom computer program to produce points on 500m centres within the grid square that covers KNP. These coordinates where then used as indexes within an 85 by 45 cell array, and the searches performed within a nested loop. Latitude and longitude was also required by each point.

WNDCOM also requires the date, time, adjustment of local time from Coordinated Universal Time, atmospheric transmissivity, and geostrophic wind speed and direction. Atmospheric transmissivity is an index of sky conditions (0.9 for clear to 0.4 for overcast). The geostrophic wind is the unrestricted airflow over the surface at about the 750mb level (3000m AMSL). These wind speed and direction values are obtained from the nearest weather office from 750mb maps or radiosonde data. All of these parameters are common to each point in the model.

The actual WNDCOM calculation program was written to prompt the user for the 'global' parameters and then read the data for each point and make the WNDCOM calculations. Using the coordinates established for each point, a map of wind speed and direction is then plotted. Frequency statistics can be obtained by importing the data to spreadsheet, database, or statistical programs. The wind data for each point can also be imported to SPANS, contoured to produce a wind field map, and then used as an overlay for other analyses (such as the ROSMAPS application or investigating vegetation type occurrence with areas of frequent high wind speeds due to terrain effects, for example). Refer to 'Spatial wind prediction in mountainous terrain' by the same author for more details and examples. A version of the WNDCOM calculation program was provided to Forestry Canada for implementation on the KNP trial of the Intelligent Fire Management Information System (IFMIS, see Section 2.10). Copies of the KNP WNDCOM program have been distributed to offices of Forestry Canada, BC Ministry of Forests and Lands, Alberta Forest Service, Universities of Calgary and Alberta, and various offices within the Canadian Parks Service.

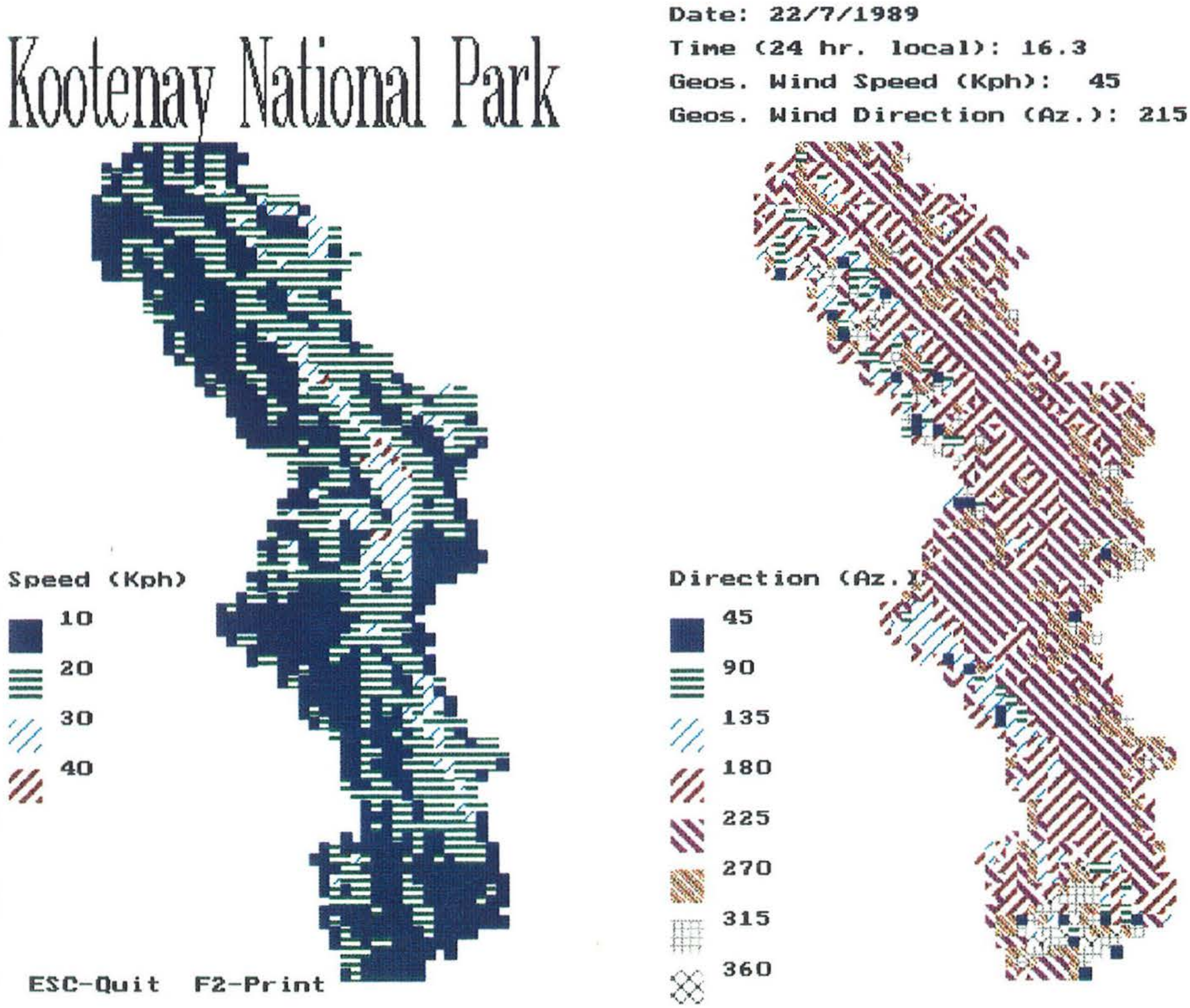
Figures:

- Menu and input screens from the WNDCOM program for KNP. The program is menu driven and prompts the user for date, time, atmospheric, etc. information to run the model.

- Example run of the model for KNP showing the results of 1406 WNDCOM calculations (1 per km). In this instance (a warm, summer day with geostrophic wind from the SSE) the strongest wind speeds occur in steep canyons and on SW facing slopes, due to surface heating on the slopes and chanelling of wind by surrounding terrain. This data can be exported to an ascii file for statistical processing or import to SPANS for use as an overlay.

```
            Gone With The WindCom
   By Alan Masters - November, 1989

        F1   Help
        F2   Directory
        F3   Set Files and Data
        F4   Calculate and Show Wind
        F5   Show Last Map
        F6   Write last to ASCII
       F7   Quit

(c) 1989 - Canadian Parks Service
```

```
                          Gone With The WindCom

              Day => 22     Day of month (eg. 12)
            Month => ·7
             Year => 1989
             Time => 16.3
        Time Zone => 3
                     2
     Atmos. Trans. => 0.9
Geos. Wind Speed => 45.0
 Geos. Wind Dir. => 215
    Horizon File => ··KHORIZ.HRZ
    Out Put File => ····TEST.WND
   Title for map => Kootenay National Park

(c)Press F10 key when finishedice
```



Kootenay National Park
Date: 22/7/1989
Time (24 hr. local): 16.3
Geos. Wind Speed (Kph): 45
Geos. Wind Direction (Az.): 215
Speed (Kph)
10
20
30
40
ESC-Quit F2-Print
Direction (Az.)
45
90
135
180
225
270
315
360

WARDEN SERVICE

2.4 LANDSAT IMAGE ANALYSIS FOR FOREST FUEL TYPES

Full details regarding this project can be obtained from KNP in the following: Terms of Reference for Contract KKP0099 (1989/90) with Intera Technologies of Calgary, Landsat project files, and the final report for the project by Intera Technologies, Ltd. (in progress February 1990). The following presents a summary of progress to date.

An image analysis project for the purpose of identifying forest fire fuel types was undertaken for the following reasons: 1) future fire growth models will require more detailed fuel cover maps than what can be obtained from the Park's ELC maps (because important non-fuel features such as avalanche tracks, rock out-crops, roads and rivers are not shown as spatial entities on the SPANS ELC maps); 1) having SPANS in the Park presented a unique opportunity to import classified imagery into the GIS for overlay with other map data; 2) the effectiveness of using satellite imagery for mapping forest disturbance such as mountain pine beetle infestations or other processes could be tested for future application to updating of biophysical inventories; and 3) new techniques for coping with severe shading in mountainous terrain could be tested.

The image analysis project involved the following sequence:

1) <u>Needs Analysis</u>: It was determined that 25x25m or 50x50m pixel sizes for a fuel type map would be adequate for fuel mapping for specific prescribed or wildfires. The imagery would have to be acquired at such a time as to minimize cloud cover and shading, and to maximize spectral contrast between the major types sought. The Canadian Forest Fire Danger Rating System FBP fuel types would be used as a general guide for the classification (<u>ie.</u> spruce, pine, aspen, Douglas-fir, grassland, mixedwood, slash, etc.).

2) <u>Acquire Imagery</u>: A LandSat Thematic Mapper (TM) quad (1/4 scene) of 7-spectral bands was purchased from the Canada Centre for Remote Sensing, Prince Albert Satellite Station. Because of cloud cover during overflight at the summer solstice, shading could not be minimized. An acquisition date of September 9, 1988 was chosen. Though there was some snow cover at high elevations, this date would tend to maximize contrast between deciduous and coniferous vegetation yet allow for an image to be taken on a clear day.

3) <u>Secure Contractor for Image Analysis</u>: A request for proposal was circulated to four image analysis companies and Inter Technologies of Calgary was selected. The terms of reference for the contract allowed for an initial project meeting, assistance with identifying training sites, geo-correcting of the image, actual classification, a proposed methodology for an accuracy

assessment, and a final report.

4) Establish Classes: A colour composite enlargement of the positive transparency purchased with the imagery (bands 3,4 and 7) was inspected to assist with definition of classification themes necessary to classify the image. Establishing types in addition to the forest fuel types was necessary to minimize the unclassified area of the image. This step included an aerial reconnaissance with photographing of potential training sites and to familiarize the image analysis system operator with the terrain and cover types. The following types were established for the initial classification:

Fuel Type Abbrev.	Description
C-2	Subalpine Fir/Spruce
C-3	Mature Lodgepole Pine
C-4	Immature Lodgepole Pine
C-7	Douglas-fir
D-1	Aspen
M-2	Mixedwood Summer
O-1	Grassland
S-1	Slash/Clearcuts (adjacent to KNP)
R-1	Rocks/snow
R-2	Roads - paved, gravel, gravel pits
R-3	Borrow Pits
A-2	Avalanche Tracks - grass/forb type
A-1	Avalanche Tracks - shrub/small tree
L-1	Alpine Meadow - may include larch
L-2	Alpine Larch - open or pure
W	Water
H	Shadow
G1	Glacier
U	Unclassified

5) Geocorrection and Import to Image Analysis System: The imagery was first loaded onto an Aries III image analysis system and a 'rubber sheeting' performed using ground control points selected from topographic maps. This process is required to correct the image for distortions created by viewing a curved surface, from a large distance, from a moving object (ie. a satellite in space). It was later found that this step was in error, and that geocorrection was required again using a slightly different process. Also at this time, the original 30x30m pixels in the image were resampled to provide an image made up of 25x25m pixels. This new (raw) image was then transported to a IBM PC AT 386 microcomputer based image analysis system called EASI/PACE from Perceptron Computing, Inc. (PCI). This PCI system provides an interface data standard supported by SPANS.

6) Selection of Training Sites: Training sites (ie. areas of known 'type' to be used to 'train' the image analysis system to

recognize other areas with similar spectral properties to the training site) were selected in each of the above types, including sites in shaded areas for each type. Five sites (approx 250 ha) were located for each type and digitized into the PCI system using a digitizing tablet simultaneously with viewing the raw image on a high-resolution colour monitor. This is a very important procedure, and sites must be selected very carefully to represent only the type in question (ie. to avoid overlap onto other types). Once the training sites for each type were digitized, the PCI system then constructs frequency tables of pixel values from certain combinations of the TM bands. These 'spectral signatures' are then used to perform the actual classification. (Refer to Intera report for actual bands used.)

7) Initial Classification: The procedure thus far is known as a 'supervised classification', that is, the users are specifying certain types for the image analysis system to 'look for'. The alternate procedure would be an 'unsupervised classification' where, using various statistical techniques, the system recommends band and frequency combinations that will produce the most likely different types. A combination of the two procedures was used in this project after it was determined that supervised classifications using the signatures obtained from the different training sites were producing some overlapping results (ie. signatures from different types were classifying the same type, an 'error of comission'). This initial classification was performed on subsets of the main image using a 512x512 pixel area. Several subscenes were chosen to encompass most of the types. The PCI image analysis system is configured such that the operator and client can work at the system at the same time; the operator sits in front of the keyboard and text monitor to control the system, and the client can sit in front of the colour display and operate the digitizing tablet to resize the image, switch between the raw colour image and the classified image, etc. This configuration allows for good interaction between the project personnel. Once different combinations of spectral bands and new training sites seemed to produce a 'good' classification, a maximum likelihood classification procedure was performed on the whole image (a procedure that required overnight processing).

8) Exporting the Final Image to SPANS: The original LandSat TM data required over 120 MB of disk space; the classified image from PCI was reduced to approximately 7 MB. Because SPANS converts the .pix (PCI) file to a .rnl (raster) file, and then space is also required for the .map file in SPANS, approximately 18-20 MB of free disk space was required for the import process. Once the procedure was determined (through several consultations with PCI and Tydac), the data was successfully imported to SPANS. It was here that the initial problems with geocorrection were discovered by comparing the location of Highway 93 from published maps with the correct location from a digitized vector and the

incorrect position of the highway as seen on the image. Several months elapsed before this problem was corrected and the accuracy assessment was performed.

9) <u>Accuracy Assessment</u>: A computer program was written to generate 1000 random points in the 45x85 km grid area surrounding KNP. Approximately 450 of these points fell within KNP and the remainder were discarded. Several modelling equations were written for SPANS to extract for each point the fuel type from the ELC map and the fuel type as determined from the LandSat classification. For each of these points, the 1:100,000 scale enlargement of the false-colour positive was inspected to determine the actual fuel class ('the truth'). Additional points (to a total of 501) were chosen so that each class would have a minimum of 25 points. The number of points in each class were then assembled to compare the truth versus the ELC and then the LandSat classifications. This summary is called an error matrix from which the total accuracy can be determined (simply the number of correctly classified points divided by the total number of points). At the time of writing, initial accuracy assessment figures show the LandSat image to be 40% correct and the ELC classification to be 48% correct. These results were initially discouraging but should be judged as only preliminary and subject to further analysis. It is felt that the accuracy assessment itself may be in error because of the following:

- Truth classes were sometimes difficult to determine from the 1:100,000 scale photograph, because of poor reproduction. Ground checking would be the best, but very costly.
- Accurate (within 100-200m) UTM positions are difficult to obtain on 1:50,000 scale maps. When a point would seem to fall on the boundary between an avalanche track and the surrounding forest, it was difficult to determine whether the truth in this instance should be one type or the other. Errors in determining the truth could result.
- SPANS attaches the class value of the pixel in which the point falls. If maps are overlayed that are at different pixel resolutions, SPANS assigns the class value of the pixel closest to the centre of the larger pixel to be the value of the finer resolution map. The LandSat image was classified on 25m pixels and the ELC and LandSat fuel maps in SPANS were quadded to approximately 25m resolution. However, accuracy assessment points can only be located to within 100-200m accuracy from the 1:100,000 scale photograph and the 1:50,000 scale maps.
- Training site selection may have included 'outlier pixels' which could cause much of the errors of comission seen in the error matrices.

In summary, the project was successful in performing the required

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classification and transporting the data to SPANS for use as an overlay. The accuracy assessment, however, does not indicate that overall the LandSat is any more accurate than the ELC for fuel type classification. Due to time and financial constraints, a number of techniques to improve the classification could not be pursued, but are recommended as follows:

- Re-examine the frequency distributions of the training site signatures and re-sample training sites for classes as necessary. Perform the classification using this new set of signatures.
- Utilize terrain data layers (such as elevation, slope, and aspect) or other themes in a modelling approach to further correct the classification. For example, all pixels classified as water on slopes > 0% may in fact be glacier or shadow classes. Similar rules for change could be developed for fuel types.
- Re-establish class values for the truth points using the false-colour image in PCI, 1:25,000 scale aerial photographs, or from actual ground surveys. Use of sophisticated global positioning systems (such as SatNav or Loran) would greatly improve the accuracy of truth point location description.

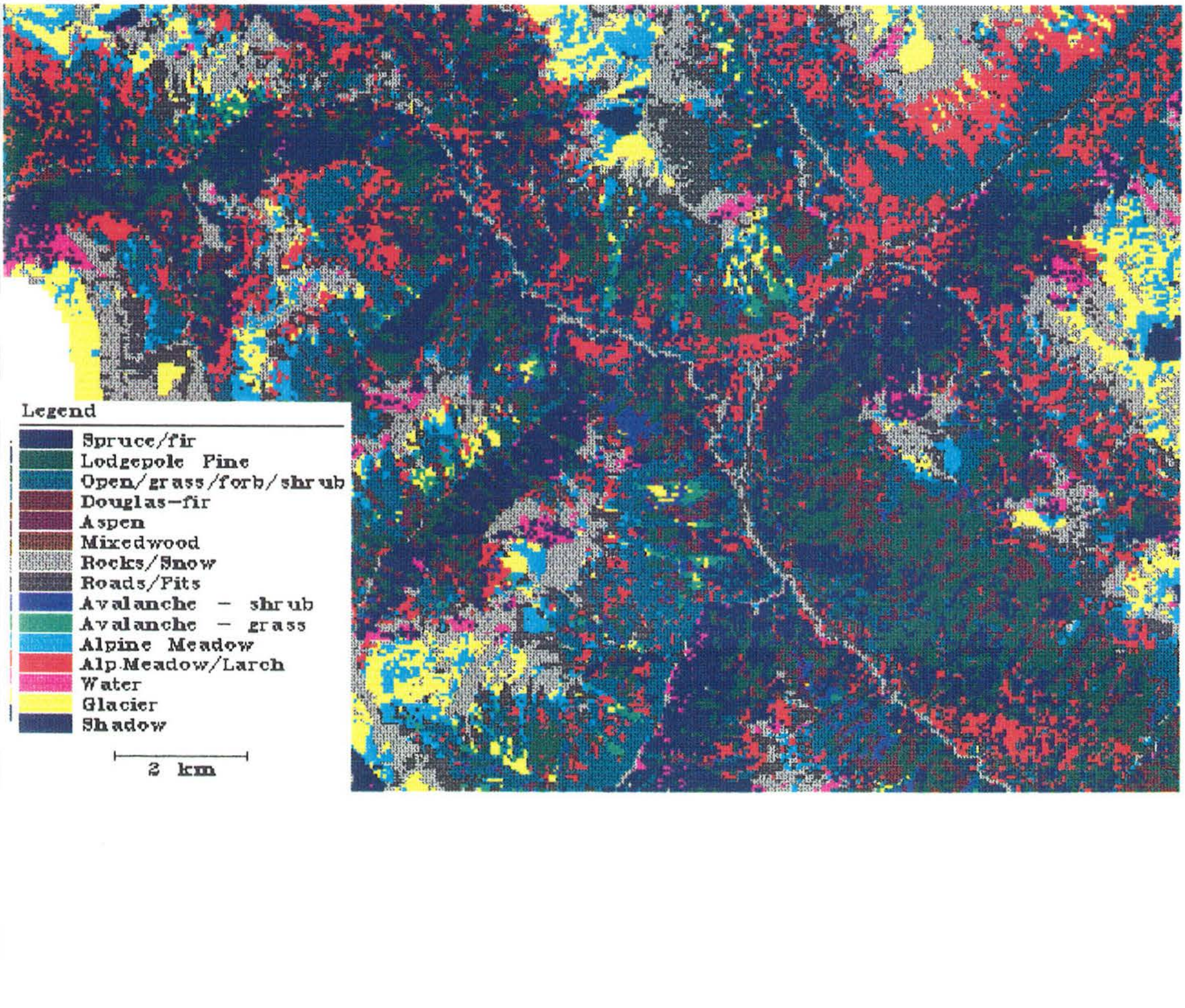
Refer to the Intera final report on this project for details concerning the final classifications, frequency values, and other information.

Figures:

- Classified subscene of Numa Flats area of KNP. Note significant area classified as shadow (no information). The shadow covers NW facing slopes as the image was acquired early morning in September (sun angle from SE). The highway and open gravel flats of the Vermilion River and tributaries are clearly visible.

- Accuracy assessment error matrices for Truth vs. LandSat, Truth vs. ELC, and ELC vs. LandSat. Diagonals indicate correctly classified pixels. KHAT statistic is used to compare different classifications. Refer to discussion in text.

LandSat Fuel Classification Numa Flats Area



LandSat Accuracy Assessment - Kootenay National Park
Run date: 1/22/1990 at 14:19:11

Truth — LSat Class Number

+	1	2	3	4	5	6	7	8	Row	Row Accuracy.
1	25	18	7	6	2	11	12	8	89	0.28
2	6	23	18	1	3	11	1	5	68	0.34
3	2	17	4	2	1	3	2	2	33	0.12
4	0	6	4	6	1	5	1	2	25	0.24
5	1	7	4	6	0	4	0	2	24	0.00
6	0	2	0	0	0	9	9	5	25	0.36
7	5	6	4	0	1	10	96	19	141	0.68
8	5	4	4	4	0	24	19	36	96	0.38

Total Points = 501
Overall Accuracy = 0.3972
KHAT Value = -0.1949
Variance of KHAT = 0.0178

CLASS LEGEND

1 SPRUCE/FIR
2 PINE
3 OPEN, GRASS, SLASH
4 D-FIR
5 ASPEN
6 MIXEDWOOD
7 ROCKS, SNOW, PITS, GLACIER
8 AVALANCHE TRACKS, ALPINE VEG

LandSat Accuracy Assessment - Kootenay National Park
Run date: 1/22/1990 at 14:20:34

Truth — ELC Class Number

+	1	2	3	4	5	6	7	8		
1	51	16	5	0	1	0	1	15	89	0.57
2	8	36	16	0	2	0	0	6	68	0.53
3	2	6	20	0	4	0	0	1	33	0.61
4	1	5	1	0	12	0	2	4	25	0.00
5	3	7	13	0	1	0	0	0	24	0.04
6	3	6	2	0	0	0	8	6	25	0.00
7	8	21	9	0	0	0	93	10	141	0.66
8	26	3	5	0	0	0	29	33	96	0.34

Total Points = 501
Overall Accuracy = 0.4671
KHAT Value = -0.2153
Variance of KHAT = 0.0215

LandSat Accuracy Assessment - Kootenay National Park
Run date: 1/22/1990 at 14:25:46

ELC — LSat Class Number

+	1	2	3	4	5	6	7	8		
1	30	12	8	3	1	18	14	16	102	0.29
2	9	28	18	7	3	15	12	8	100	0.28
3	2	23	12	6	4	11	6	7	71	0.17
4	0	0	0	0	0	0	0	0	0	0
5	0	9	0	6	0	3	0	2	20	0.00
6	0	0	0	0	0	0	0	0	0	0
7	1	0	1	0	0	12	90	29	133	0.68
8	2	11	6	3	0	18	18	17	75	0.23

Total Points = 501
Overall Accuracy = 0.3533
KHAT Value = -0.1926
Variance of KHAT = 0.0230

2.5 STRIKES: LIGHTNING STORM REPLAY

Seven Western Region national parks (including the Regional Office) obtain fire weather and lighting information from the British Columbia Ministry of Forests and Lands Protection Information System. The system provides lightning strike maps obtained from a network of electromagnetic detectors linked to a position analyzer and mainframe computer in Victoria. The Parks access this computer through microcomputers and telephone modems and specify a period and map name to generate a character-based printer map of lightning strikes. The lighting data can also be obtained in a report which lists the latitude, longitude, date, time, and polarity of the lightning strike. At present, the CPS users of this system cannot obtain graphical screen output of the lightning strikes in order to see the progression of the storm (this feature is available on the BCMFL Advanced Fire Management System).

In order to redisplay lightning storms and observe the sequence of lightning activity, a computer program was written to plot a map of the area surrounding KNP (BCMFL Map #623 covering BNP, YNP, KNP and surrounding area) and then to plot the locations of lightning strikes from a specified file. The map file was obtained by digitizing the mylar overlay used on the BCMFL printer maps using the TYDIG digitizing program provided with SPANS (certain modifications were made to the vector file). The actual lightning data is obtained from the BCMFL system by specifying output to a report file rather than a map. This report is then listed to the screen and captured to an ASCII file on the remote microcomputer. The file of lightning strikes is then edited to remove extraneous information and left in a format such that only the necessary information is retained in the file. The data is sorted by date and time, in ascending order.

The program STRIKES.exe will ask the user to select which map and strike file to use (only map 623 supported at this time) and then will proceed to plot the map and then the strikes in order of occurrence. Date and time of each strike and a cumulative strike count is also shown. Negative polarity lighting strikes (ie. strikes emitted from the lower portion of thunder clouds) are shown in green and positive strikes (emanating from the top of clouds) are displayed as a large, red, '+' (plus sign). It is necessary to know the polarity of the strikes because positive strikes are thought to produce more fires than negative strikes. Because positive strikes emanate from the top of clouds, they may travel several km laterally before striking the earth, thus avoiding precipitation that may be falling from the thunderhead.

A copy of the strikes program, documentation, and data files can be obtained from KNP.

Figures:

- Menu and input screen for STRIKES program.

- Plot of 1475 lightning strikes in the BNP, YNP, KNP area during a 48 hour period from July 10 - 11, 1988. The program plots the strikes in chronological order, thus allowing the user to 'replay' the storm and watch the progression of the storm. The red (+) lightning strikes seem to occur in bursts. The track of the storms on these two afternoons was from S to N. Lee cyclogenesis was also evident by watching the high density of strikes develop in the Rocky Mountain House area.

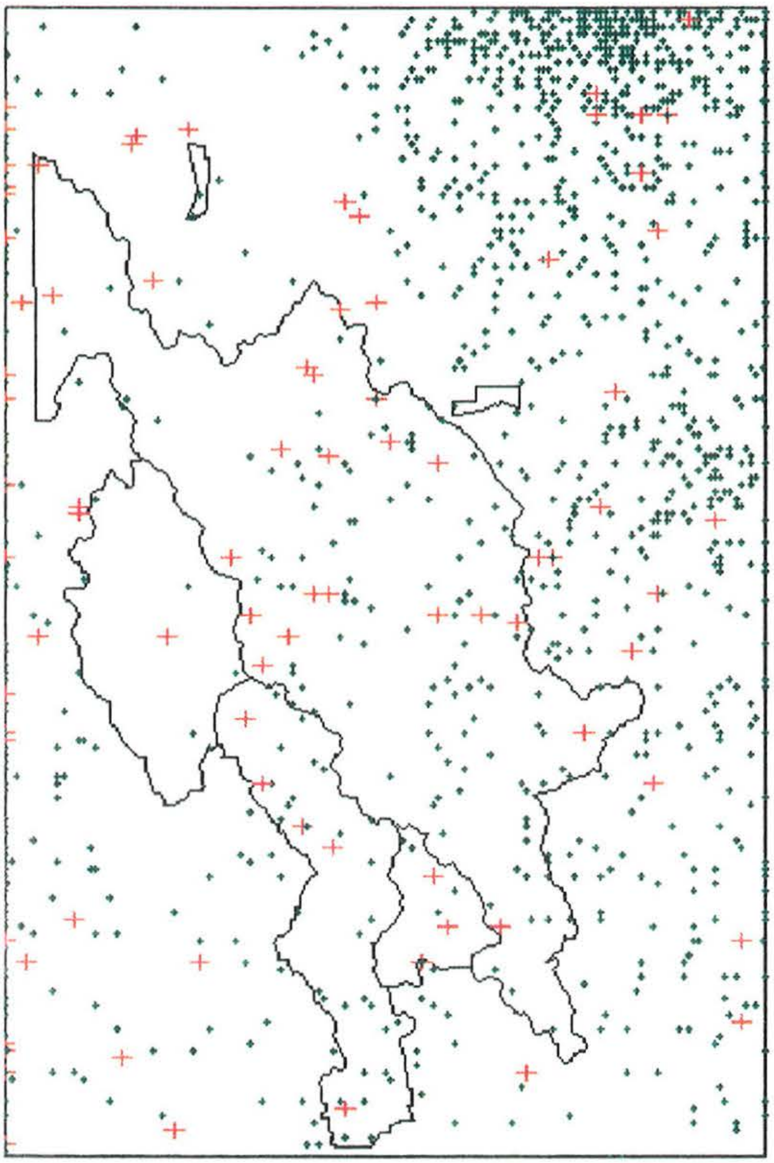
```
Lightning Strike Replay Program
Version 2 : February, 1990

F1   Help
F2   Directory Listing
F3   Set Files and Replay Speed
F4   Replay the Storm
F5   Quit

Press F10 key when finished
Map File to Use =>            BCMFL623.MAP··················
Storm File to Replay =>       LTG825.LTG····················

Replay Speed =>               10
Title for Display  =>         Lightning Strikes···

Enter drive:\path\filename if required
```



BCMFL Map #623 - Banff, Kootenay, Yoho

Strikes Plotted: 1475

ESC-Quit F2-Print

July 10-11, 1988

2.6 PRESCRIBED/WILDFIRE CONTAINMENT UNITS MAP

G. Watkins of the KNP Warden Service prepared a 1:50,000 scale map of KNP that detailed over 70 possible prescribed fire / wildfire containment units. Boundaries for the units were based on natural fuel breaks or areas where line building (by hand tools or heli-torch) would be minimized. Judgement was used to define unit boundaries that could be defended in the event a wildfire started in the unit and initial attack failed, forcing consideration of an indirect fire fighting strategy. In this way, the units can be considered Wildfire Containment Units. The same strategy is used if the units are used for intentional fires. The fire may act in a similar manner as in a wildfire, but the unit may be ignited in such a way as to consume fuel along guards in advance of the fire front. Many of the boundaries may have to be changed depending upon the circumstances of a wildfire or the purpose of a prescribed fire. In any event, this process of dividing the Park into management units based on fire control criteria is an essential and difficult task. Each unit was described in terms of size, fuels, values at risk, ignition/suppression strategies, etc. on a form that is kept at the KNP Warden Office. These descriptions will require further work.

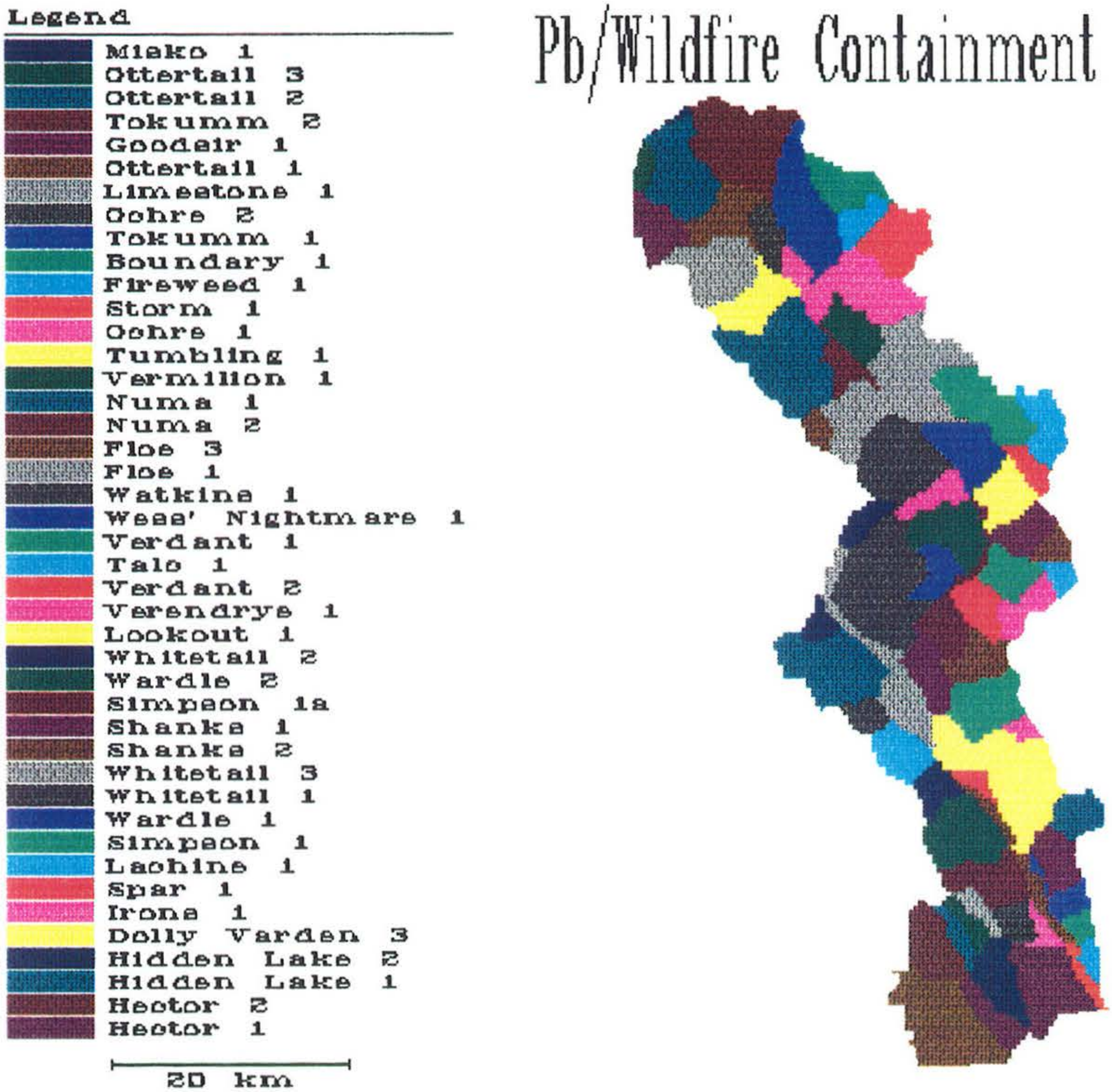
This map was then digitized and imported into SPANS for use as an overlay in the Fire/Resource Management Modelling Project (PBWFUNIT.MAP). The map was essential for use in the modelling project because it provided a starting point to develop alternate management scenarios that would embrace the whole landscape of the Park. Different management schemes may require the scheduling of units along a defined sequence (eg. to manage the elk winter range on a shorter fire cycle than the rest of the park to maintain open habitat, or to minimize fuel accumulations near boundary areas) or scheduling may be at random (with a specified probability distribution) in order to 'duplicate natural processes as closely as possible'. It was important to involve fire control staff directly in the preparation of this map in order to gain their acceptance of it's use as a planning tool.

Figures:

- Prescribed (Pb) / Wildfire containment units map. The map shows over 70 individual units (display is limited to 16 colours). Boundaries were drawn using an experienced fire control officer to interpret aerial photographs, fuel breaks, and operational concerns. This map was used to explore alternate management scenarios in the modelling workshop.

- Area analysis of PB/WF units map, showing the area of each unit and the mean forest age.

Pb/Wildfire Containment Unit Map



/ERAGE OF CLASSES BY AREA Stand Origin Date X Pb/WF Units :Window 00-Universe

Ciass	Legend Item of PB/WF Unit	Avg	% Area	Area km²
	Misko 1	1678.00	0.04	0.322
	Ottertail 3	1560.00	0.29	2.500
3	Ottertail 2	1573.12	1.68	14.648
	Tokumm 2	1722.00	1.04	9.128
	Goodsir 1	1706.39	0.35	3.058
6	Ottertail 1	1692.27	1.13	9.838
7	Limestone 1	1746.19	1.49	13.020
	Ochre 2	1739.37	0.66	5.776
	Tokumm 1	1776.73	1.78	15.567
10	Boundary 1	1804.50	0.65	5.653
1	Fireweed 1	1950.88	0.94	8.200
2	Storm 1	1881.33	1.12	9.781
13	Ochre 1	1782.64	2.76	24.155
14	Tumbling 1	1780.98	1.25	10.918
5	Vermilion 1	1830.35	1.66	14.506
17	Numa 1	1701.20	2.11	18.445
18	Numa 2	1818.80	0.63	5.464
0	Floe 3	1718.00	0.30	2.642
1	Floe 1	1787.67	4.49	39.277
22	Watkins 1	1775.05	2.85	24.922
3	Wess' Nightmare 1	1769.92	2.14	18.720
4	Verdant 1	1722.37	1.57	13.720
25	Talc 1	1720.00	0.87	7.575
6	Verdant 2	1654.70	0.41	3.608
7	Verendrye 1	1784.88	0.81	7.045
8	Lookout 1	1759.69	1.55	13.531
29	Whitetail 2	1908.26	0.64	5.568
0	Wardle 2	1860.77	1.95	17.006
2	Simpson 1a	1850.14	0.31	2.727
33	Shanks 1	1771.78	1.62	14.146
4	Shanks 2	1816.11	0.71	6.212
5	Whitetail 3	1902.61	1.44	12.575
36	Whitetail 1	1910.90	5.90	51.605
37	Wardle 1	1917.33	1.09	9.516
8	Simpson 1	1766.49	1.39	12.177
9	Lachine 1	1776.52	0.57	5.000
40	Spar 1	1867.55	0.97	8.456
1	Irons 1	1698.50	0.92	8.011
2	Dolly Varden 3	1844.07	1.58	13.787
etc. for units 43 to 65				
66	Mitchell 2	1913.72	0.58	5.047
67	Mitchell 1	1874.39	0.53	4.668
8	Kootenay 1a	1879.19	0.61	5.303
9	Swede Creek	1909.50	0.62	5.445
71	Sinclair 2	1873.29	1.96	17.091
2	Kindersley 1	1802.88	0.52	4.583
3	Kindersley 2	1858.09	0.25	2.168
74	McKay 1	1886.00	1.69	14.762
75	Kimpton 1	1868.67	3.22	28.104
6	Pink Slip 1,2,3	1848.22	4.98	43.490
Total		1823.01	100.00	873.927

2.7 TRI-PARK FIRE MANAGEMENT PLANNING PROJECT

Parks HQ initiated a project to assist three parks (KNP, Pukaskwa, and La Maurice) in preparing comprehensive fire management plans. By taking advantage of an economy of scale, a contractor would be hired to assemble the necessary databases (ie. fuels, weather, fire occurrence, wildlife information, etc.), conduct policy options simulation workshops, and then to prepare a draft of the final fire management plan. Because KNP had already completed the databases required, KNP's share of the total cost of the project was reduced (refer to Terms of Reference and contract documents for specific details). KNP became involved in this project because 1) a simulation workshop was proposed for the project in Year 1 of the study, but the park lacked the specific computer programming and modelling support required, 2) the Project Forester may not have been able to remain in KNP for a third year to complete the fire management plan, and 3) the use of simulation modelling (and the assistance of the contractor and other staff) would permit exploring a more integrated management scenario by involving wildlife and other resource management concerns in the modelling and planning process. The objective of KNP's involvement was to use modelling as a process (not a product) to prepare a 'better' resource management plan that involves fire management.

The modelling workshop was structured following the concepts of Adaptive Environmental Assessment and Management (AEAM) developed in the 1970's at the University of British Columbia. AEAM uses modelling as part of a process to involve the various participants in a resource management issue in an atmosphere of mutual cooperation, conflict resolution, learning, and exploration. The use of a computer simulation model forces participants to be explicit about resource dynamics by clearly stating what is known and what is conjecture. Conflicts between participants can sometimes result, but this 'creative animosity' can sometimes lead to the abandoning of well-worn convictions and the formation of new, innovative insights into solving the problem. The construction of a computer model is an objective only insofar as it facilitates quantitative, explicit description of resource dynamics and the implications of various policy alternatives. The model must not be taken as 'truth'. As one person stated, " ... models are tools for thinkers, not crutches for the thoughtless."

The 5-day workshop was held in KNP in December of 1989, with staff from the Canadian Parks Service (KNP, MRGNP, WRO, PHQ), B.C. Ministry of Environment Fish and Wildlife Branch (Invermere), B.C. Ministry of Forests and Lands (Invermere), University of Calgary, and the contractor (R/EMS Research, Ltd.). The 18 people in attendance represented the fields of park management, financial management, fish and wildlife, forestry, forest protection, vegetation ecology, and water resources.

Participants were selected by the Project Forester from the results of a scoping session involving the Park Superintendent, A/Chief Park Warden, Fire Management Warden, and Project Forester. It was decided to focus on the implications of three broad fire management policies: total fire control, 'let-burn', and the use of prescribed burning to manage the park's vegetation. The participants were allowed free reign to decide upon realistic actions (ie. all manner of things that 'drive' the system) and indicators (ie. the things that will be used to measure success or failure of management) to be used in the model. The team was divided into two groups: a group concerned with vegetation ecology, fire frequency, costs, and fire control and use; and a group dealing with wildlife, fisheries, and water management.

Specific details regarding the model components can be found in the Workshop Report as required by the Terms of Reference. (At time of writing, this report was in draft form and two-months overdue.) In essence, the model consists of 3 sub-models: a vegetation/fire model that uses rules of change for broad cover types depending upon timing of fire or other disturbance; an elk population model (using J. Woods' COLLIDE model for the Bow Valley) that determines carrying capacity from time-since-fire distributions and calculates populations using mortality rates for highway, natural, and hunting mortality; and a water model that estimates peak flows from snow depth estimated from canopy interception and melt period durations. Some components of the model are supported by direct observation of parameters in KNP, results of studies in adjacent locations, and informed conjecture about unknowns. Fires are simulated by using fire cycle parameters from the KNP fire history study, the prescribed/wildfire units map, and management policies as chosen by the model user. Elk population parameters use current survey data from KNP and BNP as a starting point, and model births and deaths through each year estimate population size and highway mortality totals. The water model is the most speculative because of a paucity of data for KNP.

In it's current form, the model can only be modified by someone familiar with the Turbo Pascal language and development environment. Because the model was intended to be a tool for discussion and synthesis, it may never be 'finished'. The steps required to complete the fire management planning project in 1990/91 are as follows:

- Develop Alternate Model Scenarios - At this stage, the model should be used to explore the implications of certain management options (ie. look at the indicators, and evaluate success or failure in management). These scenarios might include:
    - Varying tree survival rates on slope/aspect combinations. The KNP fire history study does not show

any correlation between fire frequency and aspect or elevation, but prescribed fire programmes may be forced to burn on south and west facing slopes (initially) for safety reasons. For a 'natural' simulation, survival rates should be set equal for all elevations, aspects, and slopes.

- Use different fire cycles. A 'natural' simulation would use the fire cycle estimates from the KNP fire history study. These values can be altered to simulate climate change or effect of fire suppression success.
- Modify vegetation change rules. Current rules are based on information from the Park's ecological land classification. These rules may require probabilities to be assigned, or changed entirely. Little is known about specifics of such changes, but the implications can be explored using the model. This component is important for exploring change in abundance and distribution of various forest types for purposes of 'representivity'.
- Modify burn unit sequences. Change the order of prescribed burn unit selection to reflect boundary security or intensive management of the elk winter range. Units may also be selected at random to simulate 'natural' conditions.
- Include random large-fire events. This involves setting a probability for Canal Flats or Yellowstone type events which appear likely in KNP from the results of the fire history study.
- Modify elk natality and mortality rates. Current rates are based on survey data from KNP and BNP. Some workshop participants expressed concern over the quality of certain parameter estimates.
- Collect additional information and include additional submodels for birds, quantitative water models, wolves, or whatever else is considered a management priority.

- Focus on 2-3 Scenarios in Detail and Describe in Plan- These detailed scenarios can form the basis for alternatives to plan implementation. As stated previously, the broad options may be total fire control, 'let-burn' natural fire, or use of prescribed burning. These alternatives will form the basis of discussion at management planning or public involvement meetings. If necessary, the model can be used to demonstrate the implications of certain actions. Of particular importance at this stage is the open admission of great uncertainty in predicting future events. The use of the model in this stage is central to the idea of developing management plans that are adaptive and facilitate active learning and adjustment.

- Complete the Final Plan - It is recommended that the plan set the strategic direction for the next 10-25 years or more

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and detail only 5 year tactical implementation guidelines. Modelling, questioning, probing, learning, and adjustment of programmes to new findings should be an on-going process. The contractor will supply a draft of the plan, but it is KNP's responsibility for actual completion (target: April 1, 1991).

Depending upon timing of receipt of the final products from the contractor, follow-up workshops should be conducted involving the original participants and new members. Due to the model's complexity, 80286 and 80386 computers with EGA or VGA graphics are recommended.

As an example of using the model to explore system dynamics, two 200 year runs of the model were conducted using different survival rates for trees on different slope/aspect classes. A significant point of discussion in the workshop revolved around the effect of elevation and aspect on fire frequency. The KNP fire history data suggests no influence of elevation or aspect, as demonstrated by plots of forest age over elevation and aspect for the Park which show no pattern. Slope and aspect adjustments to survival rates can be made in the model by editing the DEATH2.DAT file. One run was completed using higher survival rates on north and east aspects and on steeper slopes (assuming that steeper slopes occurred at higher elevations). The second run used a constant survival rate of 20% (ie. 80% mortality) for all topographic situations.

Plots of AGEEFF (forest age after 200 simulation years with the aspect/slope effect) and AGENOEFF (fores age after 200 simulation years with no aspect/slope effect) are shown here. Note that with the higher survival on north and east aspects, mean forest ages after 200 simulation years are higher on the north and east aspects. For the simulation with no aspect/slope effects, there is no discernable pattern to the forest ages. Compare these two graphs to the plot of mean forest ages by aspect as of 1988 using the stand-origin map. It should be noted that the simulation <u>with constant mortality rates for all aspects compares best with the actual situation in 1988</u>. Plots of mean ages over elevation did not reveal the same pattern using the higher survival rates for higher elevations. This may be because the slope/aspect model for simulating elevation is not working correctly.

On the basis of this simulation, supported by observed, empirical data from this study, it would appear that mortality rates of trees due to fire are not influenced by elevation, slope, or aspect. However, if a prescribed burn programme is initiated, it would likely focus on igniting fires on south and west facing slopes for safety reasons. The implications of this practice would be a departure from the apparent 'natural' conditions now in existence. The implications of this practice should be investigated using the other indicators provided in the model.

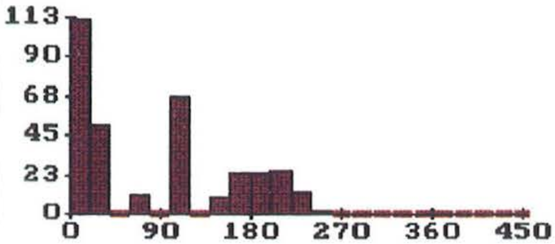
Figures:

- Cover type and age map display of K_MODEL. A number of parameters can be changed for each run of the model: fire cycle, fire unit selection, mortality for aspects and slopes, etc. The main model (K_MODEL) produces an age and cover type map after each 20 year time step and a report file which keeps a running summary of forest age and cover information. The elk, water, and woodpecker sub models use these report and map files to determine carrying capacity, mortality, population sizes, runoff, etc.

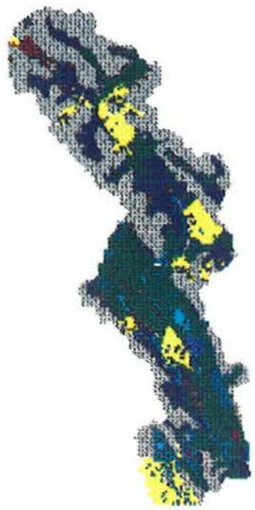
- Plots of simulated and actual forest ages versus aspect under conditions where mortality is homogenous with aspect and lower on north - east facing slopes. Note that the homogeneous mortality scenario compares best with actual conditions in 1988.

Updating Files

Elapsed time = 60 years
586.2 km² have burned
24. % survival rate
1.2 % burned per year
81.6 year fire cycle



Lodgepole Pine

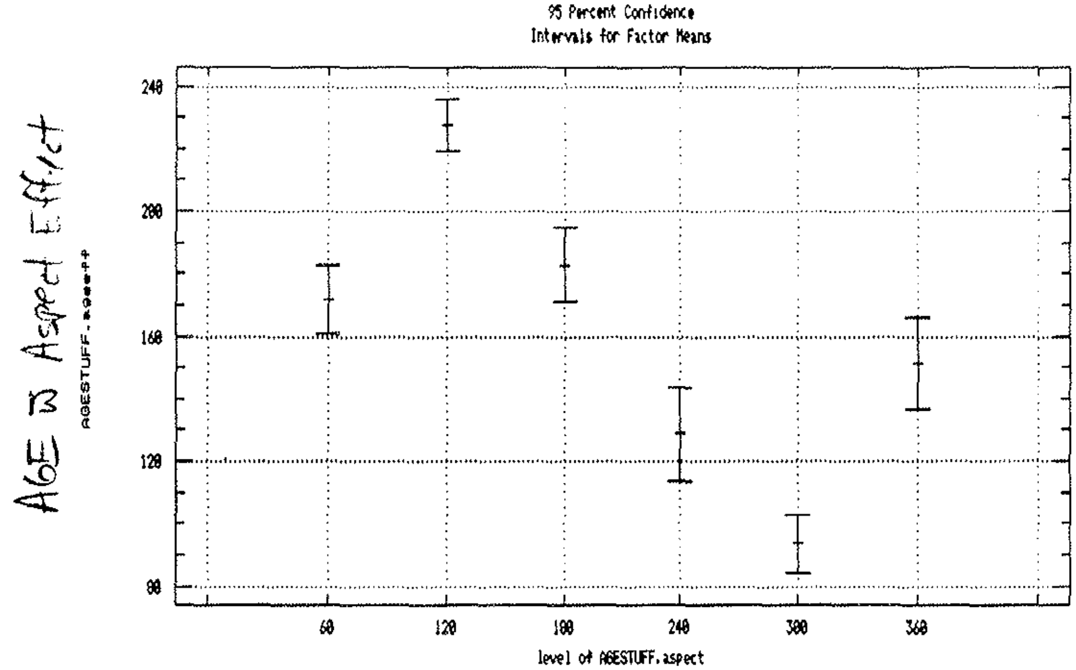


Spruce Fir
Lodgepole Pine
Doug Fir
Fir
Mixed hard,softwood
Grass
Rock
Mixed Conifer
Hardwood

0 - 50 yrs
51 - 100 yrs
101 - 150 yrs
151 - 200 yrs
201 - 250 yrs
251 - 300 yrs
301 - 350 yrs
351 - 400 yrs
401 - 450 yrs
451+ yrs

ribution Displayed is Lodgepole Pine
y/n) ?

The current Age Class dist
Do you wish to change it (


95 Percent Confidence
Intervals for Factor Means
AGE w/ Aspect Effect
AGESTUFF.ageeff
240
200
160
120
80
60
120
180
240
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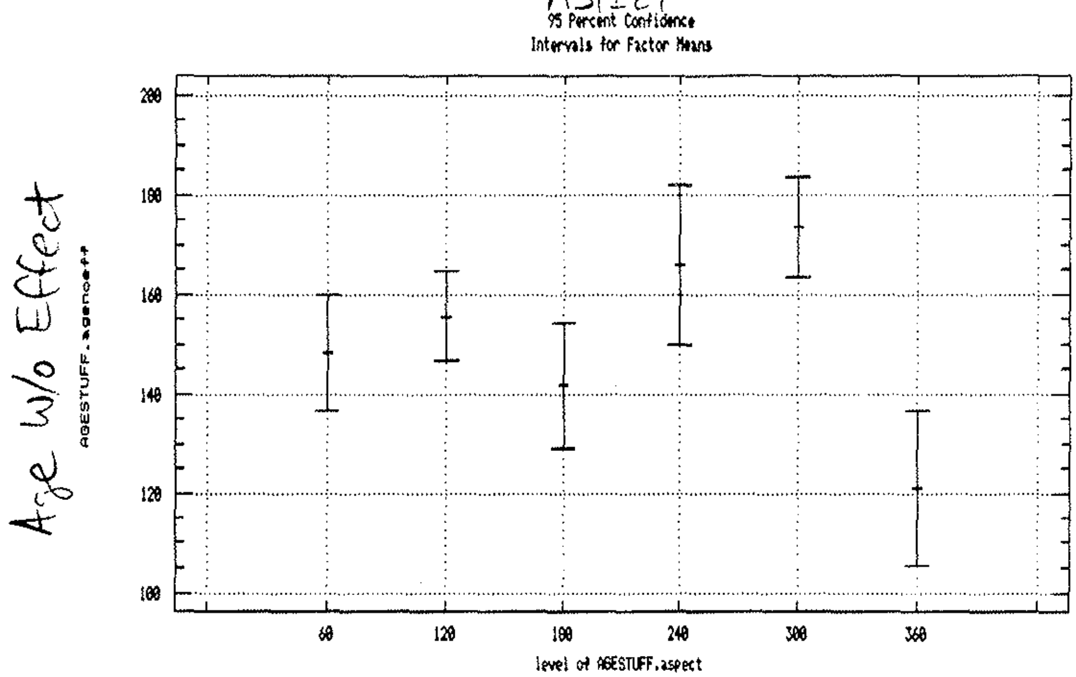
level of AGESTUFF.aspect

ASPECT


95 Percent Confidence
Intervals for Factor Means
Age w/o Effect
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200
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120
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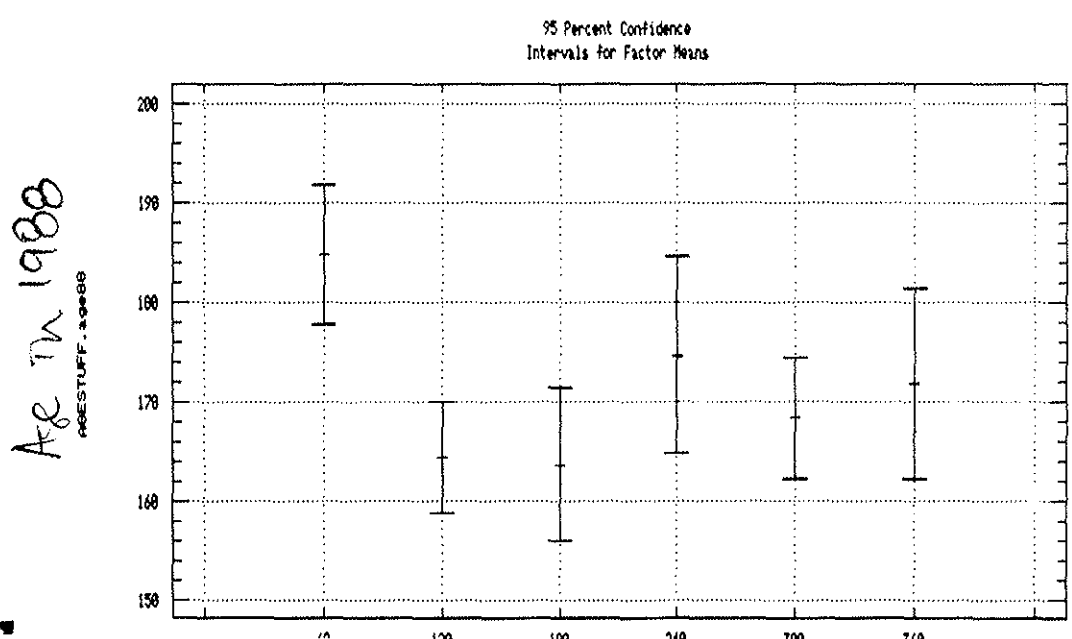
level of AGESTUFF.aspect


95 Percent Confidence
Intervals for Factor Means
Age in 1988
AGESTUFF.age88
200
190
180
170
160
150

2.8 FIRE ATLAS

During the course of the study, a large amount of weather, fire report, fire history and other data was collected and summarized. Some of the summaries and analyses of this data has been presented in other reports, while a considerable amount of useful information remains. The intent of the Fire Atlas is to collect this information and present it as a reference for fire related information. The Atlas at present contains information such as:

- fire size and cause frequency tables
- fire locations by cause during the Park era
- distribution of daily precipitation before and after fire occurrence
- fuel maps
- terrain maps (elevation, slope, aspect)
- frequency tables of occurrence of fuels by elevation, slope, and aspect by main valley in the park
- occurrence of lightning fires by aspect and elevation
- % area of the Park by elevation, slope, and aspect

etc.

This document can be expanded and will serve as a primary reference for fire management planning. During the modelling workshop, the Fire Atlas was an invaluable resource in order to quickly answer questions about the Park, especially for staff and participants un-familiar with KNP.

2.9 DISPLAY POSTERS

It is likely that long, technical reports are only read by those that are particulary interested in the subject of the report. Often, persons involved in decisions regarding the fate of projects do not have time to carefully read and take note of such reports. For this reason, two display posters were produced to communicate findings of this study to persons that may not otherwise have the opportunity to read the final reports.

The two posters consist of three 2' x 3' foam-board panels each and cover two topics: the Fire History Study of KNP, and the use of GIS in KNP. The text and figures for the posters were produced by the author of this report, and the posters themselves were assembled by G. Hendry of the KNP Warden Service. To date, the posters have been displayed at the KNP Administration Building (for consumption by Administration and other staff), the KNP Fire Management Modelling Workshop (for display to other CPS, forest service, fish and wildlife, and staff from other agencies), Western Regional Office, and Parks Headquarters in Hull.

The posters themselves have met with positive review and it is felt that many more people have been exposed to some of the results of the KNP study than would have otherwise. It is difficult to measure the effect of this, but it is presumed that a better appreciation of the problems, opportunities, needs, and results of fire history investigations and GIS use will result. This form of communication is used often by other CPS staff to communicate with the public, and should be used more often to inform staff within the CPS. Persons that are prompted to know more can always read the final reports.

2.10 IFMIS: INTELLIGENT FIRE MANAGEMENT INFORMATION SYSTEM

The Northern Forestry Centre of Forestry Canada (formerly the Canadian Forestry Service) has conducted research into applications of GIS, database, and expert system technology in fire management. To date, efforts have focused on using these technologies to build fire management information systems that assist with the assessment of fire danger, optimum allocation, and dispatch of fire control resources. The NoFC's Intelligent Fire Management Information System (IFMIS) has developed to the point where the forest protection agencies of Alberta, Saskatchewan, and Manitoba are implementing the system for use in daily management of fire presuppression and suppression programmes.

KNP was chosen as a research location for the IFMIS project for the following reasons: 1) databases for fire weather, fuel, and terrain maps have already been produced and are available in SPANS, 2) the Park is located in a mountainous area where extrapolation or interpolation of weather observations is inadequate, 3) presuppression decisions are sufficiently complex as to require the aid of computer processing, and 4) the Park expressed a willingness to test this new technology and provide material and in-kind support.

A terms of reference was developed for this project (See Appendix) which would provide for the implementation of the existing IFMI System in KNP and development of a rule based expert system for presuppression decision making using an object oriented development tool (Nexpert/Object by Neuron Data Corp.). In addition, the WNDCOM spatial wind prediction system developed by KNP would be incorporated into the IFMIS system and used with the fuel and topography data to provide more accurate maps of fire spread potential.

To date, three working sessions have been completed with staff from KNP and NoFC. The necessary databases were developed using custom software and SPANS, and a >50 rule knowledge base on fire preparedness decisions has been developed. The WNDCOM and fire weather reporting software required re-engineering to accommodate the needs of the new system.

The perceived benefits of this system are as follows:

- Integration of fire management related data. A great deal of information is collected and analyzed in a given day and it is difficult for a small staff to remain cognizant of all changes.
- Documentation of decision rules. Many excellent operating rules and observations are used by the KNP fire control staff, but unfortunately none of this knowledge is written down. As a consequence, if these persons are unavailable due

to other work assignments or leave, erratic decisions may be made.

- Consistent processing and decision making. For reasons of brevity, fatigue, or distraction, a small operational staff may make decisions using only a portion of the data available. An intelligent information system will perform analyses in the same manner each time, and will have been instructed what to do in instances of missing data.
- Documentation of decisions made. Often, fire management decisions are costly and require substantiation before funds may be released. It is difficult for the fire manager to always be in a position to document the factors leading to a certain decision such as to hire a helicopter on stand-by. Further, usually following the fire season, summaries of actions taken are required for expenditure analysis and to refine operating procedures. A good information system will fulfil the role of documentation assistant.

It is intended that the IFMIS system for KNP will be operational for the fire season of 1991, with a test version of the system ready for the 1990 fire season. An information report will be produced at the completion of the KNP IFMIS project, including an evaluation of the effectiveness of the system. Further information can be obtained from KNP or NoFC. Depending upon the results of the project, it may be prudent to expand the use of IFMIS to cover the Mountain Parks (including MRGNP) or to use the system in Wood Buffalo NP.

Figures:

- Example menus from IFMIS. The system is mouse driven and very easy to operate.
- Initial Attack coverage map for KNP for July 29, 1989. This map shows the area of the park with and without IAC coverage based on extreme fire danger conditions acually experienced. This scenario places a Bell 206 Jet Ranger helicopter and initial attack crew at each of 3 bases: Banff, Yoho (Boulder Creek), and Kootenay (Administration Building). For preparedness planning in KNP, IAC forces must arrive at the fire before it reaches 1.2 ha (3 acres) or initial attack will likely fail. The time required to reach the fire depends upon the travel speed of the aircraft used and the fire rate of spread (based on fuels, topography, and weather). This map shows that even with 3 helicopters, most of the Vermilion Valley is under conditions that if a fire were to start, IAC would not meet the 1.2 ha control objective. The only way to minimize this area on this day would have been to place an additional helicopter at Vermilion Crossing (KVX). The pointer (and UTM coordinates in the lower right corner) show the location of a fire that occurred around this day. The fire required a crew of 15 men, a helicopter, and almost a week to control, with rain assisting.
- Intensity rank chart for July 29, 1989: extreme conditions.

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Info Deploy Detect FWI FBP Maps Geo Reports DBMS

Crew Deployment
Airtanker Deployment

INTELLIGENT

FIRE

MANAGEMENT

INFORMATION

SYSTEM

Info Deploy Detect FWI FBP Maps Geo Reports DBMS

Manual
Regional Forecast

Manual Weather Import

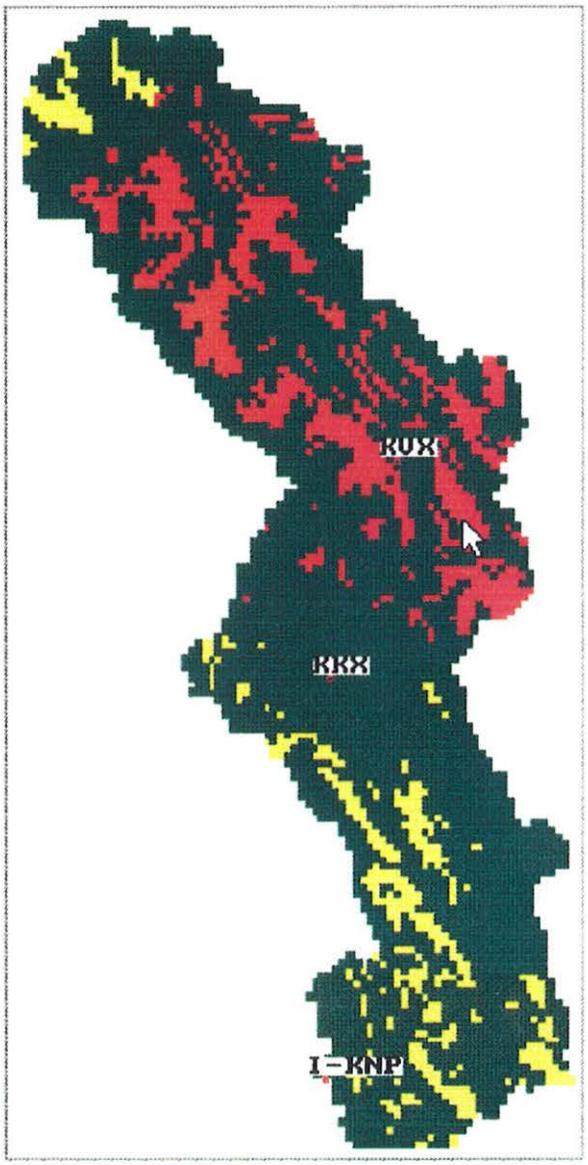
ASCII Weather Import

Day Report
Station Report
Forecast Day Report

Display Chart

SYSTEM

Kootenay
IA Coverage
JUL 29, 1989

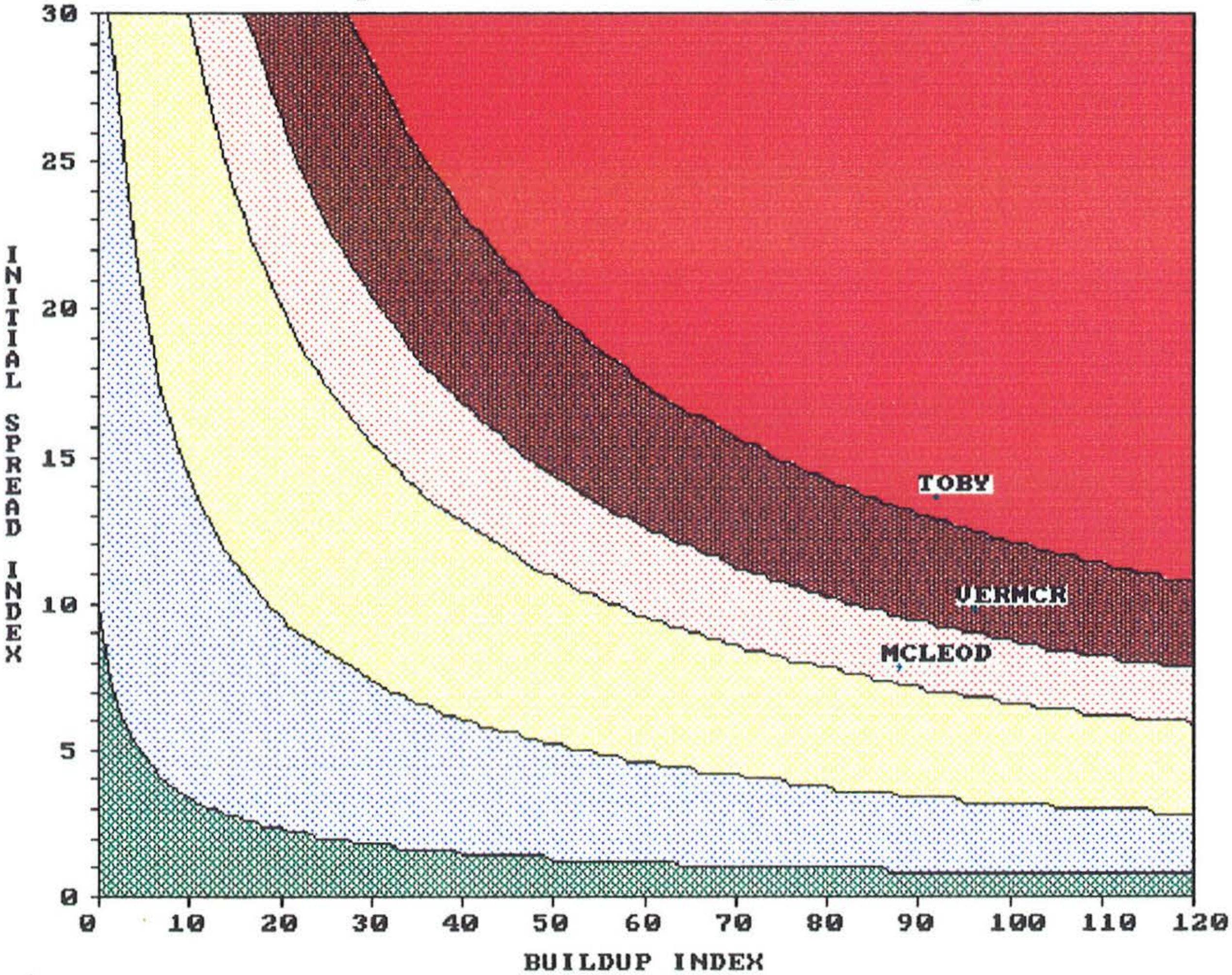


None
Single
Multiple

576460 E
5648091 N

FIRE INTENSITY RANK CHART JUL 29, 1989

(Upland Jack Pine Fuel Type -0% Slope)



2.11 OTHER PROJECTS

A number of other small projects were undertaken, including:

- Submission of a manuscript on the fire history study to a refereed scientific journal;
- Participation in the CPS national fire management initiative by contributing to the 'Keepers of the Flame' discussion document on fire management;
- Travelling to Wood Buffalo National Park to observe their fire management organization and assist with a fire history study of the park;
- Investigate the use of BC TRIM (Terrain Resource Information Management) data, and data from PAMAP and Terrasoft GIS packages for use in SPANS;
- Attempt to utilize terrain data from Energy Mines and Resources Canada (scanned 1:250,000 topographic map data in Intergraph SIF format) in generating terrain data for KNP (unsuccessful to date, though PHQ has retained a contractor to perform a similar project in WBNP);
- Communicate with BCMFL Protection Branch staff regarding fire information systems development and weather modelling projects;
- Assist two M.Sc. candidate researchers in the Park (one project regarding bird habitat and another concerned with elk habitat change);
- Representing the CPS and delivering a paper on random ignition fire management in the CPS at an international fire management conference in Bozeman, Montana ('The Use of Planned and Random Ignition Fires in Wilderness and Parks');
- Delivering a SPANS demonstration and fire history project summary to a meeting of the Western Region's Chief Park Wardens, the CanSIS Semi-Annual Review, and students from Selkirk Community College;
- Demonstrating the use of fire information systems at the first meeting of the CPS Fire Command Teams at the Forest Technology School in Hinton;
- Developed a wind speed correction factor for the McLeod weather station by performing a statistical analysis of McLeod wind data versus a temporary station located nearby;
- Preparing project reports and budget summaries, reviewing terms of reference for other projects, responding to queries and requests for assistance from other Park staff regarding statistical processing, computer applications, fire history methodology, vegetation, ecology, etc.;
- Supervising a volunteer student from a local community college.

3. RECOMMENDATIONS

Recommendations arising from the fire history study are contained in the fire history report. The following recommendations pertain to work to be completed in Year 3 of the study:

- Fire management plan. The contractor for the fire/resource management modelling workshop will provide a draft of the fire management plan for KNP. Some amount of work will be required to finalize the plan guidelines and to provide necessary operational information. This should receive high priority in the fall and winter months.
- Weather station. The existing fire weather stations in KNP are poorly sited with respect to wind observations (ie. the stations are sheltered by neighbouring trees and the wind speed data seems grossly underestimated). The stations should either be relocated or the wind masts heightened to represent 10m open wind conditions. Having the sites inspected by an AES technician is strongly suggested.
- Facility protection plan. It is likely that during severe fire events, facility protection will become the highest priority. Fuel modification or developing specialized equipment (eg. sprinkler systems) before such an event is suggested. An example location such as Kootenay Crossing should be evaluated for hazard, value, and risk and a prescription developed that would reduce the hazard or risk. This example could then serve as a model for treating other public and private facilities within the Park.
- Expand the fire atlas. This document is a convenient record of fire management related information. New information should be added as it becomes available.
- IFMIS Project. A priority should be placed on ensuring support for the NoFC staff working on implementing IFMIS in KNP. Of particular importance is the development of a fuel and weather based fire danger rating, instead of the present weather only system. It is important to establish a firm and meaningful link between the mathematical models provided by the CFFDRS and the crucial presuppression decisions made in KNP. The link may be established using thorough case studies of past fire events.
- The model of KNP vegetation/fire/elk/water produced by the interdisciplinary team during the fire/resource management modelling workshop is complex, exciting, and is the first instance of an attempt at meaningful integrated resource management in the Western Region. Having stated the model is complex, it may contain errors and is likely incomplete. Considerable effort should be made to retain the working atmosphere between the original workshop participants to further refine the model and develop research priorities and management guidelines based on this experience. Follow-up workshops should be held and development of the concept of using modelling workshops for other resource management problems should be encouraged.

- Develop public education plan. As recommended in the conclusions of the fire history study, it may be prudent to inform the public of the limits to fire control technology. It is likely that an extreme wildfire event will occur in KNP and that intense public and media interest will result. With competition for the public's favour from many interests, fire management may not gain prominence until some form of (perceived) crisis is evident. A plan to inform the public, developed with the assistance of a media relations expert, should be developed to aid discussions concerning target audiences, content, costs, and modes of delivery.

APPENDICES

CANADIAN PARKS SERVICE
KOOTENAY NATIONAL PARK

TERMS OF REFERENCE

FIRE HISTORY AND MANAGEMENT STUDY Year 2: 1989/90

April 26, 1989

Contents

1. INTRODUCTION

These Terms of Reference describe a project to be carried out from April 1, 1989, to March 31, 1990.

Year 1 of this study concentrated on a forest fire history study of KNP for which a final report has been produced and distributed. Fire weather and fire report databases were also produced during the first year. SPANS, the CPS' geographic information system, was purchased and was an integral part in the analysis of the fire history information.

Study objectives for Year 2 were proposed in the project initiation documents written in August of 1988; before Year 1 had been completed. Additional discussion with relevant fire management experts within the CPS and other agencies, new facts learned from August 1988 to March of 1989, uncompleted tasks from Year 1, and recommendations contained in the final report from Year 1, prompted the modification of the study objectives for Year 2. Several of the main objectives remain unchanged, but objectives concerning the Vermilion Pass Fire Resample and Prescribed Burn Monitoring Techniques have been deferred. The remainder of this t.o.r. describes the study objectives in full.

2. OBJECTIVES

- To provide KNP with information that will assist with the preparation of a Fire Management Plan, as required by the KNP Park Management Plan;

- To develop a fire preparedness system based on historic fire weather and fire behaviour observations in and around KNP, with additional information from fire danger rating models from the Canadian Forest Fire Danger Rating System.

- To conduct a trial of the Forestry Canada Intelligent Fire Management Information System (separate t.o.r. will be prepared; funding from a separate project).

- To prepare and submit for publishing in a scientific journal a brief version of the KNP Fire History Study report prepared in Year 1;

- To investigate fuel loading and fuel modification alternatives around an example facility in the park and make recommendations regarding additional facility protection/fuel modification initiatives required;

- To develop a database of the KNP Ecological Land Classification and use that database to construct various thematic maps of KNP resource information using SPANS;

- To produce a map of prescribed fire/wildfire containment units and a brief summary of each unit to be used in future prescribed fire and landscape management planning;

- To produce a corrected rate-of-spread map using accurate fuels data derived from satellite imagery and the ELC, improved slope, aspect, and elevation information, and a model of wind speed and direction using SPANS;

- To conduct a policy alternatives modelling workshop;

- To conduct technology transfer by preparing short articles for popular consumption, preparing posters depicting the KNP Fire History Study, assisting two M.Sc. level researchers in the park, assisting with the habitat management project for the Radium Bighorn Sheep project, conducting information and training seminars for CPS staff, etc.

3. PROJECT AREA

Most investigations will be limited to KNP but information regarding fire behaviour observations, etc. will be included from neighbouring national parks and provincial lands.

4. INFORMATION REQUIREMENTS

Information required may be used for one or several components of the study. A few of the information requirements have been satisfied by work completed in Year 1. Following is a list of the information required to be compiled by the study leader:

- *Standards and format requirements of potential journals for publication of the fire history report;*
- *Fire behaviour and fuel quantification equations (from Forestry Canada);*
- *Standard production rates for fire crews and equipment;*
- *Historic fire weather and climate observations in and around KNP;*
- *Historic fire reports and fire behaviour observations in and around KNP;*
- *Attribute rules and features for the park ELC;*
- *Location of natural fuel breaks that could be used in the design of prescribed fire/wildfire containment units;*
- *Individual pb/wc unit descriptions including information regarding fuels, climate, possible escape points, fire suppression strategy, values at risk, etc.;*
- *An accurate map of CFFDRS fuel types;*
- *A system for performing multiple calculations of a point wind speed and direction prediction model;*
- *Improved digital elevation data;*
- *Satellite imagery covering the KNP area in a format usable in SPANS;*
- *Accurate and pragmatic decision rules for assimilating fire weather and fire behaviour prediction information into a fire preparedness decision aid;*
- *Knowledge of the process of designing and implementing a rule-based expert system for fewer than 50 rules;*

5. PROJECT REQUIREMENTS

The researcher shall conduct the literature reviews, data compilation, field trips, and data analysis necessary to prepare reports and maps. Methods and techniques used by the researcher shall follow accepted forestry practices. Without limiting the generality of the foregoing, the following are required:

5.1 Review of Existing Literature

The study leader will utilize the expertise and findings of other researchers as much as possible. This will be particularly important during the process of conducting the satellite imagery classification, using the WNDCOM model for wind predictions, developing the database to be used with the KNP ELC, and in conducting the Fire Expert System Trial. Little other literature or experience exists with using GIS to create rate-of-spread maps, mapping prescribed fire units, creating preparedness systems for fire management, etc.

5.2 Data Compilation

Individual fire reports and fire weather observations will be compiled in IBM PC dBASE III+ files and linked by using relational database techniques. Existing database files for the KNP ELC will be modified for accuracy and documentation produced which will entitle other users of the data to full understanding of the database development. Satellite imagery used in the fuel type map will be retained in it's original condition on 9-track computer tapes. Classified images will be stored on tape and/or on high-density floppy disks (fully documented). Field plots required to establish control points for the fuel type classification and rate-of-spread maps will be mapped and photographs compiled and annotated.

5.3 Data Analysis

5.3.1 - The researcher shall use all manner of statistical analyses, graphical representations, and tabular summaries necessary to describe the fuel type coverage, fire preparedness guidelines, supporting fire and fuel information, and ecological land classification information (as it relates to use in SPANS).

5.3.2 - With the use of GIS in Parks there has been an increase in the requirement for accurate biometrics advice and information. The researcher will consult with experts in GIS as to appropriate spatial statistical methods to be used to test autocorellation of sample points, goodness-of-fit tests for thematic overlays derived from different sources or methods, etc.

5.3.3 - Sensitivity analysis will be conducted on the corrected rate of spread map to determine which of the numerous input variables to the WNDCOM model is the most subject to error. Valuable information will be learned from this exercise which will improved awareness of the precision required for sensitive variables.

5.3.4 - ELC information contained within SPANS will be analyzed in relation to stand-origin and fire frequency information derived from Year 1 of the study. Methods will centre on examining plots of thematic ELC overlays in relation to forest age and in relation to short to long fire cycles. Information derived from this analysis may be used in modelling of policy alternatives.

5.3.5 - Fuel loading information collected at trial facility protection sites will focus on surface and stand-level fuel complex components that contribute to crowning potential. Forest canopy descriptors will be analy with weather data using fire behaviour equations to determine canopy thinning or pruning necessary to reduce crowning potential below certain levels.

5.3.6 - Maps and descriptions of prescribed fire/wildfire containment units will be analy by expert opinion; few quantitative measures can be derived or are appropriate. Size, elevation ranges, fuel types, etc. information will be collected and summarized, but evaluations of control difficulties remain subjective.

6. SUBMISSION REQUIREMENTS

6.1 Work Plan

A work plan (including budget) will be submitted May 15, 1989.

6.2 Progress Report

A formal progress report is not required. O&M project reports are required at the end of the field season (fall), December 31, 1989, and March 31, 1989. The park liaison officers will be kept briefed of the study's progress.

6.3 Final Report

Year 1 of this project concluded with a comprehensive report on the fire history of KNP. Several, small working reports covering the varied topics in Year 2 will be produced instead of one, large final report.

Each report shall include, but not be limited to:

- *a general abstract*
- *the literature review required by section 5.1*
- *a description of the procedures in sufficient detail that another researcher could duplicate the study*
- *a description of the data collected*
- *discuss in detail the researcher's analysis and interpretations, referring to the accompanying maps, charts, etc.*
- *specific procedures used to manipulate the data and conduct analysis, particularly information relating to the use of SPANS*
- *identify information gaps*
- *a guide to the use of the report including indices to the tables, maps, photos, and text*
- *literature cited, including identification of source*
- *recommendations for management and future studies or research*
- *appendices, including raw field data and an itemized list of materials which accompany the text to comprise the final submission*

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requirements.

7. MATERIAL TO BE SUPPLIED

KNP will supply all materials necessary for this project, within the limits of the approved project resources.

8. LIAISON

8.1 - Alan Masters, Regional Forester, Western Regional Office, will be the principal researcher as defined under the terms of a secondment agreement between WRO and KNP.

8.2 - The KNP project supervisor will be the Chief Park Warden and the park Fire Management Warden.

9. SCHEDULE OF PAYMENTS

N/A.

10. SPECIAL CONDITIONS

- Funding approved: 1.2 py, 16.7K (O&M project).
- 1.0 PY to be utilized as replacement for Regional Forester in WRO (Regional Forester on secondment to KNP).
- 0.2 PY (approximately 10 person-weeks) to be divided among two seasonal Resource Conservation employees to perform project related work in the construction of the ELC databases and SPANS thematic maps, and in the production of the prescribed fire/wildfire containment unit map.
- General work plan as follows:
  - April: Finish report from Year 1, conduct presentations, prepare terms of reference for Year 2.
  - May: Give presentation on behalf of PHQ to conference in USA on CPS fire policy, initiate ELC database construction, query potential contractors for satellite imagery classification, collect additional fire weather and fire report information for preparedness system, provide technical advice to 2 M.Sc. researchers in KNP, travel to prescribed burns to collect fire behaviour information.
  - June: Analyze information for preparedness system, begin production of ELC maps in SPANS (training of operator), begin field work for prescribed fire/wildfire containment unit map, identify control points for satellite fuel type classification, prepare t.o.r and contract for satellite imagery analysis, assist with habitat/SPANS information in Radium Bighorn Sheep project.
  - July: Finish preparedness system, complete field work for fuel type control points, conduct satellite image analysis, develop WNDCOM program routines using SPANS data.
  - August: Complete prescribed fire/wildfire containment unit

map, digitize map in SPANS, complete WNCOM programs, create rate-of-spread map, begin fuel modification studies.

- September: Complete fuel measurement, analy fuels data, initiate analysis of ELC, fire history, and r.o.s. information using SPANS.
- October: Continue ELC etc. map analysis, sensitivity analysis of r.o.s map, begin writing reports for summer activities.
- November: Conduct modelling workshop utilizing information and expertise derived above.
- December: annual leave.
- January: Finalize modelling workshop results, refine GIS databases, write report.
- February/March: Additional report writing, time for unforseen problems, time for regional commitments, etc.

- Budget:

Vehicle rental	3.0
Telephone/computer	2.0
Image analysis	8.0
Travel	2.0
Equipment	2.0
	====
	17.0

(*Note* Image analysis costs are the largest item. Resubmission for additional funds may be required once estimates from contractors are received.)

ABBREVIATIONS USED

TEXTURE – STR = Stratified
COR = Coarse
MED = Medium
FIN = Fine
VAR = Variable

VEGETATION – S = Spruce – all species   AVL = Avalanche
F = Fir – all species
Pl = Lodgepole Pine
L = Larch   A = Aspen
Ce = Cedar   Bi = Birch

% COARSE FRAGMENTS – Used only % above line ie –
10-50 ← used top one
(~~0-90~~)

LANDFORM – Used Top & bottom figures ie –
Mv,b ← used
(~~R-v~~)(-V) ← used
Ri ← used

SOILS – USED ie. – O.EB, ~~E.EB~~ > O.HEB
only only for 1st and one for second separated by symbol

VEGETATION – Where no vegetation of major class – VegDesc section left blank.

WILDLIFE – SECTIONS = Small mammal Association
= Breeding Bird Community
No commas used – spaces between #'s

CALCAREOUSNESS – CALC = Calcareous
NON = Noncalcareous
NON/CALC = Non-Weakly Calcareous

SET UP FOR MASTER LEGEND - DBASE

	Field Title	#	C/N	Example
Ecosection	Various	12	C	Altrude
EcoRegion	Various	9	C	Subalpine
EcoSite	Various	3	C	WR1
Landform	MGM1	3	C	CA or C
	SE1	3	C	v or v,b
	ModPr1	2	C	-A or -v
	OrgTer1	2	C	NL NS
	LFCOMB	1	C	, or > or + or _
	MGM2	3	C	CA or C
	SE2	3	C	v or v,b
	ModPR2	2	C	-A or -v
	OrgTer2	2	C	NL NS
	LFDESC	25	C	English Description of MGM1 and 2 - ignore (), adverse for MGM SE
Calcareousness	Various CALC NON WEAK VAR	8	C	CALC or NON WEAK>NON
Texture	MED	7	C	MED, MED-COR, STR/COR
% Coarse Fragements	L%CF	2	N	20, 10
	U%CF	2	N	
Site	Dry	5	C	Dry, Wet, South, North
Soils	SOILT1	6	C	O.DYB
	SOILCOMB	1	C	>
	SOILT2	6	C	O.EB
	SOILDESC	20	C	BRUNISOL,
LUVISOL>GLEYSOL				
Vegetation	VEGT1	3	C	C11, O2
	VEGCOMB	1	C	, >

	VEGT2	3	C	C11, O2
	VEGT3	3	C	C11, O2
				Unveg. (UV) Avcomplex
(AC1				
				or
AC2)				
	VEGDESC	4	C	Se, F, Pl
Drainage Class numbers)	DRCL	2	C	(Lower
	DRCU	2	C	(Upper
numbers)				
Wildlife	DEERW	1	C	M,H,V,N,L,P
	DEERS	1	C	Same

For wildlife 2 separate fields for each animal - summer and winter
For small mamamals, breeding birds - lump together in fields, ie. 6,8,9,12,15

Forestry Canada | Forêts Canada

Your file Votre référence

Our file Notre référence

Northwest Region
Northern Forestry Centre
5320 - 122 Street
Edmonton, Alberta
T6H 3S5

(403) 435-7210
FAX (403) 435-7359

November 8, 1989

Mr. F.A. Bamber
Superintendent
Kootenay National Park
P.O. Box 220
Radium Hot Springs, B.C.
V0A 1M0

Dear Mr. Bamber:

Reference: Letter of Agreement - Fire Management Decision Support Systems Research

This Letter of Agreement confirms that Forestry Canada, Northern Forestry Centre (NoFC), will develop a forest fire pre-suppression preparedness system (FFPPS) for Kootenay National Park. The Terms of Reference for this research project have been drafted by Mr. A. Masters of the Canadian Parks Service (CPS) and Mr. B. Lee of this Centre.

The project will be undertaken by means of this interagency Letter of Agreement with $8.3K funding supplied by Kootenay National Park to NoFC by Interdepartmental Settlement. The project will require approximately one person-month of time from the CPS staff identified in the Terms of Reference. NoFC will provide all other technical and scientific support required for the project.

If these arrangements are agreeable, the return of a signed copy of the attached Terms of Reference will constitute the formal agreement.

Yours sincerely,

A.D. Kiil
Regional Director General
Northwest Region

ADK/drl

Attachment

CANADIAN PARKS SERVICE - FORESTRY CANADA

Fire Management Decision Support Systems Research

TERMS OF REFERENCE

Contents

1. INTRODUCTION

These Terms of Reference (TOR) outline a project to develop a forest fire pre-suppression preparedness system (FFPPS) for Kootenay National Park (KNP). The requirement to develop such a system has been identified as a essential component of the current Fire History and Management Study for the park.

Pre-suppression preparedness planning is the process of determining the fire control resources required to meet, or at least cope with, an anticipated fire situation. This type of operational planning is done by the fire manager, either the previous evening or the morning of each day of the fire season.

These TOR outline an approach using expert or knowledge-based systems in the design of the FFPPS for KNP. Forestry Canada (FC) has expertise in the areas of forest fire research and management, pre-suppression preparedness planning, and the application of expert systems to fire management. FC will be the primary contractor in the development of such a system for KNP. It is anticipated that the products of this research effort may be applicable to other Parks and fire management agencies.

2. OBJECTIVES

- To develop a prototype forest fire pre-suppression preparedness system for KNP that will recommend daily appropriate pre-suppression actions throughout the fire season.

- To automate the system by developing a microcomputer-based pre-suppression planning tool for operational using an expert system software approach.

- To investigate and report on the applicability of an object oriented knowledge systems for forest fire preparedness planning and the feasibility of implementation and maintenance of such systems by generalist, field personnel with minimal computer training.

- To identify data linkages to existing systems such as SPANS, FWAP, BCMFL, PFIS, IFMIS etc. and provide recommendations regarding the use/integration of these systems into the preparedness planning system.

3. PROJECT AREA

The development of the prototype FFPPS will limited to KNP. The system will incorporate concerns and data inputs from neighboring national parks and provincial lands. In spite of the preceding, Forestry Canada will keep in mind the potential expansion of pre-suppression preparedness planning to other national and national historic parks in the Canadian National Parks System.

4. INFORMATION REQUIREMENTS

The following is list of information requirements to be provided by KNP for the project:

- Historical fire weather and climate observations in and around KNP.
- Historical fire reports and fire behavior observations in and around KNP.
- TYDAC SPANS ELC, fuels, terrain, fire history, and other fire management spatial data for KNP.
- Fire management/fire suppression policies for the Canadian Parks Service and KNP.
- BCMFL fire occurrence prediction and lightning strike data for KNP and surrounding area.
- Access to KNP fire management/fire suppression expertise through structured and informal interviews.

5. PROJECT REQUIREMENTS

The project consists of five major components describe as follows:

5.1 Data Compilation and Evaluation

Fire management data will be compiled for KNP and its relevance to pre-suppression preparedness planning evaluated. Those data considered useful for pre-suppression preparedness planning will be identified as inputs into the expert system.

5.2 Knowledge Acquisition

The development of the pre-suppression preparedness knowledge base will consist of information in the form of agency policies, scientific information, and human expertise. The acquisition of this knowledge will be developed through the use of fact finding interviews and literature reviews.

5.3 Pre-suppression Preparedness System Design

A conceptual model of the preparedness system will be designed based on the available data inputs, knowledge base(s) developed , and the perceived goals of the system. The operational constraints of the organization (manpower, budget, fire management policies, etc.) will be considered when appropriate pre-suppression actions are being identified.

5.4 Computer System Development

A microcomputer-based software system will be developed to implement the forest fire pre-suppression preparedness system. The software system will take the form of a planning tool for use by the fire manager, or his/her designate, on a daily basis during the fire season. The system will be built using a state-of-the-art fifth generation software development tool called Nexpert Object. The system will integrate the required data linkages, the pre-suppression preparedness system knowledge base(s), the expert system inference engine, and user interface into a custom-built fire management planning tool for KNP.

5.5 System Validation

System performance of the 1990 operational prototype will be validated in order to revise the final version of the FFPPS. Further system monitoring and validation is beyond the scope of these TOR.

6. SUBMISSION REQUIREMENTS

6.1 Interim Meeting

An interim meeting will be held on or about April 30, 1990 to demonstrate a prototype of the forest fire preparedness planning expert system. In addition, a brief progress report will be prepared documenting the work to that date.

6.2 Final Report

A final report will be submitted to KNP no later than March 31, 1991. This report will document the approach, data objects, and knowledge base used in the development of the forest fire preparedness planning expert system. In addition, FC will deliver the stand-alone microcomputer-based software to implement the preparedness planning system complete with user documentation.

7. MATERIAL TO BE SUPPLIED

KNP will provide the following material:

- Biophysical, forest fuels, terrain, weather, and fire report data for KNP.

- Expertise for knowledge acquisition exercise. This will necessitate that key park fire management personnel are made available to the principle researcher for interviews and working sessions to review the development of the system. An estimated two to three person-weeks may be required over the term of the contract.

- A microcomputer work station capable of running the system for development, testing, and operational purposes. This system should be an 80386 based IBM AT class machine or compatible with VGA graphics. The present SPANS work station in KNP is adequate for this purpose.

- Operational testing of the prototype system over all or part of the 1990 fire season for system validation and subsequent revision - if required. Such a trial should be no less than one month in length and should require no more than 20 minutes per day.

- Bunkhouse accommodation for the principle researcher, when available.

FC will provide the following material:

- Structured and informal interviews with KNP, BCMFL, and other fire management experts.

- Provide the NEXPERT OBJECT hardware key required to run the prototype expert system.

- An interim prototype for trial during the 1990 fire season.

- A final report and working FFPPS software system, complete with user documentation.

8. LIAISON

8.1 Bryan Lee, Project Leader, Forest Fire Research, Northern Forestry Centre, Forestry Canada, Edmonton will be the principle researcher as defined under these terms of reference.

8.2 The project authority will be Alan Masters, Regional Forester, Western Regional Office, Canadian Parks Service, Calgary and Byron Irons, Park Warden, Kootenay National Park.

9. SCHEDULE OF PAYMENTS

The schedule of payments will be one lump sum of 8.3 K, payable by inter-departmental settlement within one month of signing of the TOR.

The above budget will be allocated as follows:

- Nexpert Object Run Time and hardware key...................... 1.0 K
- Travel, phone, courier services............................... 2.3 K
- Computer programming support (hardware/software/contracts)..... 5.0 K

10. SPECIAL CONDITIONS

- The work will begin immediately upon the signing of these TOR.
- General work plan will be as follows:
  - 1989 3/4: Data base network development and compilation.
  - 1990 1/4: FFPPS design and knowledge base acquisition/interviews.
  - 1990 2/4: Prototype development, interim user guide.
  - 1990 3/4: System monitoring and prototype revision.
  - 1990 4/4: Final report and user manual development.

F.A. Bamber
Superintenent
Canadian Parks Service
Kootenay National Park

A.D. Kiil
Director General
Forestry Canada
Northwest Region