# Forest Renewal Research - Annual Report

**Science Council of BC Reference # FR-96/97-392**

**FRBC Application #KB96108-RE**

**Applicant's Name and Organization:**

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**Title of Project:**

A stand and landscape level fire and successional modeling system for ponderosa pine and interior Douglas-fir forests.

**Period:** 1 April, 1996 - 30 May, 1997

## TABLE OF CONTENTS

# 1. Research Progress

## *1.1 Introduction*

Historically, dry southern interior forests (Natural Disturbance Type 4 (NDT 4) in the Forest Practises Code of B.C. Biodiversity Guidebook) were exposed to frequent, low-intensity surface fires. This fire regime produced open stands of fire tolerant species, with little surface fuel. Fire suppression, grazing, and selective logging in these forests are believed to have caused forest encroachment on grasslands and forest ingrowth (an increase in the numbers of trees in the lower canopy layers of previously open stands). Ingrowth may result in the loss of forage production and critical habitat for some wildlife species, increases in forest health problems, and an increased risk of catastrophic wildfires. However, the rate of ingrowth and impacts on other resource values and fire potential have not been well quantified at either a stand or landscape level.

Future plans for landscape units in the NDT 4 will require that targets be established to maintain a balance of grassland, open and closed forest. If these goals are to be realized, prescribed burning and/or thinning programs will likely be required to restore or maintain open forests. However, there presently is no means available in B.C. to project the results of such activities on forest stand structure and composition, even though the Forest Practises Code requires managers to be able to specify future stand structures resulting from stand management activities. Techniques to project successional change at the landscape level are also needed to assist in forest level planning.

### *1.1.1 Objectives*

The objective of this project is develop a modeling system to predict future ecosystem successional dynamics, and the impact of thinning, prescribed burning and fire suppression on forest composition, density, structure and wildfire threat at the stand and landscape scales in dry interior forests by:

1) Developing or adapting stand level models of fire effects on stand structure and species composition for use in B.C.
2) Developing a technique to extend the stand level successional model to the landscape level.
3) Testing and demonstrating the use of the models by determining the historic rate of ingrowth in several landscape units in the IDF and PP zones in southern interior B.C., and projecting future changes.
4) Quantifying the change in fire behavior potential resulting from ingrowth.

### *1.1.2 Summary of Accomplishments*

A review was carried out in 1995 which suggested that the Forest Vegetation Simulator (FVS or PROGNOSIS) Fire Model that is being developed by the US Forest Service would provide a good framework for a stand-level fire and successional model for southern interior B.C.

During 1996/97 the FVS Fire Model was examined further. The attributes that needed to be modified to use the model in B.C. were determined and data to test and demonstrate the model were assembled. An agreement was reached with the U.S. Forest Service to provide access to the code and to cooperate in the production of a B.C. variant of the FVS Fire Model.

Also during 1996/97, two landscape study areas were selected in cooperation with resource management agencies in southern interior B.C. Data required for analysis and modeling were obtained, including digital forest cover and terrain maps, contemporary and historical air photographs, and stand survey data. Preliminary assessments of successional changes and projections of future change were completed for the two study areas using these data, the FVS stand growth model and cover equations. Preliminary work on a method to assess fire behaviour potential at the landscape level in dry interior forests was also completed.

During 1997/98, work will focus on completing a B.C. variant of the FVS Fire Model, obtaining data for a third landscape study area, completing assessments of landscape change in all study areas, and developing and demonstrating techniques to project future successional patterns, and fire behavior potential across landscapes.

This work will be linked and coordinated with several other FRBC funded projects:
- development of a B.C. variant of the FVS base growth model and interfaces (BCMF Forest Practises Branch)
- monitoring of burning and thinning treatments in the Rocky Mountain Trench (BCMF Nelson Region)
- study of disturbance regimes in the IDF in Kamloops Forest Region (SFU)

## *1.2 Methods:*

### *1.2.1 FVS Fire Model*

Work on a Fire Model extension to the FVS growth model was initiated by the US Forest Service in 1995. The model represents woody debris dynamics, the effects of fire on tree mortality, and interactions between surface fuel load, crown scorch, and tree mortality. The base FVS growth model is used to predict regeneration, growth and natural mortality. As in the other FVS models, the basic input data are a tree list file (stock table) which can be developed from conventional cruise/preharvest silviculture survey data; the growth model can be calibrated with local periodic increment data. A keyword file is used to control variables such as the frequency of treatments. A beta version was completed in April 1997 based on the North Idaho variant; input data and model output are in Imperial units.

Several meetings were held with cooperators in the US Forest Service (Elizabeth Reinhardt and Colin Hardy, Intermountain Sciences Lab, Missoula, MT) during 1996/97 to discuss the FVS Fire Model extension. Recently completed work on crown scorch and crown fire modeling (Alexander 1996) was also reviewed to determine how these phenomena could better be represented in the FVS Fire Model.

Stand and fuel load data were obtained from EMBER project study sites comprising burned and unburned treatments (Finlay Ck., Invermere Forest District; and Picture Valley, Cranbrook Forest District). A beta version of the Fire Model was obtained and projections of future stand development and fuel dynamics on burned and unburned areas were carried out for the EMBER study sites in Imperial units.

The potential to incorporate the Fire Model in the FVS Windows interface that is being developed by the BCMF Forest Practises Branch was discussed with Barry Snowdon, BCMF. The BCMF interface writes the keyword file, controls the model run stream, and provides graphical output, all of which makes it much more user-friendly.

### *1.2.2 Assessing and Modeling Landscape Change*

*Study Areas*

Two landscape study areas were selected where the amount of ingrowth that has occurred over the last 40 - 50 years could be determined, and data could be obtained to test landscape models. These are Tata Creek, an area of approximately 30,000 ha in the Cranbrook Forest District, and Okanagan Mountain Provincial Park, an area of approximately 10,000 ha on the east side of Okanagan Lake.

Tata Creek was selected in consultation with BCMF staff (Tom Braumandl, Nelson Forest Region and Oliver Thomae, Cranbrook Forest District) in order to build on previous and ongoing research in the area. Tata Creek is an interim landscape planning unit and this study will provide information that will be useful in developing a landscape management plan.
It is an area of low relief (800 - 1100 m) in the Kootenay River valley, and is within the PP dh2 and IDF dm2 biogeoclimatic subzones.

Okanagan Mountain Provincial Park was selected in consultation with the B.C. Ministry of Environment, Lands and Parks (Judy Millar, B.C. Parks). It is a rugged area with an elevational range of 300 - 1700 m, classified within the PP xh1, IDFxh1, IDF dm2, and MS dm1 biogeoclimatic subzones, and is relatively undisturbed by logging or fire. This study will provide information that will be useful for developing fire management and resource management plans for the park, and techniques that can be used to assess vegetation change in other parks and protected areas.

Discussions were also held with Dennis Lloyd ( BCMF Kamloops Forest Region) regarding an additional study area in the north west portion of Kamloops Forest Region. This additional area

(Arrowstone) will be examined in 1997/98 in order to further extend the assessment and modeling of succession across the range of ecological conditions in the IDF and PP zones.

*Data Collection and Analysis*

Digital forest cover as well as TRIM (digital terrain) data were acquired for both study sites to serve as base maps. The data were translated from their original format into a common ARC-INFO format.

Air photo coverages of the study areas were also obtained for contemporary and historic (40-50 years ago) periods (Tata Creek: 1952 and 1992; Okanagan Mtn. Park: 1938, 1963, 1987).

Forest stands were identified on the photographs and classified into five crown closure classses:

| | | |
|---|---|---|
| 0 | 0 - 5% | grassland |
| 1 | 6 - 15% | treed grassland |
| 2 | 16-40% | open forest |
| 3 | 40- 55% | closed forest |
| 4 | > 55% | dense forest |

The polygons were transferred from the photographs to base maps using conventional photogrametric techniques and then the maps were digitized to produce digital ARC-INFO map files. All stands of similar class were summed for the study area for each time period (photo date) within ARC-INFO.

*Projecting Succesional Change Across Landscapes*

Projecting future landscape change in uneven-aged forests is challenging because the variability in stand structure results in complex patterns of stand development. Two approaches were examined during 1996/97.

*Stand projection*

A strategy to project changes in stand conditions using the base FVS growth model was developed as follows:

Representative tree list data were obtained for the crown closure classes in each study area. Approximately 5 stands were assessed in each cover class; 3 plots were sampled in each stand. Sampling had previously been carried out in Tata Creek by the B.C. Ministry of Forests using techniques outlined in *Guidelines for Management of Uneven-aged Douglas-fir* (B.C. Ministry of Forests 1992). These data were acquired and re-compiled into FVS format.

Further field sampling was carried out in Okanagan Mtn. Park using similar survey methods. In addition, increment cores were obtained from 2 sample trees in each plot (90 total) to determine periodic increment. The PAI data were required to use the internal growth rate calibration feature in FVS. A digital micrometer (Digimic) was used to determine growth ring width at the tree ring lab at Pacific Forestry Centre. Local calibration of the FVS growth model was believed necessary because the growth rates in the PPxh subzone in the lower part of Okanagan Mtn. are very low and outside the range for the habitat types represented in the North Idaho variant. Surface fuel loads were also assessed at Okanagan Mtn. Park for use in the FVS Fire Model.

Stand data were grouped into crown closure classes, and FVS runs were carried out using the B.C. variant of the model (S.I. version of North Idaho variant) on a 10-year growth cycle with natural regeneration. For Tata Creek, growth rates were based on typical rates for the Flathead National Forest in Northern Idaho.

Crown closure was determined at each time period by applying crown width equations (Moeur 1985) to individual tree data in the detailed FVS list file output; equations were first converted from Imperial to S.I. units. This was necessary because the FVS COVER extension is not available within the B.C. variant of FVS. Regression models of crown closure over time were developed from the modeled output and applied within ARC-INFO to project change in crown closure class for a 40-year period.

*Markov model*

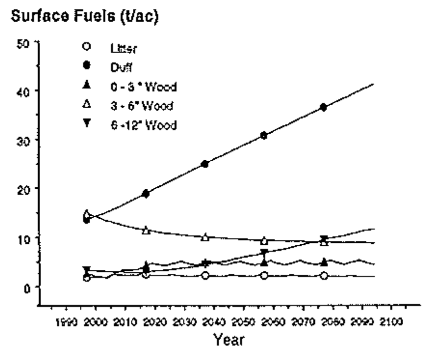
Cover class changes (e.g. the amount of class 0 becoming 1, 2, 3, and 4) were determined in each study area by overlaying crown closure maps within the GIS for different time periods and determining the union of different classes. The changes in cover class were transformed into a probability matrix. The amount of area in each cover class at the end of the next time period was determined by squaring the probability matrix and then multiplying the probabilities by the area in each class in the last time period in a classic Markov chain approach (Jeffers 1978).

## *1.3 Results*

### *1.3.1 FVS Fire Model*

It was determined that a separate B.C. variant of the Fire Model Extension is required, mainly because the extension has to interact with the B.C. variant of the base growth model, which is in S.I. units. The U.S. Forest Service have agreed to allow the Canadian Forest Service access to the code before it is publicly released, and to collaborate on improving the representation of crown scorch and the onset of crown fire. The B.C. Ministry of Forests have also agreed to cooperate in including the Fire Model extension in their Windows interface for FVS.

Examples of projections of surface fuel load using the Fire Model for burned and unburned control areas at Finlay Creek (EMBER Project; Braumandl et al. 1995) are shown in Figures 1 and 2. The potential flame height if areas were exposed to wildfire and prescribed fire is shown in Figure 3. The decomposition and snag fall rates, flame and crown scorch heights, and crown fire thresholds will be critically examined in 1997/98.



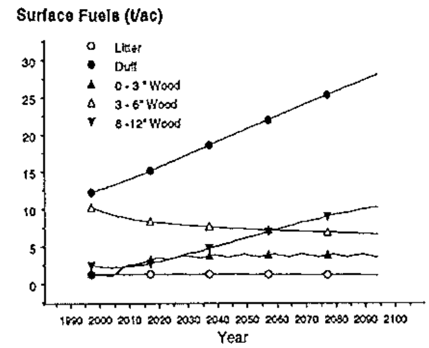




Figure 1. Projected trends in surface fuel components on the control (left) and treated areas (right) at Finlay Creek.

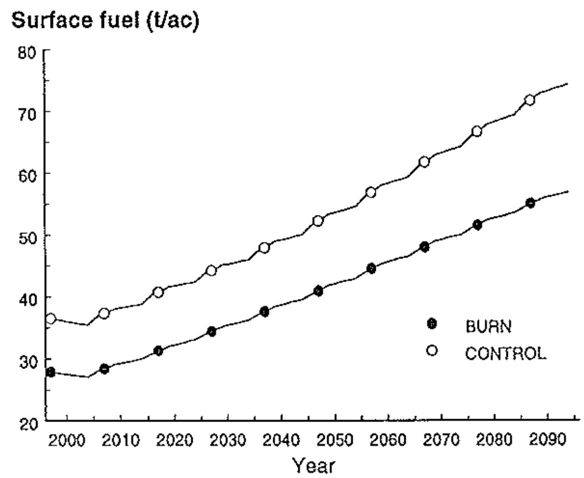



Figure 2. Projected increase in total surface load on the treated and control areas at Finlay Creek.

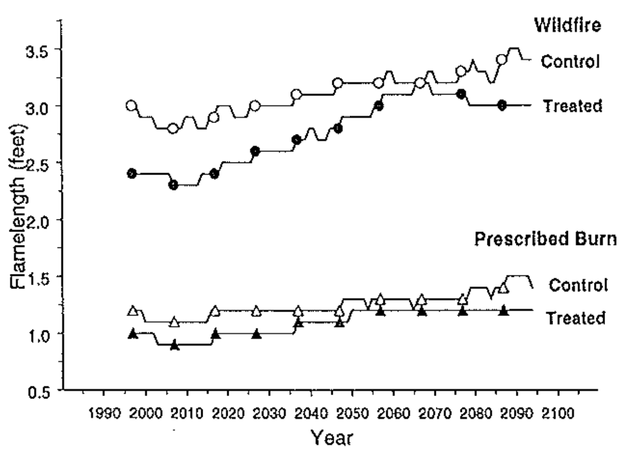



Figure 3. Potential flame length on treated and control areas in a typical wildfire or prescribed fire on the Finlay Creek site.

More complex treatment scenarios, such as repeated underburns and/or thinning treatments will be simulated and presented in an extension note during 1997.

### 1.3.2 Landscape Change

*Stand structure and composition*

Tree species composition and size distribution for stands in the five cover classes in the two study areas are shown in Figures 4 and 5. Douglas-fir and ponderosa pine are the dominant species in both areas, although there is a some lodgepole pine in both areas, and western larch and trembling aspen at Tata Creek. There has been more understory ingrowth in all cover classes at Tata Creek that at Okanagan Mtn.

Projections of change in density, basal area, and cover for a 50 year period (1997-2047) based on the FVS growth model are shown in Tables 1 and 2 by cover class. Stand density is projected to increase at Okanagan Mtn. in Cover classes 0-3 and to decrease in Class 4. At Tata Creek stand density is only projected to increase in Cover Class 0 as natural mortality occurs in the denser stands. However, basal area is projected to increase in all classes in both areas.

Projected trends in forest cover are plotted in Figures 6 and 7. At Okanagan Mtn., crown closure in Classes 0 - 3 is projected to increase slowly but significantly over the next 50 years, while in Class 4 it is projected to decrease due to natural mortality. This is already being observed due to bark beetle attack and windthrow. Larger and more rapid increases in crown closure are projected in Cover Classes 1 - 4 at Tata Creek as the present understory layer matures, and due to the faster growth rates. Crown closure in Class 0 at Tata Creek is increasing slowly due to low initial densities of large trees.

The simulations of cover changes are only as good as the simulation of regeneration, and of growth rates. Calibration of growth and regeneration functions will be addressed by the B.C. Ministry of Forests as part of their FVS Implementation Strategy. In particular, the natural regeneration submodel needs to be critically examined.

*Landscape Change*

Maps of contemporary and historic crown closure in the two study areas determined from air photographs are shown in Figures 8 and 9. The amount of area in each crown closure class is shown in Tables 3 and 5. There has been a 0, -55, -26, +1 and +56 % change in the amount of area in Cover Classes 0 - 4, respectively, at Okanagan Mtn. Park. At Tata Ck., there was a -57, -54, +8, +102, and +135 % change in the change in the amount of area in Cover Classes 0 - 4, respectively, as well as a +71% increase in the non-forest area due to development. The different amounts of change are due to differing initial conditions, differing, growth rates, and different management histories. In particular logging, prescribed burning, and development have occurred at Tata Creek, while Okanagan Mtn. has been largely undisturbed.

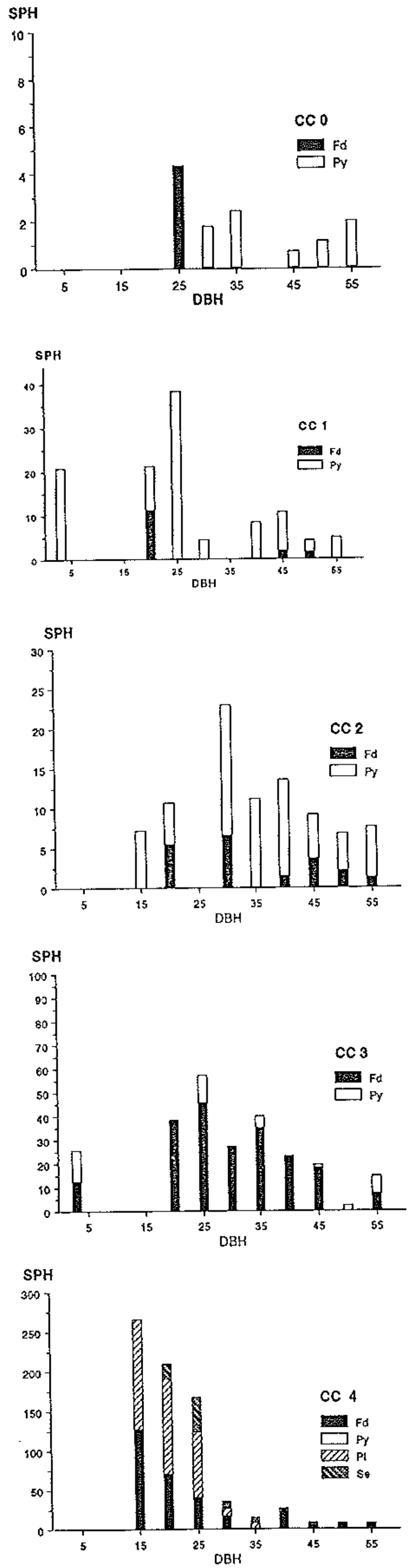



Figure 4. Diameter distributions by cover class in Okanagan Mtn. Park.

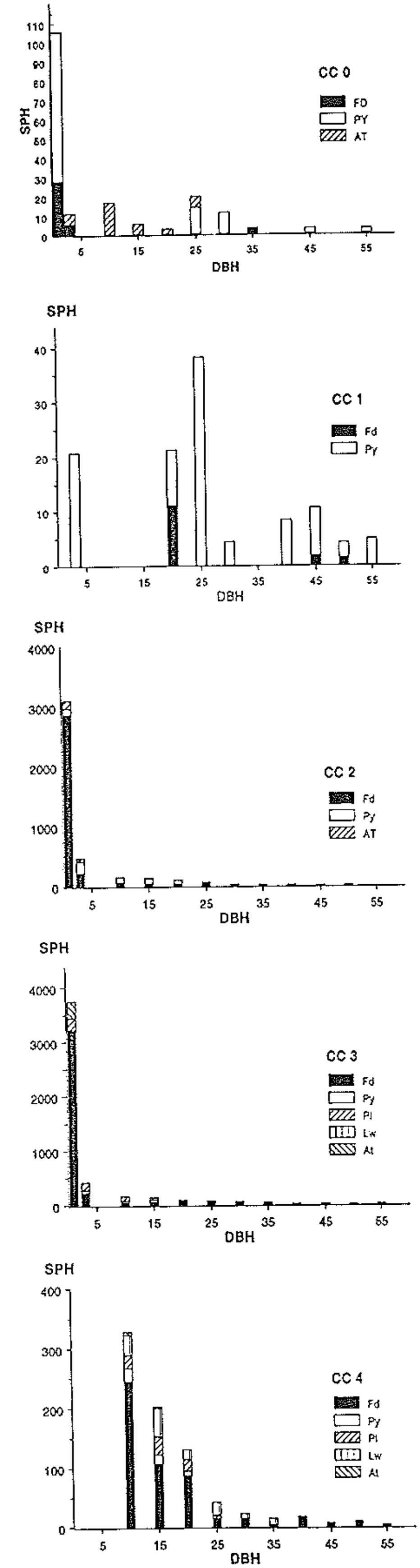



Figure 5. Diameter distributions by cover class at Tata Creek.

Table 1. Cover, density and basal area projection: Okanagan Mtn. Park

| Year | Grassland | Treed Grassland | Open Forest | Closed Forest | Dense Forest |
|---|---|---|---|---|---|
| | | Forest Cover (%) | | | |
| 1997 | 4 | 16 | 17 | 26 | 37 |
| 2007 | 4 | 14 | 16 | 24 | 32 |
| 2017 | 4 | 13 | 16 | 24 | 30 |
| 2027 | 7 | 14 | 17 | 24 | 28 |
| 2037 | 12 | 18 | 20 | 25 | 28 |
| 2047 | 20 | 21 | 22 | 26 | 27 |
| | | Stand density (sph) | | | |
| 1997 | 12 | 113 | 89 | 247 | 738 |
| 2007 | 12 | 98 | 80 | 220 | 614 |
| 2017 | 219 | 251 | 291 | 413 | 680 |
| 2027 | 200 | 209 | 247 | 357 | 558 |
| 2037 | 654 | 485 | 513 | 533 | 656 |
| 2047 | 587 | 414 | 424 | 446 | 525 |
| | | Basal area ($m^2$) | | | |
| 1997 | 1.4 | 8.5 | 9.8 | 28.0 | 31.3 |
| 2007 | 1.5 | 8.1 | 9.7 | 28.8 | 30.9 |
| 2017 | 1.7 | 7.8 | 9.9 | 42.1 | 31.0 |
| 2027 | 2.3 | 8.3 | 10.7 | 42.8 | 31.6 |
| 2037 | 3.9 | 9.2 | 11.7 | 45.5 | 32.0 |
| 2047 | 6.9 | 11.0 | 13.2 | 44.3 | 32.5 |

Table 2. Cover, density and basal area projection: Tata Creek

| Year | Grassland | Treed Grassland | Open Forest | Closed Forest | Dense Forest |
|---|---|---|---|---|---|
| | | Forest Cover (%) | | | |
| 1997 | 3 | 19 | 35 | 43 | 41 |
| 2007 | 5 | 45 | 58 | 56 | 48 |
| 2017 | 8 | 66 | 73 | 61 | 54 |
| 2027 | 13 | 67 | 77 | 62 | 54 |
| 2037 | 26 | 67 | 72 | 63 | 52 |
| 2047 | 33 | 68 | 68 | 60 | 52 |
| | | Stand density (sph) | | | |
| 1997 | 181 | 3008 | 4031 | 4761 | 4300 |
| 2007 | 174 | 2636 | 3365 | 3670 | 3356 |
| 2017 | 346 | 2672 | 3140 | 3172 | 2769 |
| 2027 | 335 | 2186 | 2605 | 2478 | 2239 |
| 2037 | 795 | 1909 | 2293 | 2011 | 1812 |
| 2047 | 751 | 1502 | 1860 | 1609 | 1460 |
| | | Basal area ($m^2$) | | | |
| 1997 | 3.4 | 7.8 | 14.4 | 21.9 | 21.2 |
| 2007 | 4.4 | 13.1 | 20.1 | 26.3 | 26.2 |
| 2017 | 6.3 | 20.8 | 26.2 | 30.3 | 31.1 |
| 2027 | 8.9 | 25.1 | 31.6 | 33.9 | 34.9 |
| 2037 | 12.2 | 27.3 | 35.5 | 37.1 | 37.9 |
| 2047 | 17.0 | 29.1 | 38.5 | 39.5 | 40.7 |

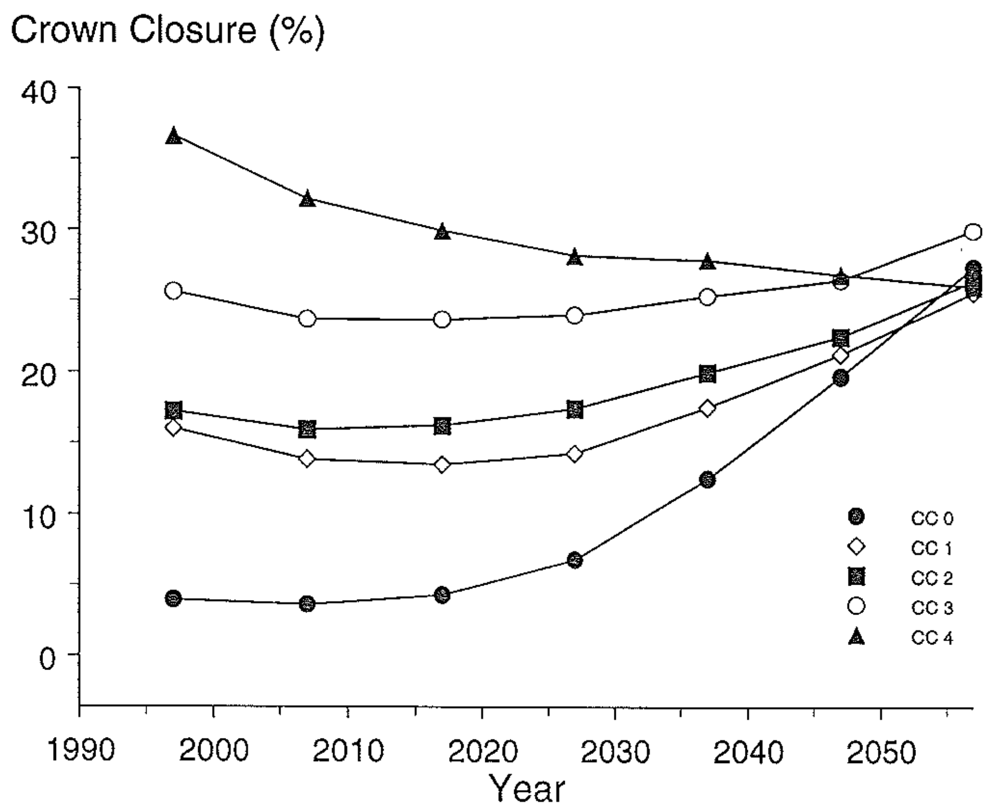



Figure 6. Projected trends in forest cover (%) by cover class at Okanagan Mtn.

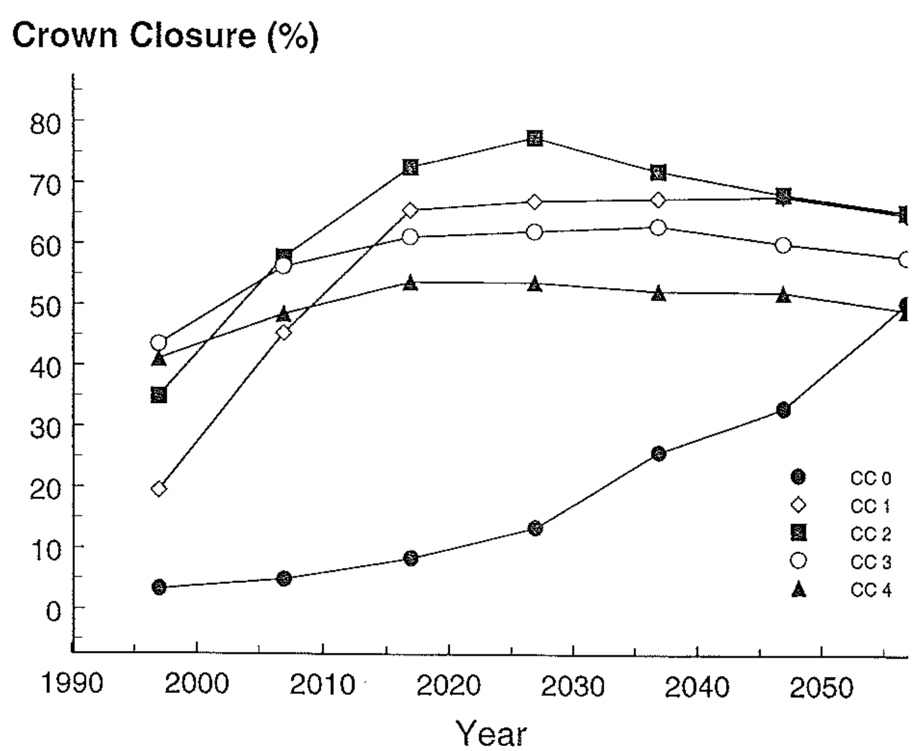



Figure 7. Projected trends in forest cover (%) by cover class at Tata Creek

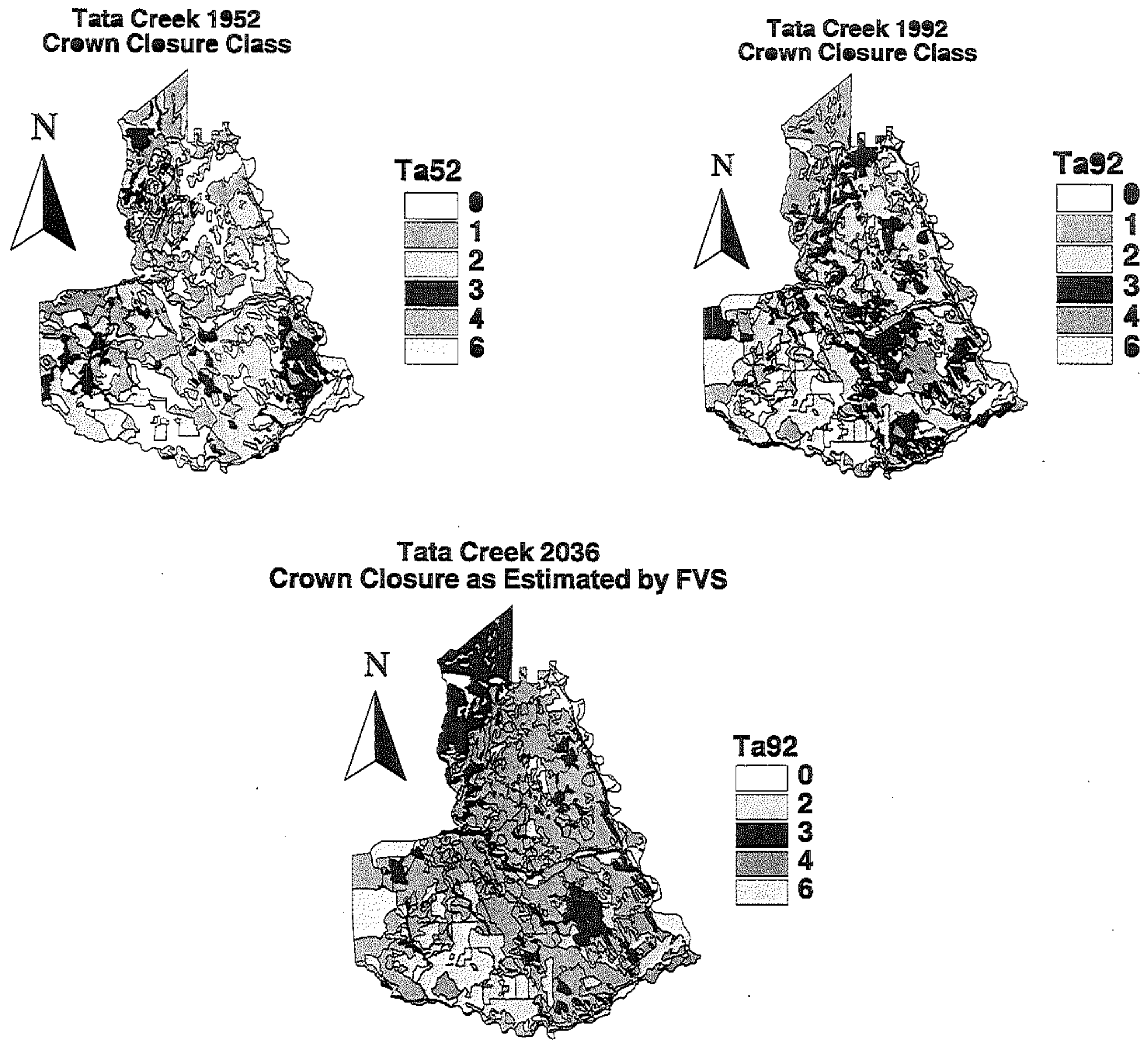



Figure 8. Historic and projected changes in crown closure at Tata Creek.

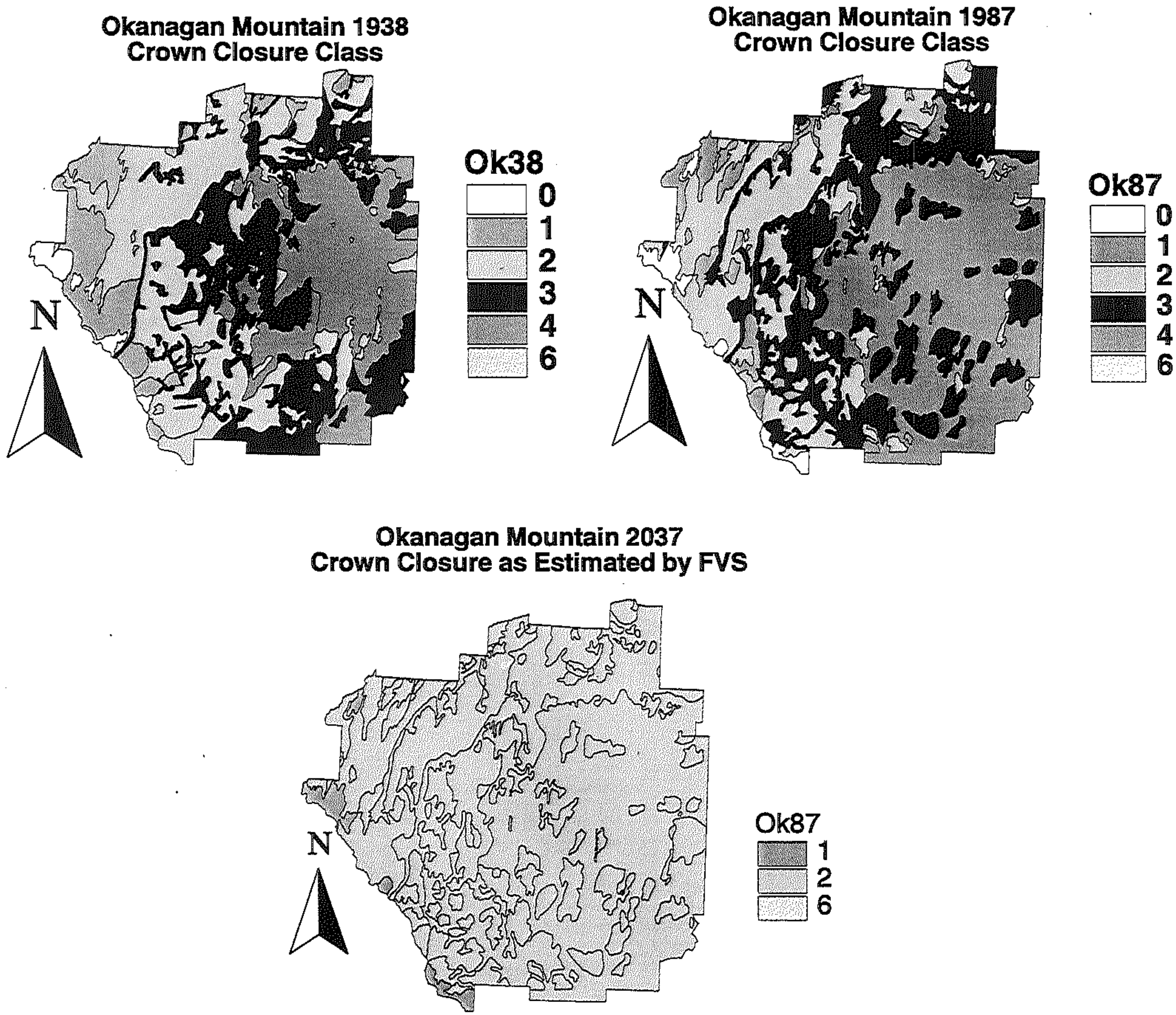



Figure 9. Historic and projected crown closure in Okanagan Mountain Park.

Table 3. Historical and projected changes in crown closure in Okanagan Mtn. Provincial Park.

| Year | Crown Closure Class | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| 1938 | 211 | 1125 | 3655 | 2993 | 2559 |
| 1987 | 205 | 505 | 2692 | 3135 | 4002 |
| 2036 FVS Projection | 0 | 202 | 10250 | 0 | 0 |
| 2036 Markov | 125 | 201 | 1433 | 2788 | 5962 |

Table 4. Probability of crown closure class change in Okanagan Mtn. Park over a 50 year period.

| Class | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 0 | 0.49 | 0.081 | 0.269 | 0.138 | 0.014 |
| 1 | 0.041 | 0.273 | 0.529 | 0.14 | 0.014 |
| 2 | 0.012 | 0.039 | 0.476 | 0.364 | 0.107 |
| 3 | 0 | 0.011 | 0.094 | 0.403 | 0.49 |
| 4 | 0.002 | 0 | 0.007 | 0.159 | 0.83 |

Table 5. Historical and projected changes in crown closure in the Tata Creek landscape unit.

| | Crown Closure Class | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | Non-forest |
| 1952 | 7055 | 8274 | 9128 | 2602 | 2040 | 3143 |
| 1992 | 3083 | 3840 | 9879 | 5274 | 4804 | 5376 |
| 2032 FVS Projection | 0 | 0 | 3095 | 4791 | 18991 | - |
| 2032 Markov | 1800 | 2759 | 7749 | 5160 | 5963 | 8531 |

Table 6. Probability of crown closure class change in Tata Creek over a 40 year interval.

| Class | 0 | 1 | 2 | 3 | 4 | Non Forest |
|---|---|---|---|---|---|---|
| 0 | 0.29 | 0.19 | 0.23 | 0.08 | 0.03 | 0.17 |
| 1 | 0.05 | 0.16 | 0.44 | 0.15 | 0.13 | 0.06 |
| 2 | 0.03 | 0.06 | 0.38 | 0.26 | 0.22 | 0.05 |
| 3 | 0.05 | 0.06 | 0.3 | 0.2 | 0.26 | 0.12 |
| 4 | 0.005 | 0.07 | 0.16 | 0.16 | 0.35 | 0.25 |
| NF | 0.07 | 0.09 | 0.02 | 0.04 | 0.02 | 0.76 |

The probability of change for a unit area within a cover class was determined by comparing the classification of individual polygons over time. The resulting probability matrices are shown in

Tables 4 and 6. Some of the change is due to classification and mapping errors. For example, there was a 16% chance that an area classified as Cover Class 4 at Okanagan Mtn. in 1938 was classified as Class 3 in 1987, though it is unlikely that cover actually decreased in these areas. The areas of significant change are shown in Figures 10 and 11.

The amount of area in each class in the future was determined from the FVS-based projection is shown in Tables 3 and 5 and in Figures 8 and 9.

The probability matrices were used to project future crown closure using a Markov chain approach; the results are shown in Tables 3 and 5. The results are different from FVS, but both approaches have a few similarities.

Both methods suggest that the area of grassland and open forest will continue to decrease, and the amount of closed and dense forest increase at Tata Ck. The decrease in grassland is less significant at Okanagan Mountain because it is very dry and rocky and regeneration success is low. The FVS projections need to be critically reviewed. The length of the simulation period needs to be carefully selected. The 50 year period used for Okanagan Mtn. resulted in a convergence towards Class 2 which is probably not realistic.

The Markov model is objective, however it is limited in that the data needed must be obtained from a specific area for two or more time periods. The projection interval is limited to the same interval, and it is assumed that the change processes (ingrowth, logging, development) are occurring at a constant rate. A dynamic model is needed to examine the effect of varying management practices.

## *1. 4 Other Project Activities and Tech Transfer:*

- Completed staffing action for GIS analyst/research associate.
- Participated in planning meetings for the Fire and Ecosystem Management Symposium to be held in Cranbrook, B.C. , September 29-October 2, 1997. The organizing committee is composed of staff from the B.C. Ministry of Forests, B.C. Ministry of Environment, Lands and Parks and the Canadian Forest Service.
- Participated in and presented the study to the Trench Restoration Workshop sponsored by the Rocky Mountain Trench Natural Resources Society (funded by FRBC) in Cranbrook, March 27, 1997. Approximately 50 persons from government agencies, the forest industry and NGOs attended.
- Participated in and presented study at Forest Renewal BC 'Dry Douglas-fir Forest Research Workshop' in Kamloops, April 29-30, 1997. Approximately 60 persons from government agencies, the forest industry and educational institutes attended.

## *1.5 References*

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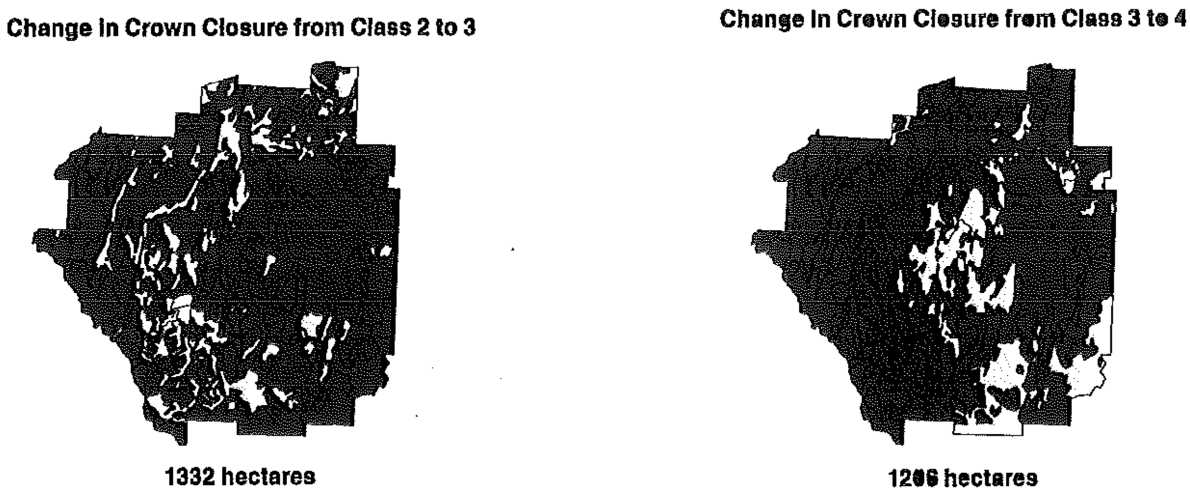


Figure 10. Location of change in crown closure classes for Okanagan Mountain Park.

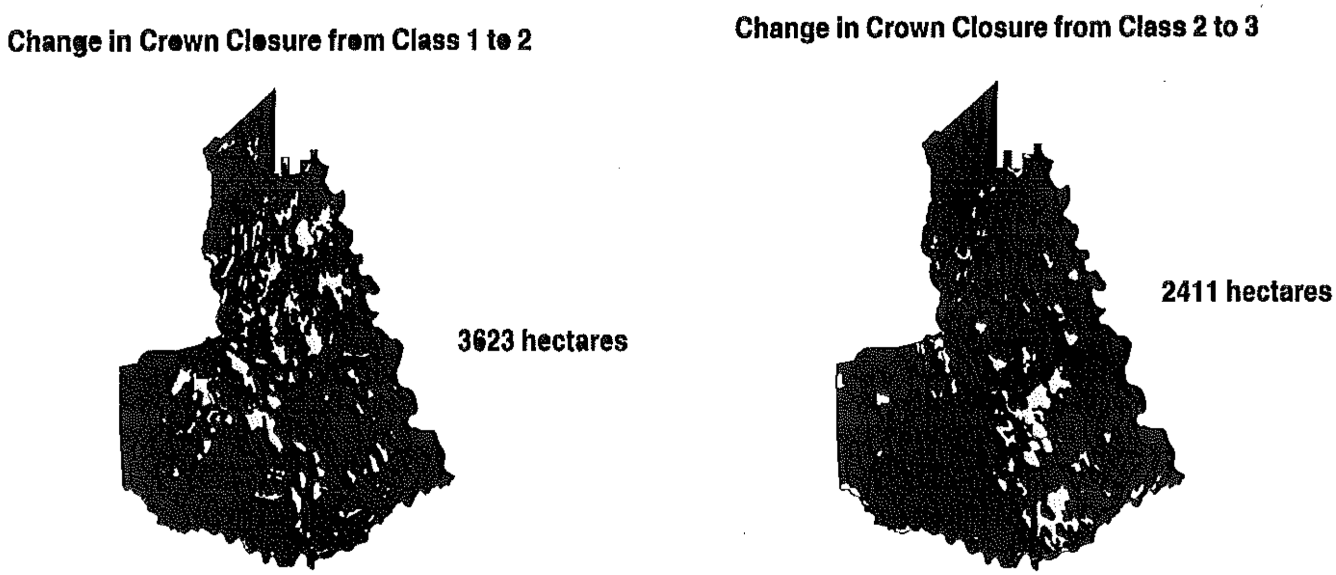


Figure 11. Location of change in crown closure classes for the Tata Creek area.

# 3. 1997/98 Work Plan

## *3.1 Objectives*

Research objectives for 1997/98 include:

1. Collaborate with USFS on completing FVS Fire Model and convert Fire Model from S.I. units (B.C. variant).
2. Collaborate with BCMF on incorporating Fire Model in Windows interface for FVS.
3. Assess stand conditions and landscape change on one additional study area as per proposal.
4. Examine use of parallel processing in FVS for projecting landscape change and spatial and non-spatial methods for simulating the effects of management practices.
5. Develop techniques to objectively determine changes in wildfire behavior potential.

Extension activities and products planned for 1997/98 will include:

1. Presentation on FVS fire model at Fire and Ecosystem Management Symposium, Cranbrook B.C., September 30 - October 2, 1997.
2. Prepare a technology transfer note on the use of the FVS Fire Model extension with case studies.
3. Present paper on successional modeling methods for GIS 98 Symposium.
4. Prepare Information Report documenting and projecting landscape change in southern interior B.C.

***A detailed activity schedule is as given on the following page.***

### 3.2 1997/98 Activity Schedule

| Quarter | Task Activity |
| --- | --- |
| 1.<br>June - August 1997 | • Critically review FVS Fire Model<br>- meet with M. Alexander C.F.S., regarding crown fire theory<br>- meet with Jeff Stone, BCFS, regarding snag fall rates used in TASS extension<br>• Obtain data for 3rd landscape unit<br>- access digital coverages and translate to ARC-INFO<br>- purchase, classify and map air photographs<br>- supervise field sampling and compile survey data<br>• Prepare extension note with guidelines for use of the Fire Model |
| 2.<br>September - November 1997 | • Produce BC variant of FVS Fire Model<br>- determine parameters requiring metric conversion,<br>- select contractor and supervise contract<br>• Develop Windows interface for Fire Model<br>- design interface look and spec out requirements<br>- select contractor and supervise contract<br>• Presentation at Fire and Ecosystem Management Symposium |
| 3.<br>December - February 1997 | • Investigate techniques to model forest level successional changes and interactions with management practices<br>- demonstrate use of WOODSTOCK for non-spatial modeling of succession<br>- investigate use of parallel processing with Fire Model<br>• Develop techniques to evaluate effects of landscape change on fire behavior potential.<br>• Presentation at GIS 98 Symposium |
| 4.<br>March - June 1997 | • Complete analysis of change in landscape units<br>• Prepare Information Reports on successional change in landscape units and modeling techniques. |