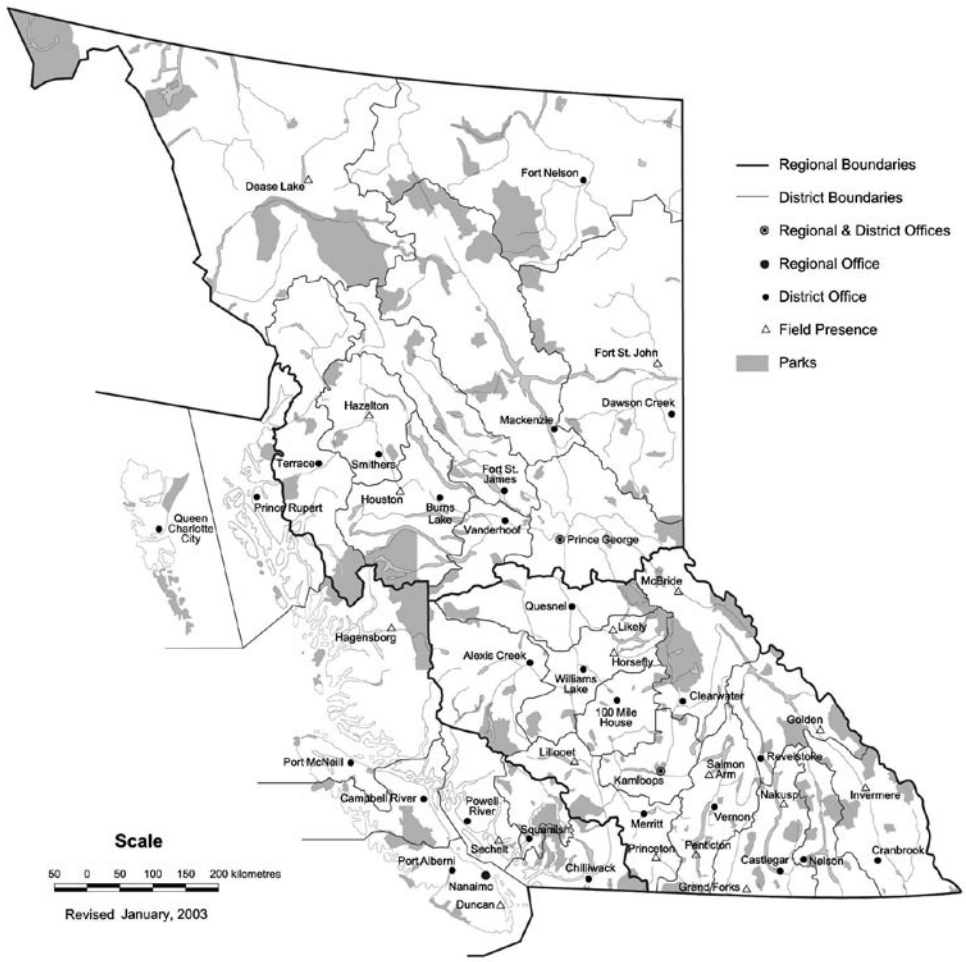
FREP

REPORT #4

FOREST AND RANGE EVALUATION PROGRAM

August 2006

Geographical Information Systems Needs Assessment



BRITISH COLUMBIA

Ministry of Forests and Range
Ministry of Environment
Ministry of Agriculture and Lands

Resource Stewardship Monitoring

Scientifically Valid Evaluations of Forest Practices under the *Forest and Range Practices Act*

Library and Archives Canada Cataloguing in Publication Data
Levesque, Lisa.
Geographical information systems needs assessment

(FREP report ; #4)

"Prepared by Lisa Levesque."--Acknowledgements.
At head of title: Forest and Range Evaluation Program.
Running title: FREP GIS needs assessment.
Co-published by Ministry of Environment, Ministry of Agriculture and Lands, and Resource Stewardship Monitoring.
Issued also on the Internet.
Includes bibliographical references: p.
ISBN 0-7726-5631-2

1. Forests and forestry – Geographical information systems. 2. British Columbia. Forest and Range Evaluation Program. 3. Information storage and retrieval systems – Forestry. 4. Forests and forestry – British Columbia – Planning. 5. Forest management – British Columbia – Planning. I. British Columbia. Ministry of Forests and Range. II. British Columbia. Ministry of Environment. III. British Columbia. Ministry of Agriculture and Lands. IV. British Columbia. Forest and Range Evaluation Program. V. Title. VI. Title: FREP GIS needs assessment. VII. Series.

SD381.5.L48 2006 025.06'63409711 C2006-960185-2

Citation:
British Columbia Ministry of Forests. 2006. Geographical Information Systems Needs Assessment. B.C. Min. For., For. Prac. Br., Victoria, B.C. FREP Ser. 004. ‹http://www.for.gov.bc.ca/hfp/frep/publications/index.htm›

Prepared by
Lisa Levesque
Forest Practices Branch
BC Ministry of Forests

Copies of this report may be obtained, depending on supply, from:
Government Publications
PO Box 9452, Stn Prov Govt
Victoria BC V8W 9V7

In Victoria (250) 387-6409
Outside Victoria 1-800-663-6105

http://www.publications.gov.bc.ca

For more information on Forest Practices Branch publications, visit our web site at:
http://www.for.gov.bc.ca/hfp/pubs.htm

List of Acronyms

BCTS	BC Timber Sales
BMGS	Base Mapping and Geomatics Services
CITS	Common Information Technology System
FAIB	Forest Analysis and Inventory Branch (MoFR)
FREP	Forest and Range Evaluation Program
FRPA	*Forest and Range Practices Act*
FTA	Forest Tenure Administration
GPS	Geographical Positioning System
GTS	GIS Terminal Server
ICIS	Integrated Cadastral Information Society
ILMB	Integrated Land Management Bureau
ILRR	Integrated Land and Resource Registry
IMF	Internet Mapping Framework
IMG	Information Management Group
LIBC	Land Information BC
LIM	Land Information Managers
LRDW	Land and Resource Data Warehouse
LRMP	Land and Resource Management Plan
MAL	Ministry of Agriculture and Lands
MoE	Ministry of the Environment
MoFR	Ministry of Forests and Range
NFI-BC	National Forest Inventory - BC
OGMA	Old Growth Management Area
OLT	Operations Leadership Team
PASO	Protected Areas System Overview
RTEB	Resource Tenures and Engineering Branch (MoFR)
RVTL	Resource Value Team Leader (FREP)
SRMP	Sustainable Resource Management Plan
TRIM	Terrain Resource Inventory Management
VRI	Vegetation Resources Inventory
WTP	Wildlife Tree Patch

Executive Summary

Background

This report outlines the value of incorporating the use of geographical information systems (GIS) into the Forest and Range Evaluation Program (FREP).[1] As the program grows in size and scope, GIS could become a valuable tool for: a) communicating FREP results to staff, the public and private stakeholders; b) facilitating field data collection; and c) providing the capability for more sophisticated and spatially explicit analysis of project data.

The specific questions addressed by this preliminary GIS needs assessment were:

1. What are the potential uses of GIS in FREP?
2. What GIS resources currently exist within FREP, or are accessible to program staff within the MoFR and other BC government ministries?
3. What additional resources are required for/associated with the potential GIS uses within FREP?
4. What are the recommended uses for GIS in FREP in the short and long term, if any?

All Resource Value Team Leaders (RVTLs), with the exception of Recreation staff, were consulted in February 2006 to determine the current level of GIS use and expertise within FREP, and identify potential immediate and future GIS needs. These meetings were followed by a review of FREP documentation, an Internet and literature review, and a number of informal meetings with subject matter experts and/or GIS users in the Integrated Land Management Bureau (ILMB), the Ministry of Forests and Range (MoFR) and the Information Management Group (IMG).

The Potential Role of GIS Within FREP

Possible uses of GIS within FREP range from basic map making and spatial representation of existing project data to complex GIS modelling for virtually all resource values. Effectiveness evaluation protocols for landscape-level biodiversity in particular will require advanced GIS knowledge and tools to answer current priority research questions. Other resource value teams could also expand their ability to tackle complex, landscape-level questions using the advanced capabilities of GIS combined or other modelling programs.

Currently, two full-time auxiliary FREP staff have sufficient GIS expertise to initiate and complete basic projects in the short term. Given that GIS knowledge and expertise is limited among FREP staff in general, however, particularly among RVTLs, tackling more complex modelling projects will require additional expertise and staff resources either from within government or external contractors. The approximately 80 Geomatics district and regional staff within the MoFR (Appendix 1), as well as GIS users and experts in various MoFR branch offices (e.g., FAIB, Research Branch), the ILMB, MOE, and IMG could be valuable assets in this regard.

FREP can immediately begin taking advantage of existing GIS and other geomatics resources available to MoFR staff, including government mapping services, spatial data repositories, on-line spatial applications, on-line discussion forums, and a range of training opportunities and on-line materials.[2]

A province-wide training initiative was initiated and completed in early 2006. The program was designed to provide basic or intermediate skills in the use of both web-based Internet Mapping Framework (IMF) applications (i.e., iMapBC and Mapview) and ArcGIS software to the MoFR geomatics community. Development of on-line training materials and LearnLinc training sessions are ongoing (as of June 2006).[3] Interest in building GIS knowledge and skills is high among RVTLs, and FREP should consider an organized effort to encourage staff training and to regularly communicate information about GIS training and other resources to FREP participants.

An MoFR GIS Task Team and a Land Information Management (LIM) Committee were formed in 2004 to examine how the delivery of GIS resources and services could be improved within the Forest Service (Ministry of Forests and Range 2006a, b). As a result of their combined

1 When FREP was first conceived, it was called the FRPA Resource Evaluation Program. Recently, the name has been changed to the Forest and Range Evaluation Program. This name change signifies the importance of FREP to last beyond a single piece of legislation and to continue serving the interests of British Columbians long into the future.

2 For a complete summary of Geomatics resources available to MoFR staff, please visit the new Geomatics Community website (created June 2006): http://gww.for.gov.bc.ca/mof/geocomm.htm.

3 Training materials and information can be accessed at the following website: http://gww.for.gov.bc.ca/his/gis/training/.

recommendations, a new MoFR Geomatics Leadership Team – composed of two branch coordinators, three Regional Geomatics Coordinators, and four Regional Geomatics Analysts – is currently being formalized. The team will be responsible for implementing a series of projects dedicated to providing the MoFR Geomatics community with continued support and stability to meet their business needs. Several of these projects will be directly relevant to FREP in the future.[4]

Recommendations

Given the feedback received by FREP participants, evidence in the literature, and consideration of the program's long-term priorities and goals, incorporating GIS appears to be not only a promising possibility but a necessary step for FREP.

Short-term recommendations include:

1. Create a series of spatial layers of FREP sampling locations from 2004–2006.
    - LRDW layers will require formalized custodianship with agreement from Ralph Archibald, Director, Forest Practices Branch. IMG can assist with the data modelling and loading.
2. Create a map summarizing general results from the 2004 and 2005 field seasons for the riparian/fish and stand-level biodiversity resource values at the provincial scale.
3. Disseminate information about existing geomatics resources and current MoFR training opportunities to all FREP participants.
4. Initiate discussion with the Geomatics Leadership Team to clarify processes and requirements for data publication to the LRDW.
5. Confirm what service allocation is available (if any) to Forest Practices Branch through the MoFR–ILMB Service Agreement.
6. Identify priority spatial data that will be crucial for the completion of FREP effectiveness evaluations, and complete a detailed review of the availability, quality and completeness these datasets. This process should leverage the FSP data review, as much of the same data will be required for FREP.

Longer term recommendations include:

7. Create an interactive map of FREP sampling locations and results from 2004–2006 to be posted on the program website.
8. Identify spatial data that does not currently exist, but is crucial for FREP business. Initiate discussions with the Geomatics Leadership Team to investigate the possibility of a formal data acquisition or creation process for missing or incomplete datasets.
9. Ensure that all FREP spatial data is made accessible to FREP participants through the FREP IMS,[5] either as interactive spatial layers within MapView and/or as static map reports.
10. Assess the value of incorporating spatial analysis and the use of GIS into the data collection and analysis strategies for all resource values, including the development of spatially explicit priority research questions.

Acknowledgements

Helpful comments on this report were provided by: Will Robins (Senior Geomatics Infrastructure Analyst, IMG); Agathe Bernard (Stewardship Forester, Nadina Forest District); Susan Elo (Contractor, C&E); Lee-ann Poisson (Stewardship Forester, Quesnel Forest District); Shannon Berch (Research Scientist, MoFR; Christina Mardell (Stewardship Forester, North Island-Central Coast); John Gallimore (Forestry Analyst, IMG).

This work relied on the valuable input from many FREP participants: Peter Bradford (MoFR), Nancy Densmore (MoFR), Peter Tschaplinski (MoFR), Dave Maloney (MoFR), Les Swain (MoE), Doug Fraser (MoFR), Francis Njenga (MoFR), Mike Curran (MoFR), Sandy Currie (MoFR), Shannon Berch (MoFR), Bill Chapman (MoFR), Frank Barber (MoFR), Ralph Winter (MoFR), Gerrard Olivotto (MoFR), Kathy Paige (MoE), Wayne Erickson (MoFR), Dianne Goode (MoFR), and Rory Annett (MoFR).

4 A comprehensive list of active projects can be accessed at: http://gww.for.gov.bc.ca/his/gis/.

5 Please see the FREP IMS website: http://www.for.gov.bc.ca/hfp/frep/ims/index.htm.

Table of Contents

List of Tables

1.0 Background

1.1 *Project Overview*

The Forest and Range Evaluation Program (FREP)[6] is rapidly growing in size and scope. Evaluation protocols and indicators have been completed for almost all resource values, an increasing number of MoFR staff members are participating in the program, and the number of field sites being evaluated will more than double in 2006 from the previous field season.

As the program begins carrying out effectiveness evaluations for new resource values and dealing with a larger volume and range of data, analyzing data and reporting on project results will become increasingly complex. The program is also beginning to consider multifaceted landscape-level questions that may require new approaches or sophisticated tools to answer.

Geographical Information Systems (GIS) are widely used for complex land management and resource planning, and have the potential to be a very valuable tool for FREP now and in the future. Incorporating GIS within FREP would provide the ability to:

1. perform more sophisticated and spatially explicit analysis of project data, particularly at the landscape scale;
2. present project data visually in the form of maps for communication or presentation purposes;
3. facilitate field data collection and location of field sites; and
4. model complex and long-term, multiple-use forest management scenarios.

This report summarizes the findings of a GIS Needs Assessment completed in early 2006 that attempted to answer the following questions:

1. What are the potential uses of GIS in FREP?
2. What GIS resources currently exist within FREP, or are accessible to program staff within the MoFR and other BC government ministries?
3. What additional resources are required for/associated with the potential GIS uses within FREP?
4. What are the recommended uses for GIS in FREP in the short and long term, if any?

Given these primary research questions, the more detailed objectives of this project were:

- To provide a comprehensive summary of existing GIS resources within FREP and the wider MoFR.
- To detail the potential immediate, short- and long-term uses of GIS products and spatial analysis capabilities for each resource value being evaluated by FREP.
- To identify where GIS could enhance data collection and analysis.
- To identify where GIS could enhance the dissemination of information to the public and among FREP staff.
- To identify the specific resource requirements (i.e., personnel, software and hardware, financial) for immediate, short- and long-term potential uses for recommended GIS map products and analysis capabilities.

A detailed project plan was completed in January 2006 (Appendix 2) and circulated to FREP Resource Value Team Leaders (RVTLs) to familiarize them with the project and solicit participation and feedback. All were invited to attend an informal “Introduction to GIS” meeting in January 2006, the intent of which was to provide basic information about the capability of GIS, and to stimulate initial thoughts and discussion surrounding how GIS could be applied within FREP. This introductory meeting was followed by a series of focus meetings with RVTLs to identify the current level of GIS knowledge among FREP participants, to identify current GIS use within the program, and to brainstorm potential map products or landscape-level spatial analysis needs for each resource value.

Following these meetings, a literature review and Internet search were completed to identify how GIS is currently being used by both the public and private sector in each of the resource value research areas, and how other similar monitoring initiatives are using GIS. In addition, a series of informal meetings with interested government staff at the MoFR Information Management Group (IMG), Ministry of the Environment (MoE) and Integrated Land Management Bureau (ILMB) were carried out to ascertain what GIS resources are currently available to FREP participants within government.

6 When FREP was first conceived, it was called the FRPA Resource Evaluation Program. Recently, the name has been changed to the Forest and Range Evaluation Program. This name change signifies the importance of FREP to last beyond a single piece of legislation and to continue serving the interests of British Columbians long into the future.

This report summarizes the results of this research. First, it provides a summary of the existing GIS resources within the BC government in general and the MoFR in particular, including: software, data, hardware, knowledgeable staff, and available training opportunities. Next, it reviews the current level of GIS use and knowledge among FREP participants, and provides a discussion surrounding the potential uses of GIS within FREP. Finally, it provides some short- and long-term recommendations for the incorporation of GIS within FREP.

1.2 *A Brief Recent History of GIS and the MoFR*

An MoFR GIS Task Team and a Land Information Management (LIM) Committee were formed in 2004 to examine how the delivery of GIS resources and services could be improved within the Forest Service (Ministry of Forests and Range 2006 a, b). After a series of user surveys, emails and workshops with GIS/LIM staff within the MoFR and BCTS, the task team identified several key issues of concern, and subsequently proposed a series of recommendations to the Operations Leadership Team (OLT) that were designed to improve the delivery of GIS services and resources to the more than 1400 MoFR staff using GIS to fulfil their daily business needs.

Also, as a result of these combined recommendations, a new MoFR Geomatics Leadership Team – composed of two branch coordinators, three Regional Geomatics Coordinators, and four Regional Geomatics Analysts – is currently being formalized. The team will be responsible for implementing a series of projects dedicated to providing the MoFR Geomatics community with continued support and stability to meet their business needs. Several of these projects have already been initiated, and will be directly relevant to FREP in the future.[7]

Further, a province-wide training initiative was initiated in early 2006 that was designed to provide basic or intermediate skills in the use of both web-based Internet Mapping Framework (IMF) applications (i.e., iMapBC, Mapview, etc.) and ArcGIS software to the MoFR Geomatics community. Development of on-line training materials and LearnLinc training sessions are ongoing (as of June 2006).[8]

Interest in building GIS knowledge and skills is high among RVTLs, and FREP should consider an organized effort to encourage staff training and to regularly communicate information about GIS training and other resources to FREP participants.

2.0 GIS Resources

FREP can immediately begin taking advantage of existing GIS and other geomatics resources available to MoFR staff, including government mapping services, spatial data repositories, on-line spatial applications, on-line discussion forums, and a range of training opportunities and on-line materials.[9] The following section provides a summary of the current software, hardware, spatial data, and training resources available to MoFR staff and FREP in particular.

2.1 *Software*

A number of freely accessible web-based IMF applications (e.g., iMapBC and MapView) and more advanced ESRI[10] mapping packages are available for use by MoFR staff. Geomatics users within the MoFR are classified into three tiers depending on their skill level and analysis needs, and access to more advanced software is limited to tier 2 and 3 users only. The three tiers of GIS users are described below in order of increasing cost and training commitment:

Tier 1: Those users whose basic knowledge and analytical needs can be met through web-based IMF tools. Users have the ability to view existing data, perform basic queries, and create simple maps using web-based tools such as *iMapBC, MapView*, etc.

Tier 2: This tier is geared towards professional staff trained in GIS who require additional functionality (e.g., custom maps, spatial analysis, complex queries, etc.). Tier 2 users are granted access to ArcView and ArcGIS software packages.

7 A comprehensive list of active projects can be accessed at: http://gww.for.gov.bc.ca/his/gis/.
8 Training materials and information can be accessed at the following website: http://gww.for.gov.bc.ca/his/gis/training/.
9 For a complete summary of Geomatics resources available to MoFR staff, please visit the new Geomatics Community website (created June 2006): http://gww.for.gov.bc.ca/mof/geocomm.htm.
10 Please see the ESRI website for more details: http://esri.com/.

Tier 3: Users who require sophisticated modelling and analysis capability will have access to ArcInfo workstation licenses through the GTS terminal server.[11]

Users are encouraged to explore the functionality of the provincial government web-based IMF applications before they request access to more advanced software through the GTS (see section 2.1.2 for an explanation of the GTS). Numerous web-based IMF applications have been custom-designed to accommodate simple queries (see below), data viewing and plotting functions in order to meet the needs of various business areas within government. All BC government IMF applications use an ArcIMS software platform[12] and contain a customized collection of data layers and suite of tools and commands relevant to a particular business area.

2.1.1 Web-based applications

A number of web-based Internet Mapping Framework (IMF) tools have been designed to meet the basic GIS user needs of various business areas. Although these programs can meet many users' basic data analysis needs, their functionality is limited, and some users will require the more advanced capability of sophisticated GIS software packages.

Among the numerous web-based applications available to government staff, there are two that are most relevant to MoFR users: *MapView and iMapBC*. Other examples that may be of interest to FREP include: the Integrated Land and Resource Registry (ILRR), FishWizard, and the Protected Areas System Overview (PASO). A list of internal and external IMF applications can be found at http://maps.bcgov/ and http://maps.gov.bc.ca/ respectively.

(a) MapView

MapView was designed and is currently maintained by the Information Management Group (IMG). MapView contains a suite of spatial layers and customized queries that are directly relevant to forest managers. It also provides various canned map views, search tools, and overlay reports organized under four tabs that have been designed to reflect forestry-related business needs: 1) silviculture, 2) tenure, 3) enforcement and 4) vegetation. MapView is constantly in development, and there may be an opportunity to incorporate specific FREP needs into MapView.

The MapView (version 4.1) application can be accessed in a number of ways. First, it can be accessed through the MoFR Geomatics and Mapping Training website. It is also accessible directly on the MoFR intranet site. Alternatively, it can be accessed via the RESULTS system when a user links to "details" for a specific opening record.

There are plans to link the FREP IMS system (currently in development) directly to MapView to meet users' operational mapping needs which would provide a third access point into the system.

(b) iMapBC

iMapBC has been designed and maintained by the Ministry of Agriculture and Lands (MAL) ILMB staff, and is geared towards meeting the needs of a more general government and public user base. The collection of layers accessible through iMapBC is considerably larger than those of other similar programs, and developers are constantly enhancing the program's functionality in order to meet a greater range of user needs.

iMapBC can also be accessed from a number of locations. A link to iMapBC is provided on the Geomatics Community homepage. Alternatively, at the time of writing, users can access iMapBC internally through http://lrdw.bcgov/.

2.1.2 ArcGIS

Some users may require additional functionality that web-based applications cannot provide. To meet this need, access to ArcView, ArcGIS and ArcInfo software is provided through the GIS terminal server (GTS), a server farm run by the Common Information Technology Systems (CITS) group on behalf of MAL. The GTS currently consists of a farm of 19 terminal servers installed with either ESRI ArcView or ArcInfo software and associated supporting programs needed for GIS analysis and GIS data production. It also provides disk space for both short- (working area) and long-term data storage (archive area).

Because there are a limited number of terminal servers, data processing can be slow at times of peak use, and storage space is also limited. If users are granted access to the GTS, they are encouraged to read all literature pertaining to best use practices, and take advantage of

11 GTS terminal server information: http://srmgww.bcgov/landinfobc/imb/aas/services/gis_services/.
12 For more information on ArcIMS applications, please visit: http://www.esri.com/software/arcgis/arcims/about/overview.html.

training opportunities being offered by MoFR Geomatics staff.[13] The MoFR will be acquiring a total of 7 TB of space in 2006, with approximately 2.5 TB for long-term storage, and 4.5 TB for working areas.[14] This is expected to come into production in the fall of 2006.

Users may request access permission for a number of different spatial databases accessible through the GTS that are most relevant to their business area. All users have automatic access to raw spatial data layers housed in the Land and Resource Data Warehouse (LRDW; see section 2.2.1) and to spatial imagery available in the Digital Image Warehouse (see section 2.2.2).

IMG currently facilitates granting access permissions to the GTS to MoFR staff.[15]

Once permission has been granted, users access the GTS server through the BCGOV farm in the Citrix Program Neighborhood, which links users to one of the 19 terminal servers.

2.2 *Data*

The fundamental consideration in any GIS project is the quality and appropriateness of available data. Spatial data can either be derived from raw data sources (i.e., hard copy maps, aerial photography, satellite imagery, survey records, etc.) or acquired from a number of public and private sources.

For BC government employees, most freely available spatial data pertaining to land and resource management is housed in the LRDW, or a number of other operational databases (e.g., RESULTS, FTA, Tantalis) that feed updated information into the LRDW on a routine basis. In some cases, the most current datasets are available through regional warehouses of spatial data in ILMB regions and MoFR district and regional offices, which have not yet been incorporated into the LRDW. Very high quality spatial or image data can also be bought from private distributors, usually at a fairly high cost.

The following section outlines the data sources that will be most relevant to FREP.

2.2.1 Land and Resource Data Warehouse

(a) Overview

All official government spatial data is housed in the Land and Resource Data Warehouse (LRDW), the corporate repository for integrated land, resource and geographic data that supports a variety of business requirements for the natural resource sector, other government agencies, industry and the public. Users can search the database or browse data layers according to predefined drop down lists using the Land Information BC Discovery Service (LIBC), or can view the spatial data directly in ArcGIS if they have been granted access permission.[16, 17]

(b) About the data

Various government ministries/agencies (e.g., MAL, MoE, ILMB, MoFR) and business partners (e.g., forest companies, consultants, federal government, First Nations) provide data for loading (publishing) into the LRDW. Although there are detailed guidelines for populating and updating the majority of content in the LRDW, differences in the level of knowledge and commitment among data custodians (see below) has led to some inconsistency in terms of final data quality and the observation of consistent standards during data creation.

As a result, **datasets in the LRDW do not always represent the most current or accurate data**, and regional databases may be the best source in many cases. In the case of Old Growth Management Areas (OGMAs) or Wildlife Tree Patches (WTPs) for example, limited data exists and some of the data remains in draft form within the LRDW, but regional databases contain much more current and complete information.

---

13 At the time of writing, best practices for use of the GTS environment and other relevant literature could be accessed at http://srmgww.bcgov/landinfobc/imb/aas/services/gis_services/.

14 Given the GIS needs identified later in this report, it is expected that FREP will require roughly 50–60 GB of storage space if work is completed in-house. If this need increases, FREP staff should contact the Senior Geomatics Infrastructure Analyst at IMG to notify them of additional space requirements (Robins pers. comm. 2006).

15 At the time of writing, users wishing to gain access to the GTS environment should contact the MoFR branch liaisons at IMG – Robert Johnson or Cheryl Edwards. Potential users are asked to provide a description of their specific business need, and evidence of their GIS expertise before access permission is granted.

16 Instruction on how to access the LRDW using ArcGIS products can be found at the following URL: http://srmgww.bcgov/landinfobc/imb/aas/services/gis_services/connect_lrdw.html.

17 For assistance with LRDW Applications, Data (content) and Services, e-mail: MALMoE.Helpdesk@gov.bc.ca.

There are several operational database systems (e.g., Tantalis, MTA, FTA, RESULTS) that send updated spatial information related to land and resource management to the LRDW on a daily basis, and many others that send updates with varying frequency (e.g., ICIS,[18] TRIM, ABR). Some data layers, however, are updated sporadically or not at all (e.g., OGMAs).

Data quality is a major issue with respect to forest management and other forestry-related data. Prior to 2001, districts were responsible for updating and maintaining the forest cover inventory, now the Vegetation Resources Inventory (VRI). Individual districts, with varying degrees of success, combined information submitted by licensees with satellite imagery, air photos, timber cruise data, or GPS traverses to update forest cover maps.

Since 2003, when the RESULTS e-submission system was implemented, licensees have been required to submit site plans spatially. Pre-2003 forestry data, however, (e.g., cutblock locations, riparian reserve zones, etc.) is not always represented spatially within the LRDW unless it was either voluntarily submitted by the licensees or compiled by district staff. In addition, despite the fact that these spatial data submissions have been required since 2003, many licensees have simply not yet submitted the required information.

A formal three-year FTA cleanup process will be completed at the end of the 2006/2007 fiscal year, and users can expect to see significant improvements in spatial data quality related to forestry tenures-related data. Information about this project is available on the Geomatics Community Home Page.

Communication with the appropriate data custodian (see (d) Data Custodians below) is necessary in order to devise a strategy for effectively completing or updating the information contained in a given layer. If the dataset simply does not exist, FREP should initiate discussion with the Geomatics Leadership Team to investigate the possibility of acquiring, compiling or creating these crucial datasets.[19]

(c) Metadata

All available metadata (e.g., the update cycle of a given layer, information about the government branch responsible for maintaining the layer, information about data precision and accuracy, data accessibility, etc.) is housed in the **Metastar** database which can be accessed in a number of ways:

1. When accessing data through the **Land Information BC** service, the metadata is accessible through a hyperlink included in the search results.
2. In **iMapBC**, all data layers are directly hyperlinked to their associated metadata document.
3. In **MapView**, each layer, many of which are composites of any number of individual spatial layers from the LRDW,[20] is hyperlinked to a metadata document created by IMG. From this document, users can access Metastar directly for more detailed metadata information.

The accuracy of metadata remains questionable however. Presently, there is an initiative being carried out by staff at ILMB to update all metadata and data custodian information within Metastar, which should be completed sometime in early 2006.[21]

(d) Data custodians

Each data layer within the LRDW has a designated “data custodian” who is accountable for the data published in the LRDW. The data custodian is responsible for ensuring that the data is organized and “packaged” in an appropriate way, is up-to-date and of high quality, follows clear and consistent standards, has security “clearance”

18 Spatial data produced by the Integrated Cadastral Information Society (ICIS) is sometimes referred to as Integrated Cadastral Information (ICI) or Integrated Cadastral Fabric (ICF), but all refer to the same collection of integrated parcel fabric and related parcel links (i.e., BC Assessment, Crown and private interest and engineering infrastructure, land use).

19 For example, at present, most available stream class information was derived from TRIM topographic data and has not been ground truthed in the field. As a result, the dataset is largely inaccurate, but would be invaluable to FREP riparian and water effectiveness evaluations. Much of this information is routinely collected by licensees but is not currently required for RESULTS e-submissions, therefore possibilities may exist for formally acquiring these data in the future.

20 The “Transportation” layer in MapView for example includes several LRDW layers including all roads, railroads, and other transportation corridors.

21 For updates on this project, see the link located on the following URL: http://lrdw.bcgov/whats_new/index.html.

for release, is uploaded using reliable and secure processes, and contains comprehensive and accurate metadata. Some custodians are diligent at updating the information on a routine basis, but some are not even aware of their role. Typically, official data custodians are branch directors, but in some cases within MoE, Regional Managers take on the role. In reality, any number of data stewards are responsible for keeping the LRDW up-to-date.

Identifying the current data custodian is not always straightforward, but the name of the Data Custodian Organization is at the top of each layer's metadata document, and could be contacted to find out this information. In some cases, a contact person is identified in the metadata document as well, which can also be a good starting point.

2.2.2 Digital Image Management Program

The Digital Image Management Program (DIM) was initiated in 2001 to establish and maintain a semi-automated, computer-based system to support the acquisition, discovery, management and distribution of geographic digital imagery for the province of BC. DIM manages an extensive database of various types of digital imagery, including scanned photographs, air photos, orthoimagery, satellite imagery, etc. All data are stored in the DIM Image Warehouse managed by Base Mapping and Geomatics Services (BMGS) at the ILMB.

The extent of airphoto coverage for the province varies from year to year, but at least some provincial air photo coverage exists from 1963–2005. The ILMB has recently launched the BC Airphoto Inventory Web Viewer, and as of February 2006, air photo information up to 2005 (i.e., airphoto operation areas, flight lines, airphoto footprints, and the most recent provincial TRIM orthomosaic) are accessible through this service. Imagery is also accessible in iMapBC under the "Imagery" folder.

Two black and white orthophoto mosaics[22] are currently available, and coverage for the province is almost complete. The first overview mosaic was created at 64 m pixel resolution, and the second at a 1 m pixel resolution. The orthophoto image was created using airphoto imagery from 1987–2003 combined with TRIM 2 base data.[23] A partial colour orthomosaic at 1 m resolution has also been created from air photos flown between 1999–2004.[24] Coverage exists for a large portion of the Southern Interior region and a large area around Prince George.

The DIM Warehouse also currently contains some SPOT 5 satellite imagery for the southwest corner of the province from 2004–2005.

2.2.3 Useful forest cover datasets

(a) Vegetation Resources Inventory (VRI)

The VRI is the definitive forest cover layer for the province of BC and will be invaluable for virtually all FREP GIS projects.[25] Unfortunately, because of the inconsistency in quality and completeness of data throughout the province, the VRI should be used with caution (see section 2.2.1 for a more extended discussion). On average, the VRI is approximately three years out of date,[26] although in the future, the average is expected to drop to six months to one year. An annual projected version of the VRI will be produced each year, and this is the version that should be used for all FREP analysis.

Currently, staff at the Forest Analysis and Inventory Branch (FAIB) is in the process of completing an extremely valuable VRI Update project using a change detection process that incorporates GIS, image analysis, and

22 An "orthophoto" is a uniform-scale photograph. It is a **photographic map**. A conventional perspective aerial photograph contains image displacements caused by the tilting of the camera and topography. It does not have a uniform scale. You cannot measure distances on an aerial photograph like you can on a map. The effects of tilt and relief are removed from the aerial photograph by the rectification process to create an orthophoto. An "orthophoto mosaic" is a seamless mosaic of a series of air photo images.

23 Please refer to the following URL for a map showing the current provincial black and white orthophoto coverage and date of photography: http://ilmbwww.gov.bc.ca/bmgs/trim/date_of_photo_B&W.html.

24 Please refer to the following URL for a map showing the current provincial colour orthophoto coverage and date of photography used: http://ilmbwww.gov.bc.ca/bmgs/trim/date_of_photo_colour.html.

25 Creation of the VRI occurs in two phases. The photo interpretation (Phase I) involves estimating vegetation polygon characteristics from existing information, aerial photography, or other sources. The ground sampling phase (Phase II) provides the information necessary to determine how much of a given characteristic is within the inventory area. Ground samples alone cannot be collected in sufficient numbers to provide the specific locations of the land-cover characteristics being inventoried.

26 Melanie Boyce, presentation at Forest Information Management Workshop, June 6, 2006.

eCognition software.[27] The goal is to evaluate each Timber Supply Area (TSA) for cutblock and fire boundary mapping accuracy, and to update the VRI with this new information. The process utilizes a combination of RESULTS data, LandSat imagery, and a Vegetation Resource Inventory Management System (VRIMS) cut-in tool.

(b) The National Forest Inventory (NFI)

Developing the ability to report on the current status of the forest resource in British Columbia and to monitor changes in the forest has become increasingly important in recent years. The National Forest Inventory – British Columbia Program (NFI-BC) was initiated to ensure that these new data needs are met.

The permanent plot design of the NFI-BC allows for the repeated measuring of forest attributes at defined locations. While permanent plots have been used for more than 80 years to track changes in the growth of trees across the province, the NFI-BC has expanded the practice to include the monitoring and measurement of photo-based information. The program has also increased the amount of ecologically based data collected on the ground.

The program is designed to provide status and trend data – at the provincial and, ultimately, national levels – on 25 attributes of sustainability. The permanent, re-measurable design of the NFI-BC puts in place a statistically based system of monitoring and reporting, which can be completed in conjunction with the national program.

Monitoring information of this kind may be extremely useful for FREP, and the program should at least be aware of this initiative. Future FREP analyses, particularly at the landscape scale and for the landscape-level biodiversity resource value, may want to consider similar change detection techniques, or the incorporation of this data into program reporting.

2.2.4 Locally available data

In many cases, the most accurate and up-to-date data is created, acquired and/or maintained locally, and is usually available through regional Geomatic staff with ILMB and MoFR regional or district offices. For example, special zoning designations or harvesting constraints outlined by various local-level planning processes (e.g., LRMP or SRMP) may not currently be available within the LRDW.[28]

In some areas of the province, concern among local decision makers about the quality of provincially available data has resulted in the formation of formal data sharing partnerships or initiatives. Examples include the Northwest Data Sharing Network (NWDSN) and the Kootenay Spatial Data Partnership (KSDP). These initiatives review the various possible data sources (e.g., LRDW, local government, industry, etc.), select the most accurate data, and make it available through locally managed databases. It is frequently this data that local partners and decision makers use for various land management decisions. Such initiatives may represent an extremely valuable source of information that FREP should consider.

2.3 *Training*

For MoFR, all GIS training materials and associated links can be found on the newly launched GIS Training website. The site includes links to hard-copy training materials, video tutorials, LearnLinc sessions, and the MapView and iMap BC web-based applications. The site also links users to information about the GTS and how to connect to the Citrix Neighborhood. Finally, all current information about GIS training courses and opportunities will be posted on this site.

The following section provides a brief overview of training opportunities available to FREP staff at the time of writing. It is recommended that FREP participants look to the local Geomatics staff in MoFR regions and districts (many MoFR Geomatics staff are committed to delivering Mapview and iMapBC courses) or to LearnLinc sessions sponsored by IMG.

Important Note: Interested FREP participants should refer to the GIS Training website for the most current GIS training information.

27 At the time of writing, the contact person for the VRI Update project is Ann Morrison at the MoFR Forest and Inventory Branch.

28 In the Nadina Forest District, for example, one SRMP identifies various landscape units where the requirements for wildlife tree patches exceed the legislated MoFR minimums – a fact that could have important implications for future analyses of FREP RSM data (Bernard 2006, pers. comm.).

2.3.1 MapView and iMapBC

There are three separate training streams currently being offered by IMG to familiarize users with the capabilities and functions of the MapView and iMapBC web-based applications:

1. **Train the Trainer:** These sessions are targeted to intermediate and advanced GIS users who are interested in training employees in their local offices. Once their training is complete, each trainee will hold a series of one-on-one or group training sessions for their colleagues.
2. **Self-Serve Training:** Involves a series of exercises focused on specific MoFR business topics. These self-serve exercises have been developed to provide students with step-by-step business scenarios to develop their iMapBC and MapView skills. The exercises use a combination of real world and fictional iMapBC and MapView use case scenarios to demonstrate iMapBC and MapView tools in an MoFR context. The exercises are designed to be downloaded and followed while using iMapBC and/or MapView.
3. **LearnLinc Training:** This approach will focus on the same topics offered though the self-serve training stream and is ideal for those employees who prefer instructor-led training.

ArcGIS

The first round of 1.5-day ArcGIS Basic Training workshops was completed in February 2006. No courses are planned for the near future, however, the ArcGIS Basic and Intermediate Training materials are available for review on-line.

Staff persons at IMG have indicated that there may be opportunities to organize additional courses in the future if there are both sufficient interest and resources. Given the overwhelming interest among FREP participants in furthering their practical knowledge of both web-based applications and ArcGIS tools, FREP should pursue this potential opportunity.

MoFR users also have the opportunity to access the suite of ESRI Virtual Campus courses,[29] which provide fundamental and advanced training in the concepts and use of ArcGIS software packages.

29 Requests for access to the ESRI Virtual Campus can be made to Robert Johnson (IMG).

2.4 *People*

The following list is not intended to be exhaustive, but rather should act as a starting point for identifying other potentially useful contacts within the MoFR and wider GIS user community. Many of the users listed below are presently involved in FREP and are actively using GIS to achieve effectiveness evaluation objectives.

2.4.1 GIS users within the MoFR

Forest Practices Branch

Tim Ebata – Forest Health Project Specialist

Jacques Marc – Visuals (Landscape Forester)

Ralph Winter – Stand Management Officer

Alanya Smith – FFT Effectiveness Evaluation and Monitoring Co-ordinator

Lisa Levesque – FREP Researcher

Forest Analysis and Inventory Branch

Ann Morrison – Update Forester (VRI Update project)

Melanie Boyce – Director

Greg Lawrance – Timber Supply Forester

Xiaoping Yuan – Forest Statistics Officer (National Forest Inventory)

Don Gosnell – Assistant Director (MoFR–ILMB Service Agreement reviewer)

Information Management Group

Will Robins – Senior Geomatics Infrastructure Analyst (Geomatics Leadership Team)

Cheryl Edwards – Senior Development Analyst

Robert Johnson – Business Application Analyst

(+ Other new members of the Geomatics Leadership Team – TBA)

Resource Tenures and Engineering Branch

Dave Anderson – Geomatics Project Manager (Geomatics Leadership Team)

Doug Kelly – Manager, Engineering & Real Estate Operations (MoFR–ILMB Service Allocation)

Regional and district offices

Agathe Bernard – Stewardship Forester
(Nadina Forest District)

Jennifer Naylor – Geomatics Analyst
(Campbell River Forest District)

(+ see Appendix 1 for a list of approximately 80 regional/district GIS/LIM staff – compiled by the GIS Task Team in February 2005).

2.4.2 GIS users – other Ministries

Ministry of the Environment

Dave Clark – Wildlife Habitat Ecologist
(Broad Ecosystem Inventory Mapping)

Matt Austin – Species Specialist, Biodiversity Branch
(Land Cover Mapping/modelling)

Integrated Land Management Bureau

Chris Spicer – Access Services, Corporate Information Services (Digital Imagery)

Insha Khan – Business Leader, Corporate GIS

Malcolm Gray – (Baseline Thematic Mapping/
Land Cover Mapping)

2.4.3 MoFR–ILMB Service Agreement

The intent of the new MoFR–ILMB Service Agreement[30] is to provide a mechanism for individual MoFR offices to negotiate service agreements with ILMB. An annual review of the service agreement will be completed by Don Gosnell (MoFR) and Larry Price (ILMB), and results and will published for review by MoFR staff.

There are three ways to secure service through the Service Agreement (Gosnell 2006, pers. comm.):

1. utilize the ILMB service allocation (formerly the "quantum" allocation[31]);
2. provide service back to ILMB of equal value; and
3. pay ILMB for services rendered.

Historically, most of the service allocation was provided to and used by RTEB, and "surplus" or unused allocations could be used by other branch offices (although few took advantage of this opportunity).

Under the Service Agreement, the MoFR is eligible to access a suite of standard geomatics products and services as well as custom products and services that are not included in the catalogue.[32] Currently, some allocation may be available to FREP through this agreement, and this possibility should be explored in detail. Corporate Business Area contacts are listed below (Table 1), and would be appropriate to approach for exploring this possibility.

Table 1. *Corporate business area contacts – MoFR–ILMB Service Agreement*

Business Area	Primary	Secondary
Protection	Mike Winder	Judi Beck
RTEB	Doug Kelly	Dave Andersen
C&E	Marg Shamlock	Cassandra Mann
FAIB	Greg Lawrance	Don Gosnell
IMG	Cheryl Edwards	Gloria Wills
NIR	Dick Nakatsu	Wayne Martin
SIR	Bernie Peschke	Craig Sutherland
CR	Hal MacLean	

3.0 Current Role of GIS Within FREP

The level of GIS expertise varies considerably among FREP participants. Some resource value teams have taken considerable advantage of GIS capabilities for analysis purposes in the past, while some have not used GIS at all. The intent of this section is to provide an overview of the current level of knowledge among FREP staff, and to provide some examples of past GIS use for FREP.

3.1 *Expertise Among FREP Staff*

A total of 18 respondents, mostly Resource Value Team Leaders, provided written or verbal feedback through an informal "FREP GIS Needs Assessment Questionnaire" (Appendix 3). All participants were asked a series of questions about their level of knowledge and experience working with both web-based GIS systems and ArcGIS

30 At the time of writing, this agreement was in draft form only, and expected to be finalized in the coming weeks/months (Gosnell 2006, pers. comm.). Contact Don Gosnell for the most current Service Agreement.

31 The concept of a "quantum allocation" originated in the era of the Ministry of Sustainable Resource Management (MSRM) and now is implemented through the ILMB, known as the "Service Agreement."

32 ILMB will publish a catalogue of standard products and services in July 2006, which will provide samples, descriptions, constraints/dependencies, contact information and pricing. Contact: Insha Khan.

systems. Some respondents had additional experience with other image software, GIS, or geographical modelling programs. A summary of the responses is provided in Table 2.

Table 2. Summary of GIS experience among FREP Resource Value Team Leaders

Description	Number of Respondents		
	No	Basic[a]	Advanced[b]
Web-based GIS applications (e.g., MapView, iMapBC, FishWizard, etc.)	5	12	
ArcGIS, ArcView, other GIS programs	14	2	2
Other Geomatic software			1
Interested in GIS training	5	11	2

a Basic: viewing data; adding data layers to a map.

b Advanced: uploading GPS coordinates; creating a map; basic analysis (e.g., buffering, overlays); advanced analysis (e.g., watershed modelling, terrain stability mapping).

Among FREP Resource Value Team Leaders, most have had some experience working with MapView or iMapBC, while five people were not familiar with any web-based applications at all. About half of respondents use MapView on a regular basis for viewing layers or printing maps. One person noted that they find the collection of orthophotos in MapView very useful for locating field sites, despite the fact that the image collection is incomplete. Another mentioned that they use the hillshade feature in MapView regularly for field use.

A few people mentioned that the capabilities of MapView could not meet their needs. Others mentioned having some additional basic functionality through MapView (e.g.,overlays, basic queries, labelling features, etc.) would be very helpful, and a couple were interested in learning how to make maps from their own data collected in the field.

There was very limited experience among the group working with more sophisticated ArcGIS or other GIS programs, but the majority of these people also indicated that they were very interested in at least a basic level of GIS training. Most people (4) that were not interested in training felt that they would not need the practical skills, but were still interested in becoming familiar with the capabilities of GIS, particularly examples of GIS use in monitoring and evaluation programs.

Several respondents indicated that one of their primary frustrations was being unable to find or access LRDW data quickly and efficiently. This should be a focus of any training session offered to FREP participants in the future.

The visual quality resource value team uses a custom built 3-D landscape visualization tool – Landscape Manager – for a lot of their work, but unfortunately the recent government “refresh” did not have this particular software on the “accepted software” list. Investigating similar capabilities in the ESRI suite of software tools would be useful in this regard.

3.2 *Current Use of GIS Within FREP*

The responses from this section of the questionnaire were variable, and largely influenced by what stage of the evaluation process a particular resource value team was at. Participants were asked if their resource value team had either used GIS themselves, or sought GIS expertise from within or outside of government to create maps, analyze FREP data, or locate FREP field sites. The results are summarized in Tables 3 and 4.

Table 3. Previous use of GIS by FREP resource value teams

Resource value	Map creation	Data analysis	Locating field sites
Fish/Riparian	N	N	N
Water	Y	N	Y
Forage	N	N	N
Timber	Y	N	N
Cultural Heritage	N	N	N
Soils	Y	Y	Y
Visual Quality	Y	Y	Y
Wildlife	Y	Y	N
Biodiversity	N	N	N

Almost all resource value teams have hired outside contractors for various GIS projects, indicating that there could be a need for permanent GIS capacity within FREP. Several different RVTLs indicated that although their current GIS budget was small or insignificant, they expected that it would increase considerably in the future, and at least two clearly indicated that they see many possibilities for using GIS for FREP-related projects should additional in-house resources become available.

Only three resource value teams have used GIS resources within government. Only the water resource value team has taken advantage of the ILMB quantum system. The riparian/fish team used to have access to a GIS technician, but currently is not using government GIS resources.

Table 4. Summary of the use of GIS resources both within and outside of government for each resource value team

Resource value	Government resources	Contracted out	Comments
Water	Yes	Yes	• Budget has been insignificant, but expect it to increase substantially· • Some use of ILMB quantum allocation
Riparian/Fish	Yes	Yes	• May be interested in using government data to look at MPB blocks· • Used to have GIS technician
Forage	No	Yes – Coastal Resources Mapping	
Timber	No	Yes – Timberline Consulting (Victoria)	• Insignificant budget at the moment, but see lots of possibilities
Soils	MoFR – RB	Yes – Selkirk College staff and students	• Budget around 15–20K, but likely to increase
Visual Quality	No	Yes – HR GIS Solutions	• Bark beetle damage modelling· • Development of custom landscape visualization software
Wildlife	No	Yes	• Hired contractors to complete GIS work for Effectiveness Evaluations for gopher snake and Rocky Mountain tailed frog· • No clear idea of where to look for government resources
Biodiversity	No	No	• MoE may have done some very relevant work related to landscape-level biodiversity assessments
Cultural Heritage	No	Yes	• Mapping of archaeological sites • Mapping of known cultural heritage resources, and areas of known Aboriginal interest

3.3 *FREP IMS*

The new FREP Information Management System (IMS), currently in development, will support the core business activities carried out by FREP participants conducting resource stewardship monitoring. District staff and other potential users have clearly identified mapping capability as an essential feature of the system. The FREP IMS will be linked to MapView to meet these mapping needs, and the FREP IMS team will work closely with MapView developers at IMG to tailor the MapView system to meet FREP requirements where possible.

Several new map display options and some additional reporting options specific to FREP will be developed within MapView in the second phase of implementation. Details of these developments have not been finalized, but will be detailed on the FREP IMS website as they become available.

3.4 *Data Availability*

Participants were also asked whether any maps or data that they needed for FREP business were unavailable, incomplete or poor quality. Responses are summarized in Table 5.

Some common concerns were the quality of TRIM road network maps, and the fact that orthophoto coverage for the province was incomplete. In the case of the cultural heritage value, much of the data that would be useful from a GIS perspective is currently not available at the provincial scale, although some is certainly available in district databases. In general, most resource value teams did note some data quality issues, mostly surrounding the completeness and currency of the data within the LRDW.

Table 5. Summary of comments regarding data quality and availability for each FREP resource value

Resource value	Comments
Cultural Heritage	• Not a large amount of spatial cultural heritage information available (e.g., maps of cultural heritage resource, culturally modified trees). • Cultural resource/archaeological information can be very sensitive, with restricted access.
Wildlife	• Layers with questionable quality/accuracy issues that have been used in past evaluations: TRIM road networks in remote areas; land status/tenure maps; fire potential mapping; historic fire regime maps.
Visual Quality	• Most spatial information related to visual quality is not current (e.g., established visual quality areas, established scenic areas). Most current information is in the district offices, some in digital format, some on mylars. • LRDW has no archiving capability, which is important for looking at change over time.
Forage	• Orthophoto coverage is incomplete.
Soils	• Orthophoto coverage is incomplete. • Road network requires updating.

4.0 Potential Role of GIS Within FREP

The value of incorporating the use of Geographical Information Systems (GIS) within FREP appears to be substantial. From facilitating field work planning and data collection to sophisticated watershed or forest management modelling, feedback from participants and relevant literature suggests that GIS would be a valuable tool.

Information from the participant questionnaire has been collated and summarized in section 4.1, and section 4.2 offers discussion of relevant GIS work being done in each of the resource value research areas. Finally, section 4.3 discusses important considerations for the integration of GIS into FREP.

4.1 *Questionnaire Results*

4.1.1 Priority datasets

A list of datasets that could potentially be useful for FREP field work and subsequent data analyses is summarized in Table 6. No specific research has yet been done to investigate the availability, quality or completeness of the data listed here – the list therefore represents a "wish-list" based on RVTL feedback and knowledge of FREP goals and priority evaluation questions.

A distinction has been made between datasets that could be useful for planning and/or facilitating field data collection (marked with an F) and datasets that could be useful for subsequent analysis of those field data or more complex GIS-based analyses that are not based on FREP field data (marked with an A).

Certain information was clearly important from the perspective of several FREP resource value teams, and was identified as a high priority dataset (Table 6, shaded cells). In some cases, the relevant spatial data may already exist, while in others, it may need to be updated, collated or created.

FREP should complete a detailed review of the availability, quality and completeness of these high priority spatial datasets (summarized following Table 6).

__Table 6.__ Table of potentially useful map information organized by resource value. Table codes include: F = useful for fieldwork and/or A = useful for data analysis. High priority data layers are shaded and are summarized following the table.

Desired Map Information	Resource Value										
	SLBD	Riparian	Water	Soils	Forage	Visual Quality	LLBD	Rec	Wildlife	Timber	Cultural Heritage
A-class seed distribution	A						A			A	
Archaeological sites	F	F									F/A
Bark beetle kill maps	A	A	A	A		A	A		A	A	
Bedrock type				A							
Biogeoclimatic zones (BEC)	F	F/A	F/A		F/A		F/A		F	A	A
Broad ecosystem units									F		
Climate maps (precip. zones, temperature zones, etc.)		A	A	A					A		
Community watershed boundaries					A						
Contours (elevation)	F	F/A	A		A	F	A				A
Cultural heritage resources											A
Culturally modified tree locations	F										A
Cutblock boundary labelled with opening #	F/A	F/A	F/A	F/A	F/A	F/A	F/A		F/A	F/A	F/A
Erodible soils		A	A	A	A						
Established scenic areas	F					A					
Established visual quality areas (VQO)	F					A					
Fire – historic fire									A		
Fire potential/risk							A		A		
First Nations traditional territories											A
Fish-bearing streams				A	A						A
Fisheries sensitive zones				A							A
Forest cover maps (VRI)	F/A	F/A	A	A	A	F	A		A	A	A
Forest district (MoFR admin. boundary)		A	A	A			A				
Forest region (MoFR admin. boundary		A	A	A			A				

Desired Map Information	Resource Value										
	SLBD	Riparian	Water	Soils	Forage	Visual Quality	LLBD	Rec	Wildlife	Timber	Cultural Heritage
Free-growing blocks					A						
Grasslands					A		A				
Habitat suitability mapping									A	A	
Harvest date	F/A	A	A	A	A	F	F/A		F/A	F/A	F/A
Harvest season				A							
Invasive species (plants)	F/A	F/A			A		A		A		
Land and Resource Management Plans (LRMPs)											A
Land ownership/ tenure					F					A	A
Livestock stocking densities					A				A		
Non-harvestable timber areas (OGMAs + UWRs + WHA + Parks + Reserves)	F/A	F/A					A		F/A		F/A
Old growth management areas (OGMA)	F	A	A				A		A	A	A
Open range					F						
Orthophotos	F	F/A	F/A	F/A		A	A				
Parks and protected areas	A	A	A				A		A		
Range condition					F/A				A		
Range reference areas			F/A		F				A		
Recreation use						A		F/A	A		
Riparian reserve boundary	F/A	F/A	F/A	F/A			A		A		
Riparian treatment (from site plan)	F/A	F/A	A				A		A		
Roads	F/A	F/A	F/A	F/A	F/A	F/A	A		F		A
Road density	A	A	A	A	A		A		A	A	A
Site Plans	F/A	F/A	F/A	F/A	F/A				F/A	F/A	F/A
Slope failures/ landslide locations		A	A	A							
Snow zones									A		
Soil mapping		F	F	F	A				A		
Soil texture maps				A							
Species at risk maps					A		A				
Species distribution maps							A		A		
Standard units	F/A									F	

Desired Map Information	Resource Value										
	SLBD	Riparian	Water	Soils	Forage	Visual Quality	LLBD	Rec	Wildlife	Timber	Cultural Heritage
Streams/rivers/ lakes	F/A	F/A	F/A		A		A	A	F		A
Streams (with stream class S1–S6)	F/A	F/A	F/A		A						
Stream crossings (road crossings)		F/A	F/A		A						
Terrain stability maps		F/A	F/A	A							
Terrestrial Ecosystem Mapping (TEM)					A		A		A		
Timber value										A	
Timber revenue										A	A
Timber Supply Areas										A	A
Timber Forest License										A	A
Traditional use studies maps (TUS)											A
Ungulate winter range (UWR)	F/A	F/A					A		A		
Urban growth mapping									A		
Water temperature maps									A		
Watershed boundaries		A	A				A		A		
Wetland monitoring sites		F			F						
Wetlands	F	F			F/A						
Wildlife distribution maps							A		A		
Wildlife habitat areas	F				A		A		F/A		
Wildlife tree patches	F						A		F/A		

High Priority Spatial Datasets

- Bark beetle kill areas
- BEC zones
- Contours/elevation
- Cutblock/opening boundaries
- Harvest date
- Soils mapping (i.e., soil texture, soil stability/erodability)
- Forest cover (VRI)
- Reserves/non-harvestable land base (including OGMAs, WTPs, WHAs, parks and protected areas)
- Orthophotos
- Roads
- Water features
- Stream class

4.1.2 Potential pilot projects

Each resource value team had the opportunity to provide ideas for GIS-based projects that would address their research needs. The most interesting suggestions by each resource value team have been listed below. At this point, the feasibility of these projects has not been considered. They may represent potential pilot projects for early stages of a GIS program that can be completed by FREP staff, or they may require a longer-term commitment in terms of development and maintenance from an established GIS program within the MoFR or elsewhere.

Each of the projects should be considered on an individual basis, and a detailed project plan developed to determine: a) whether a similar project has already been initiated, b) the status of the required datasets, and (c) the resources and commitment involved (e.g., time, people, cost).

POTENTIAL PILOT GIS PROJECTS

Cultural Heritage

- Map of the location/density of culturally modified trees for the province

Biodiversity (stand level and landscape level)

- Habitat connectivity analysis
- Compile provincial coverage of Old Growth Management Areas
- Compile provincial coverage of wildlife tree patches

Wildlife

- Species dispersal maps for priority species at the provincial level
- Create a map of non-harvestable timber base (i.e., parks and protected areas, WHAs, WTPs, OGMAs, UWRs and other reserves)
- Small mammal distribution mapping

Visual Quality

- Provincial coverage of significant viewpoints
- Database of field photographs hyperlinked to viewpoint location
- Map of “green-up” modelled using harvest date, climate factors and BEC zone
- Provincial coverage showing % of provincial scenic areas in each visual quality class

Forage

- Spatial representation of Range Reference Areas
- Modelling of existing time trends using retrospective data from range database
- Invasive species mapping

Timber

- Series of timber revenue generation maps (e.g., look at revenue generation by: elevation, proximity to existing mills, species compositions, etc.) for the province
- Series of provincial timber value distribution maps; patterns over time?
- Overlay analysis of revenue generation x timber value x harvest volume = what are the relationships?
- Map of logging intensity across the province

Soils

- Level of soil disturbance by MoFR district, MoFR region
- Density of permanent access features; where are the “hotspots” in the province?
- Map of landslide activity
- Soil texture maps

Riparian/Fish/Water

- Areas of high stream-crossing density
- Location of licensed water intakes in the province
- Map of livestock grazing intensity
- Fisheries sensitive zones
- Provincial coverage of stream class

4.1.3 Creating FREP datasets

All resource value teams agreed that having access to maps of past FREP sampling locations is essential for both operational as well as reporting purposes. Taking it a step further, all agreed that having a visual map representation of FREP results rolled up to the district or regional level would be extremely valuable.

There were several suggestions on how these data should be presented, including the possibility of creating an interactive web-based map of FREP data to be posted on the FREP website. These suggestions should be explored in more detail at the data creation stage.

All those surveyed agreed that making FREP datasets available for viewing and analysis in MapView should be a longer-term goal. This implies that the data need to be available in the LRDW. Detailed guidelines available on the LRDW website should be consulted and discussion with IMG staff should be initiated as soon as possible to determine the appropriate procedures and data creation guidelines for posting information to the LRDW (Ministry of Sustainable Resource Management 2004).

4.2 *GIS and FREP Resource Values*

A preliminary Internet and literature search revealed scores of examples where GIS and/or remote sensing has been used by resource managers, private industry, researchers, and others for monitoring or evaluation purposes. Examples range in both complexity and scale, from the simple mapping of field site locations at a local scale to sophisticated habitat modelling and land cover change initiatives at the federal level.

The following discussion provides a brief overview of various GIS research projects that may be relevant to FREP. Comprehensive evaluation of the applicability of all available methods and GIS technologies should be completed for each resource value in the future.

4.2.1 GIS and cultural heritage

Mapping the location of cultural heritage resources using GIS, including archaeological sites (Ebert 2004), large historical monuments (e.g., Wager 1995), and culturally important landscape features (e.g., Johnson 1997) has become a widely used inventory and management tool among cultural heritage managers. The spatial capability of GIS allows heritage managers to generate permanent records of heritage sites, which will in turn facilitate the monitoring and management of these sites in the future.

The field of archaeology in particular is increasingly using GIS to document and manage cultural heritage resources (Ebert 2004), and the province of BC itself has mapped a large portion of the archaeological sites across the province using GIS.[33]

As well, GIS provides the ability to ask questions about how cultural heritage relates spatially to the surrounding natural and human environment. Managers can investigate links between cultural resource locations and other geographically represented information such as topography, wetlands, elevation and vegetation type, and may even use this information to locate cultural resources or predict areas of high cultural value (Fry et al. 2004). Furthermore, GIS provides the ability to test proposed development models, conservation strategies and resource extraction for their impact to known heritage sites (Johnson 1997).

At the global scale, large organizations like UNESCO[34] are using GIS for the management of cultural sites and resources (Box 1999). At the local scale, indigenous communities across the world are using GIS for mapping culturally important resources and features through community mapping initiatives (Chapin 2005, Johnson 1997). This latter activity is gaining importance in BC, with many First Nations launching GIS programs in recent years for documenting and managing cultural and other resources within their traditional territories.[35]

Recently in BC, the Ministry of Sustainable Resource Management (MSRM) completed a series of traditional use studies (TUS) across the province through which First Nations cultural resources were mapped using GIS, and this information is currently accessible by government employees (Ministry of Sustainable Resource Management 2003). These and documents from the Land and Resource Management Planning (LRMP) process could become a valuable resource for FREP as they likely contain some of the most current and spatially accurate information about the nature and location of cultural resources in the province of BC.

33 This information is available as a series of spatial layers housed in the LRDW, but only accessible to those with special access permissions.
34 To download a hard copy of this guide, please visit the UNESCO website at: http://www.unescobkk.org/index.php?id=1329.
35 For additional references and discussion, please see the Aboriginal Mapping Network website: http://www.nativemaps.org/.

Clearly, linkages between GIS and cultural heritage resource preservation and management are well established. The central challenge facing the use of GIS for the purpose of FREP effectiveness evaluations is the quality and completeness of cultural heritage data for the province.

Furthermore, issues surrounding data sensitivity and access are major considerations in the province of BC. In many cases, First Nations may be reluctant to reveal the specific location of culturally significant sites or features for fear of vandalism or exploitation by the public or private sector (Weinstein 1998). A thorough inventory of existing spatial cultural heritage information is needed before FREP proceeds with any GIS analysis related to the cultural resource value.

4.2.2 GIS and the range resource

BC's grasslands represent less than one percent of the provincial land base and are among Canada's most endangered ecosystems (Grasslands Conservation Council 2004). Given this limited extent and ever-increasing pressure from forest encroachment, weed invasion, subdivision of agricultural and grazing land, inappropriate grazing practices, abusive recreation and urban expansion, the land base available for providing high-quality forage is increasingly limited. As such, determining the geographical extent of available forage area in BC is a crucial focus area for FREP if they are to effectively evaluate how range practices are affecting the quality and quantity of forage across the province.

To this end, the BC Grasslands Mapping Project[36] has embarked on a critical effort to locate and map all grassland areas in the province (Grasslands Conservation Council 2004) and relies heavily on GIS technology. The project is relying almost exclusively on existing information (inventories) from around British Columbia to build a Grasslands GIS and associated 1:20 000 scale maps for the whole province. Grasslands mapping fills a critical need and will provide solid baseline information on a provincial scale that FREP can potentially take advantage of in the future.

There are several examples in the literature of how a combination of remote sensing and GIS can be used to evaluate and manage the range resource. Satellite imagery and GIS can be combined to map grazing intensities and estimate their effect on plant biomass (Kawamura 2005, West 2003), while GIS alone has been used to document temporal trends in grazing intensity over time from stocking density information contained in grazing licenses (Yuguang 2004). Other research has focused on predicting pasture productivity (above ground dry matter in kg/ha) for a given area using environmental and management variables to develop a decision tree model that was then integrated with a GIS system (Zhang et al. 2006).

Those documenting forest expansion into adjacent grasslands due to changes in climate, grazing patterns or the lack of fire frequently rely heavily on aerial photographs and GIS to map forest expansion over time (e.g., Yool et al. 1997). Some have incorporated the effects of physical factors (i.e., topography, slope aspect, slope degree) on these patterns using more complex GIS modelling (Yuguang 2004). Similarly, GIS has been used to model the potential risk of invasion by individual weed species in rangelands by combining physical site characteristics and the weed species' life history (Gtllham 2004).

Clearly, there is a considerable body of literature related to using GIS to predict forage quality and the extent of rangeland areas. FREP could potentially benefit enormously from combining the excellent field-based Range Reference Area information[37] with a GIS system, and results and data from the Grasslands Mapping Project to monitor the forage resource over time (Grasslands Conservation Council 2004).

4.2.3 GIS and recreation

Recreation managers have taken advantage of GIS both for locating new parks or recreation areas, as well as monitoring visitor impacts on the quality and condition of recreation sites. In both cases, information about visitor-use patterns is needed, and GIS is often the tool used to document and analyze this kind of information.

Population demographics, visitor-use preferences, and the location of existing parks and recreation areas are used to inform decisions about where new facilities are located, or what kind of recreation site would be optimal for a particular area (Lee and Graefe 2004). GIS is an ideal tool for examining the spatial relationships between these types of factors to facilitate decision making.

36 Please see: http://www.bcgrasslands.org/projects/conservation/mapping.htm for more information.

37 Please see the MoFR Range Reference Areas website for more information: http://www.for.gov.bc.ca/hfp/range/rra/rra.htm.

Visitor impacts are often more pronounced where visitor-use numbers are highest. Researchers have looked at how trail degradation is related to visitor-use patterns and environmental variables (Nepal and Nepal 2004), as well as how visitor-use patterns are related to the condition of recreation site facilities (Campbell 2003, Dumont et al. 2005). This latter type of analysis could be useful for targeting limited resources for recreation site management in BC.

4.2.4 GIS, wildlife and landscape-level biodiversity

There is a large body of literature detailing how GIS and remote sensing technology are used at various scales to assess biodiversity values on the landscape. Uses range from mapping habitat use by an individual species (e.g., Burger et al. 2005) to complex ecosystem modelling involving multiple biophysical and human impact indices (e.g., Aurambout et al. 2005).

Terrestrial habitat loss due to increasing human development pressures, resource extraction and climate influences has been widely recognized as perhaps the number one threat to plant and wildlife species. More recently, however, landscape ecologists have brought increasing attention to the relationship between habitat pattern and landscape processes, including species' use of and movement through the landscape (Gergel and Turner 2002).

More specifically, the effects of habitat fragmentation, habitat connectivity, patch size and shape, and edge effects on various species have emerged as focal research areas for conservation biologists (Aurambout et al. 2005, Gergel and Turner 2002). Spatially explicit analyses like these require the use of GIS, and often rely on additional patch analysis software packages to address these questions.[38]

The scale of enquiry is particularly relevant when considering landscape pattern and habitat connectivity indices (Gergel and Turner 2002). For example, a habitat patch for a small bird species is entirely different from a patch that is relevant to a grizzly bear. For this reason, evaluating these indices at multiple scales is necessary.

One approach is using a general model, adaptable for specific species, capable of identifying suitable habitat patches within fragmented landscapes and investigating the capacity of populations to move between these patches (e.g., Aurambout et al. 2005).

Temporal trends in habitat loss and landscape pattern changes have been widely studied. The vast majority of such projects involve a combination of GIS and satellite imagery (e.g., Li et al. 2001, Radeloff et al. 1999) or aerial photography (e.g., Jackson et al. 2000, Rhemtulla et al. 2002) from multiple dates. This type of analysis for the province of BC, focusing on changes in forest cover over time, could provide very useful information for FREP.

Forest structural complexity, species composition, and other forest attributes are also extremely important indicators of forest health and determinants of quality forest habitat. Remote sensing and GIS have proven to be very useful tools for modelling such forest attributes (e.g., Frazer et al. 2005), and new developments using lidar technology may be promising to explore (e.g., Kimes et al. 2006).

An extensive body of work was completed by researchers at MSRM in 2002 that was directly focused on addressing many of the issues outlined above. This database of information, logic models, sample data themes, and spatial layers could provide an excellent starting point for the future development of landscape-level biodiversity or wildlife indicators, and may provide a useful method for analyzing existing stand-level biodiversity data collected by FREP participants.[39]

Clearly, with the current level of GIS expertise within FREP, these sophisticated uses of GIS and other ecosystem modelling programs may not be possible. If FREP decides to begin utilizing GIS in this capacity, additional expertise within the program will be required.

4.2.5 GIS and watershed modelling

Watershed modelling could be used as a tool to meet the needs of the soils, water, and riparian/fish resource values. Techniques for watershed modelling abound, and are continuously being enhanced and improved. At the more basic level, terrain stability modelling uses terrain parameters (i.e., slope angle, elevation, soil type) and climate characteristics (i.e., rainfall, temperature, winter

38 Some widely used patch analysis software packages include: FRAGSTATS (http://www.umass.edu/landeco/research/fragstats/fragstats.html), and two ArcGIS extenstion products, Patch Analyst (http://flash.lakeheadu.ca/~rrempel/patch/) and VLATE (http://www.geo.sbg.ac.at/larg/vlate.htm).

39 Contacts: Graham Hawkins, Ministry of Environment; Insha Khan, Integrated Land Management Bureau.

snow pack) to identify areas with a high risk of slope failure or high erosion potential. These maps can then in turn be used for more complex watershed modelling (Kumar et al. 2001, Whitaker 2003).

More complex watershed or soil erosion vulnerability models incorporate land cover information and/or human development indices (e.g., road density) to more accurately model "environmental vulnerability" (Li et al. 2006), or the potential detrimental effects of sediment loading on downstream water bodies or fish habitat (Lim et al. 2005). Recent work has developed models sensitive enough to estimate sediment yield from a single storm event (Lim et al. 2005), a technique which might provide a useful framework for modelling the effects of individual cutblocks on downstream water quality. Modelling the cumulative downstream effects of forest harvesting within a given watershed is also possible with current GIS modelling technology.

Existing landslides or slope failures are often detectable using remote sensing imagery (i.e., satellite images, orthophotography). These can be either delineated with GIS to create large-scale coverage maps of failure locations, or can be identified and selected for future field assessments.[40]

There is clearly a precedent for using GIS to investigate landscape-scale soil stability, and risks to water or riparian values in the literature. In addition, terrain stability mapping projects have been completed in the Lilloet, Merritt and Kamloops areas, and are currently available through the LRDW. These efforts could potentially be utilized within FREP, or used as a baseline for future similar work for remaining areas of the province.

4.2.6 GIS and visual quality

The application of information technology to landscape analysis dates back to the early work in computer-based mapping. The mapping of viewsheds was a key feature of early GIS systems, a process that was applied to determine both view characteristics and potential visual impacts of various landscape management decisions (Bishop 2003).

Various algorithms and GIS extensions have generated models of visual quality and visual impact using mapped variables, and there are many examples of the use of viewshed analysis for landscape planning purposes in the literature (e.g., Bishop 2003, Thorn et al. 1997).

These tools and techniques have been applied by the MoFR to create the Visual Landscape Inventory (VLI) spatial layer currently housed in the LRDW. The attribute information contained in the VLI has been used to create additional spatial layers, including established Visual Quality Objectives (VQOs), and Visual Sensitivity Class maps. This information currently requires updating, and should be used with this stipulation in mind.

More recently, it has become apparent that the essentially two-dimensional approach to viewshed analysis afforded by traditional GIS alone is inadequate in situations with strong three-dimensional elements (Muhar 2001). Additional terrain modelling software or CAD applications are increasingly being combined with GIS to address these needs, and several sophisticated 3-D visualization software packages are available on the market (e.g., Nute et al. 2004, Muhar 2001).

The MoFR has taken advantage of this type of tool for landscape visualization and decision support in past visual stewardship planning (Meitner 2001), and the visual quality resource value team was using 3-D landscape modelling software – Landscape Manager – for similar landscape visualization work until the recent government "refresh." New restrictions on software will not allow the use of this particular software package. In the current market, an increasing number of visualization systems is now available, and the team will need to research alternatives that are compatible with ArcGIS software or are acceptable under current government standards. The ESRI ArcGIS 3-D Analyst extension may be promising in this regard.

Modern GIS packages also have the ability to handle large volumes of spatially linked imagery or photographs. The ability to store time-series landscape views from significant scenic viewpoints across the province that are then hyperlinked to a map location would be of considerable benefit to the visual quality resource value team. This capability would allow comparisons over time and under different management regimes, allowing managers, and potentially the public, to effectively evaluate if visual quality objectives are being met for a given area.

40 The soils resource value team is currently experimenting with high definition air photos, orthophotography and satellite imagery for this purpose, and their techniques and/or results may be applicable to other resource value evaluation programs in the future.

4.2.7 GIS and the timber resource

As land tenure becomes increasingly complex, competing land uses are placing more and more pressure on the forested land base. Forest values other than timber production are being increasingly recognized and the ability to manage forests for multiple uses is becoming more and more important. Sustainable forest management attempts to ensure the long-term health, productivity and genetic diversity of the forested land base in order to sustain economic timber extraction as well as other forest values such as biodiversity or cultural values. This multi-faceted approach requires tools that can handle the complexity of modern forest management (Naesset 1997), and incorporate inherent spatial elements.

Spatially explicit models that combine remote sensing with GIS offer great promise to forest managers. They consider the arrangement of landscape elements in time and space, and provide the ability to view multiple datasets over large areas. Basic information about patterns of harvesting intensity across the province, the effect of disease or pest infestation on the forested land base, and time-series analyses of harvesting activities over time are all possible using GIS. GIS software packages are beginning to incorporate functionality specifically related to forest management, and many are marketing this particular aspect of the system (e.g., ESRI ArcGIS products).

Decision making for forest ecosystem management can include the use of a wide variety of GIS combined with modeling tools. These tools may include vegetation growth models, timber harvest allocation models, silvicultural models, and visualization tools like those discussed in the previous section. These models simulate different forest management scenarios to create hypothetical landscapes in either 2- or 3-D that the user can then view and evaluate (e.g., Gustafson and Crow 1998, Wintle 2005). A user may, for example, simulate a landscape with varying sizes of timber production areas, cutblock sizes, forestry techniques or initial stand age distributions, and compare alternative management scenarios in space and time.

This type of forest harvesting scenario modelling would allow the FREP timber resource value team to evaluate possible future outcomes of current forest management policies and practices, and current silvicultural activities. Creating maps from existing economic, market trends and timber yield data, combined with basic GIS overlay analyses, could meet many of the priority research areas that have been identified by this resource value team.

4.3 *Important Considerations*

Clearly, GIS could be a valuable tool for almost all FREP resource value teams in varying capacities. At the operational level, GIS programs offer the ability to create and view custom maps for use in the field or for planning field work activities. GIS can also be used to view and analyze FREP data spatially, providing the ability to display the data in the form of maps for communication or analysis purposes. Modern GIS has the ability to tackle very complex, spatially explicit questions in space and time, providing FREP with the ability to tackle emerging landscape-level questions.

If FREP does begin to incorporate GIS, there are two fundamental issues that require consideration:

1. Data management

Outlining a spatial data management and maintenance plan is critical.

This will involve identifying the required update cycle and an appropriate data custodian for each layer, as well as a long-term plan for data continuity. For example, mapping out sample locations for the 2005 riparian/fish evaluations may be useful in the short term, but the information will become increasingly irrelevant if this kind of data is not continuously collected in subsequent years. Missing or incomplete data greatly reduces the level of confidence. A clear data storage and version control plan is also needed (Ministry of Sustainable Resource Management 2004).

2. Staff

The level of sophistication that FREP decides to adopt needs to be sustainable. Although some data layers could potentially be created with a minimum of expertise, and some initial analysis can be completed by current FREP staff, any more complex analyses or advanced modelling will require additional expertise, particularly when current auxiliary staff persons are no longer available.

It is important to recognize that GIS work requires a substantial time commitment. In the short term, FREP should fully explore all expertise and staff available to them through formal agreements with other ministries, district staff, etc. In the longer term, FREP needs to focus on building GIS knowledge and skills among all participants. There is enormous value in FREP staff being familiar with the capabilities of GIS so that appropriate spatial questions can be developed, and simple projects can be completed internally. If GIS does become a central element of FREP, however, managers may need to consider creating a formal GIS position to oversee this work.

5.0 Recommendations

This final section summarizes previous discussions into a series of short- and long-term recommendations. Given the feedback received by FREP participants, evidence in the literature, and consideration of the program's long-term priority evaluation questions and goals, incorporating GIS appears to be not only a promising possibility, but a necessary step for FREP.

Short-term recommendations include:

1. Create a series of spatial layers of FREP sampling locations from 2004–2006.
   - LRDW layers will require formalized custodianship with agreement from Ralph Archibald, Director, Forest Practices Branch. IMG can assist with the data modelling and loading.
2. Create a map summarizing general results from the 2004 and 2005 field seasons for the riparian/fish and stand-level biodiversity resource values at the provincial scale.
3. Disseminate information about existing geomatics resources and current MoFR training opportunities to all FREP participants.
4. Initiate discussion with the Geomatics Leadership Team to clarify processes and requirements for data publication to the LRDW.
5. Confirm what service allocation is available (if any) to Forest Practices Branch through the MOFR–ILMB Service Agreement.
6. Identify priority spatial data that will be crucial for the completion of FREP effectiveness evaluations, and complete a detailed review of the availability, quality and completeness these datasets. This process should leverage the FSP data review, as much of the same data will be required for FREP.

Longer term recommendations include:

7. Create an interactive map of FREP sampling locations and results from 2004–2006 to be posted on the program website.
8. Identify spatial data that does not currently exist, but is crucial for FREP business. Initiate discussions with the Geomatics Leadership Team to investigate the possibility of a formal data acquisition or creation process.
9. Ensure that all FREP spatial data is made accessible to FREP participants through the FREP IMS,[41] either as interactive spatial layers within MapView and/or as static map reports.
10. Assess the value of incorporating spatial analysis and the use of GIS into the data collection and analysis strategies for all resource values, including the development of spatially explicit priority research questions.

GIS could play either a minor or major role within FREP, but could clearly benefit the program. Current resources within FREP can support some basic GIS use, but in the longer term, additional GIS capacity within FREP will likely be required to create and maintain FREP-specific data, and to investigate how advanced GIS capabilities can enhance FREP in the future.

41 Please see the FREP IMS website: http://www.for.gov.bc.ca/hfp/frep/ims/index.htm.

6.0 References

6.1 *Cited References*

Aurambout, J.P., Endress, A.G., and Deal, B.M. 2005. A Spatial Model to Estimate Habitat Fragmentation and Its Consequences on Long-Term Persistence of Animal Populations. Environmental Monitoring and Assessment, 109(1-3), 199–225.

Bishop, I.D. 2003. Assessment of visual qualities, impacts and behaviours in the landscape by using measure of visibility. Environment & Planning B: Planning and Design, 30(5), 677–688.

Box, P. 1999. GIS and Cultural Resource Management: a manual for heritage managers. UNESCO. Accessed online March 2006 at: http://www.unescobkk.org/index.php?id=1329.

Burger, A., Page, R., Ronconi, R., and Conroy, C. 2005. Habitat use by Marbled Murrelets on southwest Vancouver Island and implications for forest management: Final report to forest science program and Price-Waterhouse-Coopers for 2004/2005. FSP project Y051061. University of Victoria, Victoria, B.C. 24 pp.

Chapin, Mac. 2005. Mapping Indigenous Lands. Annual Review of Anthropology, 34(1), 629–638.

Ebert, D. 2004. Application of archaeological GIS. Canadian Journal of Archaeology, 28(2), 319–341.

Frazer, G.W., Wulder, M.A., and Niemann, K.O. 2005. Simulation and quantification of the fine-scale spatial pattern and heterogeneity of forest canopy structure: A lacunarity-based method designed for analysis of continuous canopy heights. Forest Ecology and Management, 214, 65–90.

Fry, G.L.A., Skar, B., Jerpåsen, G., Bakkestuen, V. and Erikstad, L. 2004. Locating archaeological sites in the landscape: a hierarchical approach based on landscape indicators. Landscape & Urban Planning, 67 (1–4), 97–108.

Gergel, S.E. and Turner, M.G. 2002. Learning landscape ecology: A practical guide to concepts and techniques. Springer-Verlag, New York, N.Y.

Grasslands Conservation Council. 2004. BC Grassland Mapping Project: A Conservation Risk Assessment – Final Report. Accessed electronically March 2006 at the following URL: http://www.bcgrasslands.org/projects/conservation/mapping.htm.

Gtllham, J.H., Hild, A.L., Johnson, J.H., Hunt, E.R. and Whitson, T.D. 2004. Weed Invasion Susceptibility Prediction (WISP) Model for Use with Geographic Information Systems. Arid Land Research and Management, 18(1), 1–12.

Gustafson, E.J. and Crow, T.R. 1998. Simulating Spatial and Temporal Context of Forest Management Using Hypothetical Landscapes. Environmental Management, 22(5), 777–787.

Jackson, S.M., Pinto, F., Malcolm, J.R., and Wilson, E.R. 2000. A comparison of pre-European settlement (1857) and current (1981-1995) forest composition in central Ontario. Canadian Journal of Forest Research, 30, 605–612.

Johnson, B.D. 1997. The use of geographical information systems (GIS) by First Nations. Aboriginal Mapping Network, Vancouver. Accessed electronically March 2006 at URL: http://www.nativemaps.org/abstracts/ben.html.

Kawamura, K., Akiyama, T., Yokota, H., Tsutsumi, M., Yasuda, T., Watanabe, O. and Wang, S. 2005. Quantifying grazing intensities using geographic information systems and satellite remote sensing in the Xilingol steppe region, Inner Mongolia, China. Agriculture, Ecosystems & Environment, 107(1), 83–93.

Kimes, D.S., Ranson, K.J., Sun, G., and Blair, J.B. 2006. Predicting lidar measured forest vertical structure from multi-angle spectral data. Remote Sensing of Environment, 100(4), 503–511.

Kumar, S., Jain, S.K., and Varghese, J. 2001. Estimation of soil erosion for a Himalayan watershed using GIS technique. Water Resources Management, 15(1), 41.

Kumsap, C., Borne, F., and Moss, D. 2005. The technique of distanced decayed visibility for forest landscape visualization. International Journal of GIS, 19(6):723–744.

Lee, B. and Graefe, A. 2004. GIS: A tool to locate new park and recreation services. Parks and Recreation, 39(10), 34–41.

Li, A., Wang, A., Liang, Shunlin, and Zhou, Wancun. 2006. Eco-environmental vulnerability evaluation in mountainous region using remote sensing and GIS — A case study in the upper reaches of Minjiang River, China. Ecological Modelling, 192(1–2), 175–187.

Li, X., Lu, L., Cheng, G., and Xiao, H. 2001. Quantifying landscape structure of the Heihe River basin, northwest China using FRAGTATS. Journal of Arid Environments, 48, 521–535.

Lim, K.J., Sagong, M., Engel, B.A., Tang, Z., Choi, J. and Kim, K.S. 2005. GIS-based sediment assessment tool. Catena, 64(1), 61–80.

Meitner, M. 2001. Visualization as a decision support tool. In: Looking beyond the trees Visual Stewardship of the Working Forest Visual Resource Management Conference Compendium Kamloops, British Columbia, Canada April 17 to 19, 2001 (conference proceedings), Marc, J. (ed.), 191–192.

Ministry of Sustainable Resource Management. 2003. Guide to using traditional use study (TUS) information. Unpublished document: Terrestrial Information Branch, Victoria, B.C.

Ministry of Sustainable Resource Management. 2004. Land and Resource Data Warehouse Population Procedures – version 1.1. July 2004. 16 pp.

Ministry of Forests and Range. 2006a. Geographic Information Systems Program Task Team Report. Unpublished report (Feb. 6, 2006).

Ministry of Forests and Range. 2006b. Land Information Committee Report. (Unpublished document).

Muhar, A. 2001. Three-dimensional modelling and visualisation of vegetation for landscape simulation. Landscape and Urban Planning, 54(1/4), 5–17.

Naesset, E. 1997. Geographical information systems in long-term forest management and planning with special reference to preservation of biological diversity: a review. Forest Ecology and Management, 93(1/2), 121–135.

Nepal, S.K. and Nepal, S.A. 2004. Visitor Impacts on Trails in the Sagarmatha (Mt. Everest) National Park, Nepal. Ambio, 33(6), 334–340.

Nute, D., Potter, W.D., Maier, F., Wang, J., Twery, M., Rauscher, H.M., Knopp, P., Thomasma, S., Dass, M., Uchiyama, H., and Glende, A. 2004. NED-2: an agent-based decision support system for forest ecosystem management. Environmental Modelling and Software, 19(9), 831–843.

Radeloff V.C., Mladenoff, D.J., He, H.S., and Boyce, M.S. 1999. Forest landscape change: The northwest Wisconsin Pine Barrens before European settlement and today. Canadian Journal of Forest Research, 29, 1649–1658.

Rhemtulla, J. M., Hall, R.J., Higgs, E.S. and MacDonald, S.E. 2002. Eighty years of change: Vegetation in the montane ecoregion of Jasper National Park, AB, Canada. Canadian Journal of Forest Research, 32, 2010–2021.

Thorn, A.J., Daniel, T.C., Orland, B. and Brabyn, N. 1997. Managing forest aesthetics in production forests. New Zealand Forestry, 42(2), 21–23.

Vestal, D., and Pinter, N. 2002. A multivariate analysis of landslide susceptibility on an overgrazed rangeland, Santa Cruz Island, California. Geological Society of America, 34(2), 18–25.

Wager, J. 1995. Environmental Planning for a World Heritage Site: a case study of Angkor, Cambodia. Journal of Environmental Planning and Management, 38 (3), 419–425.

Weinstein, M.S. 1998. Sharing information or captured heritage: access to community geographic knowledge and the state's responsibility to protect aboriginal rights in B.C. Paper submitted to Crossing Boundaries, the 7th conference of the International Association for the Study of Common Property. Vancouver, B.C. June 9–14, 1998.

West, N.E. 2003. Theoretical Underpinnings of Rangeland Monitoring. Arid Land Research and Management, 17(4), 333–347.

Whitaker, A. 2003. Application of the distributed hydrology soil vegetation model to Redfish Creek, British Columbia; model evaluation using internal catchment data. Hydrological Processes, 17(2), 199–224.

Wintle, B.A., Bekessy, S.A., Venier, L.A., Pearce, J.L., and Chisholm, R.A. 2005. Utility of Dynamic-Landscape Metapopulation Models for Sustainable forest management. Conservation Biology, 19(6), 1930–1941.

Yool, S., Makaio, M.J., and Watts, J.M. 1997. Techniques for computer-assisted mapping of rangeland change. Journal of Range Management, 50(3), 307–407.

Yuguang Bai C.E., Broersma, K., Thompson, D., and Ross, T. 2004. Landscape-level dynamics of grassland-forest transitions in British Columbia. Journal of Range Management, 57(1), 66–75.

Zhang, B., Valentine, I., Kemp, P., and Lambert, G. 2006. Predictive modelling of hill-pasture productivity: integration of a decision tree and a geographical information system. Agricultural Systems, 87(1), 1–17.

6.2 *Internet References*

ArcIMS software information
http://www.esri.com/software/arcgis/arcims/about/overview.html

BC Airphoto Inventory Service
http://ilmbwww.gov.bc.ca/bmgs/airphoto/IMF/Index.htm

BC Grasslands Mapping Project
http://www.bcgrasslands.org/projects/conservation/mapping.htm

BC Range Reference Areas
http://www.for.gov.bc.ca/hfp/range/rra/rra.htm

Citrix Program Neighborhood information
http://srmgww.bcgov/landinfobc/imb/aas/services/gis_services/

ESRI homepage
http://support.esri.com/index.cfm?fa=homepage.homepage

FishWizard
http://www.fishwizard.com/

FREP Information Management System (FREP IMS)
http://www.for.gov.bc.ca/hfp/frep/9_frep_IMS.html

Geomatics Community Homepage (MoFR)
http://gww.for.gov.bc.ca/mof/geocomm.htm

GIS Projects Homepage (MoFR)
http://gww.for.gov.bc.ca/his/gis/

Information Management Group (IMG) GIS Training
http://gww.for.gov.bc.ca/his/gis/training/

Integrated Land and Resource Registry
http://aardvark.gov.bc.ca/apps/ilrr/html/ILRRWelcome.html

Kootenay Spatial Data Partnership
http://www.sgrc.selkirk.ca/imf/imf.jsp?site=ksdp

Land and Resource Data Warehouse (LRDW)
http://lrdw.ca/summary.html

- Connecting to the LRDW
  http://srmgww.bcgov/landinfobc/imb/aas/services/gis_services/connect_lrdw.html
- Land Information BC Discovery Service
  http://srmapps.gov.bc.ca/metastar/home.do

Ministry of Forests GIS Terminal Server (GTS)
http://srmgww.bcgov/landinfobc/imb/aas/services/gis_services/

Ministry of Sustainable Resource Management (MSRM) Internet Mapping site
http://srmgww.bcgov/landinfobc/imb/aas/services/gis_services/

MoE/MAL Computer Help Desk
MALMoE.Helpdesk@gov.bc.ca

National Forest Inventory – BC
http://www.for.gov.bc.ca/hts/nfi/

North West Data Sharing Network
http://www.nwdsn.org/

Protected Areas System Overview
http://wlapgww.bcgov/esd/PASO/paso_index.htm

RESULTS
http://www.for.gov.bc.ca/his/results/

UNESCO – GIS and Cultural Heritage Resources
http://www.unescobkk.org/index.php?id=1329

APPENDIX 1. Geomatics staffing snapshot (July 2006)

Coast	MoFR Geomatics Analyst	MoFR Geomatics Technican	BCTS Geomatics
Campbell River	Jennifer Naylor	Clyde Loggie	Ralph (Bud) McKeown Jennifer Matthews
Chilliwack	Mike Smith	Lindsay Scott Marina Dunn	Holly Meagher
North Coast		Leah Cuthbert	Sandra Shippit Andrew Reviakin Meg Hoole
North Island – Central Coast		Karen Schalm Cyndi Schofield Angela Jones	Marshall Desjardins Phil Spencer
QCI		Doug Louis	Holly Meagher
South Island	Joel Graboski		Todd Davis
Squamish		Brenda Triance	Holly Meagher
Sunshine Coast		Cris Greenwell	Ralph (Bud) McKeown Jennifer Matthews
CFR Total	**3**	**10**	**9**

North Interior	MoFR Geomatics Analyst	MoFR Geomatics Technican	BCTS Geomatics
RNI region	Diane Roberge Stafford Shuman		
Terrace		Ralph Lenard	Sandra Shippit Meg Hoole
Smithers/Hazelton		Andrew Revaikin	Andrew Revaikin
Burns Lake	Wren Gilgan	Jamie Ballard	Andy Muma Wren Gilgan Cindy Barden
Vanderhoof		Britt Yorston Jenny Hague	Andrew Fraser Brenda Barber Deb Sewell
Fort St James		Darryl Volk Warren Wilkinson	Andrew Fraser Brenda Barber Deb Sewell
Prince George	Deanna Leask Selena Ross	Dan Crawford Marian Daniel	Birthe Miller Chris Turner
Mackenzie		Peter Loewen	Birthe Miller Chris Turner
Dawson Creek		Gwen Brace Craig Hartel Robert Davidson	Marc Mayhew Zeka Zejnulahovic
Fort Nelson		Michael Eastwood	Marc MayhewZeka Zejnulahovic
NIR Total	**5**	**14**	**13**

South Interior	MoFR Geomatics Analyst	MoFR Geomatics Technican	BCTS Geomatics
Quesnel	Lisa Lefebvre	Ken Edwards Janis Horley	Patricia Rodgers
Williams Lake		Gloria Loewen Isabel Foote Patsy Kohnke	Patricia Rodgers
Alexis Creek		Jasmine Pflanz	Patricia Rodgers
100 Mile House	Lew Greentree		Devona Hay Erin Hunter
Merritt	Rob MacLaren Gail Smith		Devona Hay Erin Hunter
Kamloops	Will Robins	Penny Scott Perry Lambkin	Devona Hay Erin Hunter
Vernon	Daryl Flindt	Dave Anderson Tiia Meere John LaBoyne Bill Dowedoff (Aux)	Pierre Rossouw Carol Davidson
Castlegar		Chris Cummings Alex Popoff	John Sherbinin Herb Scheltens
Kootenay Lake		Rick Logan Barb Hanlon (Aux)	John Sherbinin Herb Scheltens
Revelstoke	Val Beard		Pierre Rossouw Carol Davidson
Cranbrook		Rex Durell	John Sherbinin Herb Scheltens
Clearwater		Darrell Scott Scott Lindeburgh (Aux)	Devona Hay Erin Hunter
SIR Total	**7**	**19**	**7**
Province	**14**	**43**	**26**

Source: Ministry of Forests and Range (2006). Geographic Information Systems Program Task Team Report. (unpublished report) Feb. 6, 2006. Updated by Will Robins, IMG Senior Geomatics Infrastructure Analyst – July 2006.

APPENDIX 2. FREP GIS NEEDS ASSESSMENT PROJECT PLAN

Project Title	FREP GIS Needs Assessment
Project Lead	Lisa Levesque Forest Practices Branch Phone No. 250-812-6305 Email Lisa.Levesque@gov.bc.ca
Project Purpose	To determine the value of incorporating Geographical Information Systems (GIS) into various stages of FREP.
Background Situation	The value of incorporating the use of Geographical Information Systems (GIS) within FREP appears to be substantial. Potential uses range from the simple mapping and visual display of information to more complex spatial data analyses of project results. More specifically, GIS could be valuable tool for 1) improving both the communication of FREP results to the general public and among staff, 2) facilitating the identification and location of field sites, and 3) providing the capability for more sophisticated and spatially explicit analysis of project data, among other uses.
FREP question(s)/ research question(s) project will attempt to answer	1. What are the potential uses of GIS in FREP? 2. What are the resources required for/associated with these potential uses? 3. What resources (i.e., staff with existing GIS skills, GIS software, datasets) currently exist within FREP, or are accessible to the program within the MoFR? 4. Given the potential opportunities and the associated resource requirements, what are the recommended uses for GIS in FREP?
Objective(s)	To provide a comprehensive summary of existing GIS resources within FREP and the wider MoFR. To detail the potential immediate, short- and long-term uses of GIS products and spatial analysis capabilities for each resource value being evaluated by FREP. To identify where GIS could enhance data collection and analysis procedures. To identify where GIS could enhance the dissemination of information to the public and among FREP staff. To identify the specific resource requirements (i.e., personnel, software and hardware, financial) for immediate, short- and long-term potential uses for recommended GIS map products and analysis capabilities.
Scope (In & Out)	**In:** All FREP participants. **Out:** All persons not directly involved with FREP, other government agencies.
Method/Actions	**1. Send copy of work plan to potential participants** These may include: • FREP Resource Value Team Leaders • Appropriate MoE, ILMB contacts • Information Management Group (IMG) staff involved in GIS • Involved MoFR district contacts • FREP core staff (FREWG members, Ralph Winter, Alanya Smith, Thomas Chen) **2. Conduct an informal "Introduction to GIS" seminar** • Involve all interested parties to familiarize them with the capabilities of GIS, and provide initial guidance/examples of GIS use for landscape-level planning. Key participants are RVTLs and other staff involved with the soils, visual quality, and biodiversity resource values. **3. Interview key FREP participants** • Design an initial open-ended interview to be conducted with RVTLs involved with the soils, visual quality, and biodiversity resource values.

Method/Actions (cont.)	**4. Conduct general written survey** • Design a more detailed, written survey that will be given to additional key FREP participants and other identified parties. The creation of questions for this second survey will be informed by responses from the initial interviews with key FREP participants. The goal of both surveys is to identify specific mapping needs and/or possibilities for using GIS within FREP. • Administer survey to project participants. • Tabulate survey results. **5. Review relevant existing FREP documentation** • Review "Summary of District Requirements Gathering Comments – FREP IMS" and extract all references to mapping/GIS needs identified in the past field data collection season. • Review existing FREP protocols/checklists, and identify specific areas or activities where GIS may be a useful tool. • Review draft documents from soils, biodiversity and visual quality resource values. **6. Conduct literature review** • Conduct detailed Internet search and literature review to identify other landscape-level evaluation initiatives in North America (Oregon Monitoring Initiative, USDA monitoring efforts, etc.). **7. Identify existing GIS resources** • Identify the level of GIS experience among existing FREP staff. • Outline existing GIS personnel resources currently available to or being accessed by FREP in the wider MoFR community. • Identify currently available software within the Forest Practices Branch, and MoFR in general, including location of equipped machines and accessibility of those machines. • Identify training opportunities available to FREP staff. • Review and list all existing datasets currently available within the MoFR. • Identify and review all documents outlining MoFR and MoE standards and protocols for the use of GIS. **8. Produce a final report summarizing main recommendations for GIS use within FREP** • Categorize survey responses into increasingly sophisticated types of GIS use, and identify which of these "use categories" would be required by each resource value team. Examples might include: simple visual data representation (i.e., for conveying project information to the public), technical use (i.e., to improve or streamline data collection procedures), or basic/complex spatial data analysis, etc. • Create a preliminary list of potential base data that would be required for each of the identified use categories. • Identify software requirements for each use category; compare to available software. • Identify expertise/time requirements for each use category; compare to existing resources among FREP staff. • Identify approximate costs for each use category. • Recommend potential immediate, short- and long-term GIS uses within FREP.

Key Deliverables/ Milestones and Timelines (detailed work plan attached)	**Deliverable/Milestone**	**Responsibility**	**Timeline**
	Send copy of work plan to potential participants	Lisa Levesque	January 7, 2006
	Conduct an informal “Introduction to GIS” seminar (and/or individual briefings)	Lisa Levesque Alanya Smith	January 19, 2006
	Interview key FREP participants	Lisa Levesque	January 27, 2006
	Conduct general written survey	Lisa Levesque	February 3, 2006
	Review relevant existing FREP documentation	Lisa Levesque	January 17, 2006
	Conduct literature review	Lisa Levesque	January 17, 2006
	Identify existing GIS Resources	Lisa Levesque	February 28, 2006
Estimated Cost (total and breakdown)	Total estimated workdays needed to complete project = 45		
Stakeholder Involvement	FREP Resource Value Team Leaders FREWG members		
Risk Management	Some potential risks that may hinder or negatively affect the completion of this project may include: • Inability of some FREP members to participate. • Time constraints for project lead – on auxiliary status until March 31 only. • Restricted/denied access to GIS software and MoFR datasets.		
Quality Management	Final report to be reviewed by FREWG members.		
Other (e.g., related initiatives or considerations of note)	N/A		
FREWG Approval	Name: Peter Bradford	Date: January 6, 2006	
Comment:	Project Supervisor		
Project Team Commitment and sign-off			

APPENDIX 3. FREP GIS NEEDS ASSESSMENT PARTICIPANT QUESTIONNAIRE

Name of interviewee(s): ____________________

Resource Value Team: ____________________

Date: ____________________

Context

The value of incorporating the use of Geographical Information Systems (GIS) within FREP appears to be substantial. Potential uses range from the simple mapping and visual display of information to more complex spatial data analyses of project results. More specifically, GIS could be valuable tool for 1) improving both the communication of FREP results to the general public and among staff, 2) facilitating the identification and location of field sites, and 3) providing the capability for more sophisticated and spatially explicit analysis of project data, among other uses.

The purpose of this questionnaire is to gather detailed information from FREP Resource Value Team Leaders in order to identify if, and how, spatial information and analysis capabilities might benefit effectiveness evaluations for their particular resource value.

Section A: Background Questions

Assessment of existing GIS skills/knowledge among FREP participants

1. Have you ever used a custom GIS application (e.g., MapView, iMap, ILRR, FishWizard, EcoCat, Watershed Atlas) to view geographic information, or create a map or report for business purposes? ❑ Yes ❑ No

   1a. If yes, for what purposes?

   ____

   1b. Did you require any additional functionality that these applications could not provide?

   ____

2. Do you have experience using more sophisticated GIS programs for business purposes (i.e., ArcView, ArcGIS or ArcInfo)? ❑ Yes ❑ No

   2a. If yes, please identify which of the following functions you feel comfortable performing in a GIS environment:

   - ❑ Viewing data
   - ❑ Adding data layers to a GIS work session
   - ❑ Uploading GPS coordinates (e.g., sample site locations) into a GIS
   - ❑ Creating a map from data collected in the field
   - ❑ Performing basic analysis functions (e.g., buffering, overlays, querying two or more layers)
   - ❑ Advanced analysis and modelling functions (e.g., watershed analysis, time-series analyses, etc.)

3. Would you be interested in participating in GIS training opportunities if they were available?

   ____

   ____

Assessment of the current role of GIS within FREP

4. Since FREP's inception, has your resource value team used GIS for any of the following?
   - ❑ Creating maps
   - ❑ Data analysis
   - ❑ Locating field sites for sampling

5. Has your resource value team sought GIS resources or expertise from within the provincial government?
   ❑ Yes ❑ No

   5a. If yes, what map products or analysis were completed?

   5b. If yes, which ministry and/or branch provided the service?

6. Has your resource value team sought GIS expertise outside of government?

   6a. If yes, what work was completed?

   6b. If possible, please estimate the total budget for GIS-related work to date.

7. To the best of your knowledge, were any of the data or maps required to meet your business needs unavailable, difficult to obtain, incomplete, or of poor quality?

Section B: Data Collection and Management

8. *"It would be great to have a map showing…"*

   Please consider the following in your answer:

   a) Data and results that your resource value team has collected during completed effectiveness evaluations or resource stewardship monitoring.

   b) The visual display of existing data (e.g., land cover, resource use, management activity, etc.).

Most useful map scale

9. Has your resource value team completed any field sampling to date? ❑ Yes ❑ No

   9a. If yes, have site and access maps met past field sampling needs for your resource value? ❑ Yes ❑ No

   9b. If current field maps are not meeting your needs, what information was missing?

   ____

   ____

10. Would it be useful to have access to a map showing past sampling locations? ❑ Yes ❑ No

   10a. If yes, how would you like to see this information organized? (colour-coded by year, colour-coded by accepted/rejected sites, colour-coded by resource value, etc.)

   ____

   ____

   10b. If yes, what map scale would be the most useful?

   ____

Section C: Data Analysis

11. What biotic, abiotic or management factors could make a site "high risk" with respect to your resource value?

   ____

   ____

   11a. Would a map showing high-risk areas be useful for either:

   a) Stratifying field sampling? ❑ Yes ❑ No

   b) Stratifying data analysis? ❑ Yes ❑ No

12. Are there any landscape-scale questions related to your resource value that you are currently unable to answer?

   Some examples:

   a) Is there sufficient habitat connectivity between existing OGMAs to achieve acceptable levels of landscape-scale biodiversity?

   b) Where are the highest road densities in the province?

   c) How are culturally significant features distributed across the province?

   d) What is the average distance between study sites and the nearest road?

   ____

   ____

   ____

   ____

Section D: Reporting

13. Specifically, with respect to sharing FREP information with the public, what maps would you like to see created to communicate the results from your team's effectiveness evaluations?