VISIBILITY ANALYSIS: A DECISION SUPPORT TECHNIQUE FOR FOREST RESOURCE MANAGEMENT PLANNING

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ABSTRACT

Dendron Resource Surveys Inc. has developed a technique aimed at reducing conflict between fibre and recreational values. The technique provides the following:

- the identification and quantification of potential conflict areas between fibre (as defined using the Timber Management Planning process) and recreation (specifically, the viewscape from waterways) values;
- detailed stand level analyses which can be used to further reduce the areas of potential conflict; and
- technical support for field work which efficiently allows an evaluation of results from computer-based analyses to be compared with the actual situation.

Further, the technique provides for the constructive involvement of stakeholders at early stages of the planning process.

RÉSUMÉ

Dendron Resources Surveys Inc. a mis au point une technique destinée à réduire les conflits entre les fonctions de production de matière ligneuse et de loisirs de la forêt. Cette technique permet :

- d'identifier et de quantifier les possibilités de conflits entre la fonction de production de matière ligneuse de la forêt (telle que définie à l'aide du processus de planification de l'aménagement forestier) et sa vocation récréative (plus précisément le paysage observable des cours d'eau);
- d'effectuer, au niveau du peuplement, des analyses détaillées dont les résultats peuvent servir à réduire davantage les superficies pouvant donner lieu à des conflits;
- d'apporter un soutien technique aux travaux sur le terrain et d'évaluer efficacement les résultats d'analyses informatiques et de les comparer à la situation réelle.

Cette technique permet de plus aux intervenants de participer de façon constructive au processus de planification dès le tout début.

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VISIBILITY ANALYSIS: A DECISION SUPPORT TECHNIQUE FOR FOREST RESOURCE MANAGEMENT PLANNING

1.0 INTRODUCTION

Northern Ontario waterways and the land bordering them are the source of numerous values for various groups. Recreational users value views from the water and campsites. Aboriginal groups have cultural or heritage values associated with many areas. Industrial interests have fibre values on bordering lands. Integrated resource management in these areas requires planning efforts that take all values into account, where possible, in an unbiased, scientific manner.

Dendron Resource Surveys Inc. has developed a methodology which addresses this issue. The methodology includes geographic information system (GIS) and field photogrammetry technologies and is designed to address the operational requirements of resource managers. It identifies potential areas of conflict between visual and other values and assists in the development of alternatives for integrated resource management planning efforts.

The technology is operational and the North Bay District and the Central Ontario Forest Technology Development Unit of the Ontario Ministry of Natural Resources (OMNR) were eager to implement it in an area where fibre and recreation values are likely to overlap and where planning efforts are upcoming. A previous OMNR-funded study helped identify refinements to the technique to make results more useful to resource managers and stakeholders. Financial support to implement these refinements was provided by the Northern Ontario Development Agreement/Northern Forestry Program. The project was conducted in the northwest corner of Thistle Township to the north and west of Thistle Lake and Red Cedar Lake in OMNR's North Bay District.

The objective of this undertaking was to enhance a decision support technique which identifies areas of potential conflicts between multiple values, with concentration on fibre and recreation, and provides support to the development of integrated resource management solutions.

2.0 METHODOLOGY AND RESULTS

2.1 Preparation

2.1.1 Data Input

In preparation for the project, a digital data set was prepared for the study area using a geographic information system (GIS); the GIS used for this study was PAMAP GIS Version 3.0. This data set included a 1:20,000 digital Ontario Base Map (OBM) map with 10 meter contours and point elevations. Forest cover information was digitized from 1:15,840 Forest Resource Inventory (FRI) maps. Stand boundaries were digitized and registered to the OBM while the stand descriptions were entered into the GIS database. Supplementary forest cover information, such as forest cover descriptions for islands, was interpreted from 1:15,840 aerial photographs, transferred to the map and digitized.

A digital elevation model (DEM) was generated for the project area using OBM data. The model allowed the GIS to simulate the topography of the area in order to assess visibility. Stand heights are another key parameter for visibility analysis and these were added to the DEM as single-height blocks of vegetation cover on top of the terrain model.

This project does not attempt to assess the accuracy of the visibility analysis. The computer procedure is dependent on the data which goes into it, in particular, the elevation data (in this case, OBM maps) and the height of vegetation cover data (in this case, a verified FRI). The accuracy of 1:20,000 OBM data as provided by the Survey and Mapping Branch is as follows:

- positional accuracy ± .5 mm, or 10 m on the ground
- control point accuracy of ± .1 mm, or 2 m
- contour accuracy of ± .5 contour interval or 5 m, in <u>any</u> of the x, y, or z directions

2.1.2 Initial Visibility Analysis

An initial GIS assessment of forested areas theoretically visible from the lakes was made and demonstration materials prepared in order to explain project concepts to stakeholder groups during the 'values assessment' process (*see* Subsection 2.2) and to prepare for the field exercise (*see* Subsection 2.3). The procedure followed for the initial visibility analysis is given below:

i) Viewpoints were selected from which the GIS assessment of visibility was to be made. While a sufficient number of viewpoints was required to simulate visibility from anywhere on the lakes, care was taken to minimize redundancy in viewpoints to avoid unnecessary processing time. Seventy viewpoints were selected for Red Cedar Lake and Thistle Lake. These are referred to as the 'global' set of viewpoints.

ii) Heights were assigned to the viewpoints; 1 m above the lake surface was chosen to simulate eye level of a viewer seated in a boat. Only one shoreline location was used for this study, at Island View Camp, and this was positioned 4 m above the lake surface.

iii) The GIS was used to assess the theoretical visibility of the entire project area from individual (i.e., single) viewpoints, a combined set of several viewpoints, and all viewpoints (i.e., the global view).

iv) Since forest cover data (stand boundaries and height) were added to the DEM, creating single-height blocks of vegetation cover on top of the terrain model, results were interpreted as the portions of forest stands visible from the viewpoints.

2.2 Values Assessment

2.2.1 Stakeholder Consultation

Three key interest groups were identified by the OMNR. Interviews were conducted with spokespersons for each in order to identify critical values. These were as follows:

Island View Camp
(spokesperson: Gordon Mitchell)

Island View Camp is a tourist operation providing accommodations, outfitting, and guiding services for fishing, moose hunting, and bear hunting within the study area. Critical related values included an undisturbed (with respect to harvesting activities) viewscape from waterways (maintaining the perception of remoteness), as well as the provision of habitat suitable to maintain a supply of wildlife for the outfitting business (i.e., moose, black bear, fish).

Goulard Lumber
(spokesperson: Claude Goulard)

Critical values for this group were of a fibre nature and included red pine and white pine for their sawmill and black spruce, white birch, and aspen for sale to pulp and chip consumers.

Teme-Augama Anishnabai
(spokesperson: Robin Koistenan)

The Teme-Augama Anishnabai are indigenous people of the study area. Critical values included cultural/heritage values such as known heritage sites, historic portages and trails, as well as habitat values to support wildlife for sustenance hunting and traditional industries (e.g., moose and furbearers).

2.2.2 Quantification of Values

Timber: The best available source of data for timber values was the FRI. Ontario's Timber Management Planning (TMP) process is the system used to identify and quantify areas which are eligible for harvesting activities and, in subsequent steps, areas which are allocated for harvesting, taking into account a number of considerations (e.g., measures for protecting tourism, wildlife and fish values, and public input). For the purposes of this study OMNR provided a list of stands considered eligible for harvesting in the project area.

The stand information was used to generate a map and associated tables which displayed and quantified the eligible areas. Most of the forest within the study area was eligible. These eligible areas were broken down by working group (groups of tree species) according to the species (product) preferences of Goulard Lumber, e.g., pine, intolerant hardwoods (aspen, birch), tolerant hardwoods, and spruce. These categories have harvesting method implications which impact on planning decisions in areas of conflict between timber and visual values, i.e., a selection harvest system (required for pine) might be more acceptable than a clearcut system (possible for spruce and intolerant hardwoods) in areas visible from the water (depending on such factors as distance from visible areas and frequency of visibility).

Natural viewscape from waterways: GIS simulation and analysis (*see* Section 2.1.2) provided the theoretical assessment of such areas and is a major component of this study. Results are presented in subsequent sections.

Culture and heritage: No specific culture or heritage sites were identified. However, there is at least one computer model which might be used to assist in the identification of potential sites. Although beyond the scope of this project, this would be a consideration for future work. The DEM created for this project might provide input to this work. It is assumed that for the time being all cultural/heritage values in proximity of the shoreline would fall within the coverage provided by areas visible from the water.

Wildlife: Wildlife values in the project area were identified on OMNR maps but were not added to the digital map. These values include cold and warm water fisheries and critical habitat for moose and other species. These may place constraints on timber supply and are taken into account during the TMP process. Habitat supply models may be available for a number of species in the project area and this may be a consideration to be incorporated in future work.

Water quality/shore protection: OMNR specified buffers for lakes, creeks, and wetlands were added to the digital map. The following buffer zones were used:

Lakes: 60 m no harvest zone + 60 m modified management zone from shoreline.

Creeks and wetlands: 15 m no harvest zone + 30 m modified management zone from treed edge.

2.3 Field Work

2.3.1 Preparation

A field exercise was conducted to check the theoretical results of the GIS simulation and to provide additional technical support material for resource managers and planners. The following steps were undertaken to prepare for the field exercise:

i) A subset of 14 viewpoints was selected for field verification from the global set of 70 viewpoints. These were chosen to approximate the visibility coverage provided by the global set. Viewpoints close to the shoreline were selected to facilitate locating them in the field. These were marked on FRI photographs.

ii) Individual viewpoint visibility analysis was conducted for each field point. Visible areas and bearings to the boundaries (left and right) and/or centre points of theoretically visible polygons and distances were provided on maps. An example is shown in Figure 1.

iii) Visibility analyses from the 14 individual viewpoints were combined to ensure that the aggregate visibility from individual viewpoints was approximately the same as the coverage from the global set of viewpoints.

iv) The final set of viewpoints for field verification was determined and marked on photographs and individual viewpoint visibility maps were laminated to allow for field use.

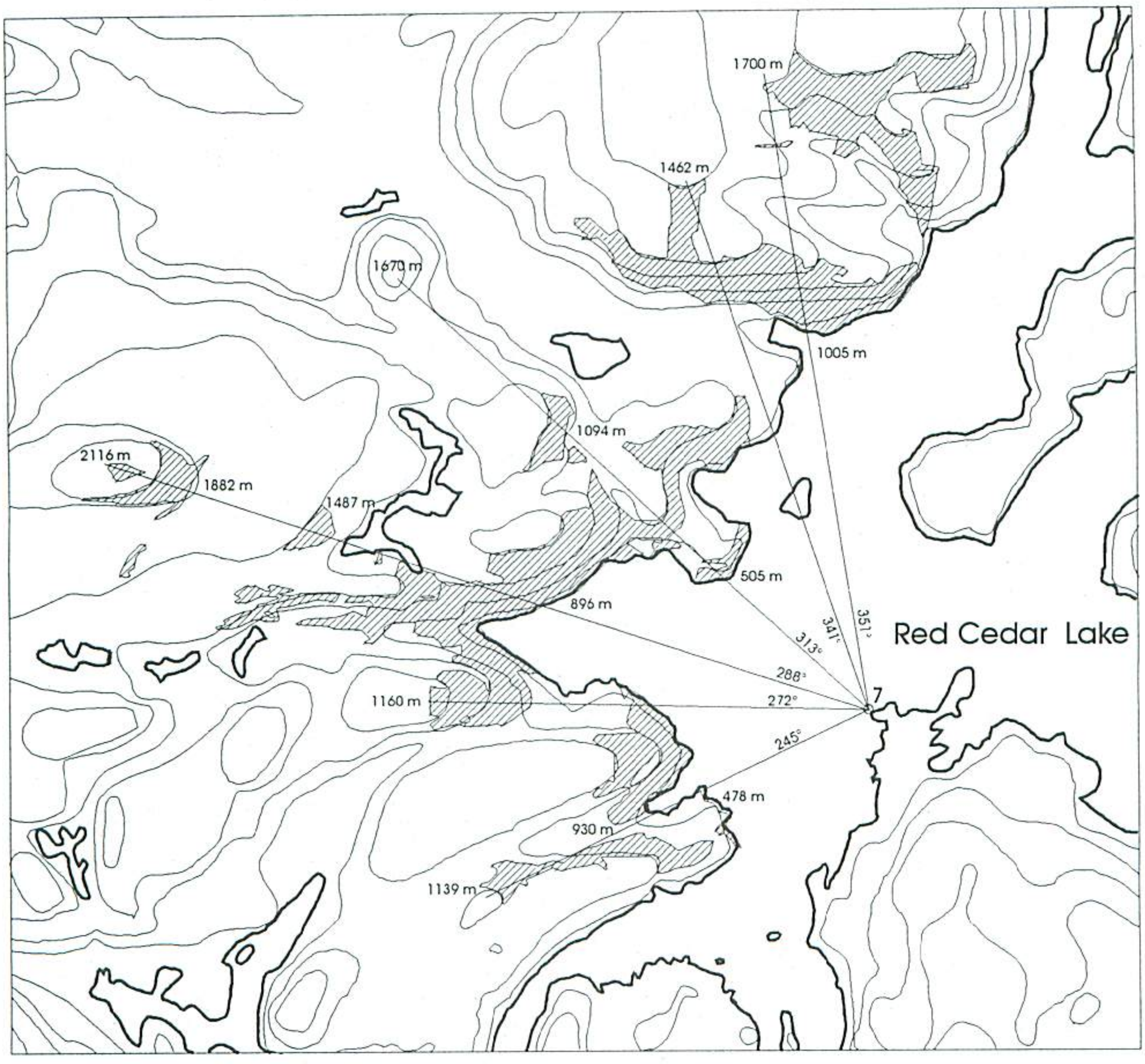

Figure 1. Results of an individual viewpoint visibility analysis showing viewpoint (#7), visible areas (cross-hatching), bearings of lines-of-sight and distances to visible areas (m). Scale is 1:15,840.

2.3.2 Field Exercise

A two-camera, fixed-base system was used to provide stereopair photographs from which range determinations could be made. Photographs were taken from the preselected viewpoints to provide coverage of theoretical and actual visible areas. Viewpoint number, bearing, and comments were recorded for each photograph. Three additional viewpoints were selected by the field crew to improve coverage of the area. These viewpoints were marked on FRI photographs and maps to enable subsequent visibility analysis. Observations in the field also resulted in expanding the global set of viewpoints to 81 to improve coverage.

2.3.3 Photograph Analysis

Field photographs were annotated with an identification number (the viewpoint and the bearing of the photograph centre, e.g., 7–263, as well as camera identification, **L**eft or **R**ight, film roll #, and frame #). A scale indicating the field of view was attached to the top of each photograph; the width of this field was dependent on the camera lens. A centre point was scaled at "0" with degrees to the left or right indicated as "minus" or "plus", respectively. Any location on the photograph was determined with reference to the known centre bearing. Points of interest, difficult to discern on a single photograph, but observed in stereo, were labelled on the water portion of the left stereo pair. A line-drawing of an annotated photograph is shown in Figure 2.

Photogrammetric measurements of range were made on the photographs using a Zeiss Stereocord. With a camera base of 172.1 centimeters, good resolution of distance measurements was possible for objects within approximately 1,500 meters of the view point. Table 1 lists the maximum potential resolution of the measurements. Bearing measurements were accurate to within 1°. The resolution is decreased (measurements are less accurate) with operator-related error. Specific values are dependent on operator skill and experience.

Figure 2. Representation of a typical field photograph with a scale indicating field of view in degrees (along the top), bearings to items of interest (i.e., 253, 263, 275), annotations indicating viewpoint, center bearing, camera, roll and frame (lower right-hand corner), and noted features of interest.

Table 1. The maximum potential resolution of the photogrammetric measurements.

Distance from viewpoint (m)	Resolution (%)
50	± 0.25
100	± 0.5
1,000	± 5.0
1,500	± 7.5

Initially, a "field viewpoint analysis report" was attempted for each of the viewpoints. The intention of these reports was to determine the horizontal extent and distance for every distinct 'area' on each photograph. Independently, the same information was to be collected for every distinct, theoretically visible 'area' on the maps. The expectation was that these analyses could then be compared. Unfortunately, due to the camera system limitations identified above, distances for areas on the photographs could not always be accurately determined. Furthermore, a potentially large number of distinct 'areas' could be identified, thereby requiring considerable analysis effort. For these reasons, it was decided that comparisons should be limited to potential conflict areas (this will be discussed further in Section 2.5).

An examination of the photographs taken from 14 of the individual viewpoints showed that the visibility model provided a reasonable representation of the forest cover within the project area visible from Red Cedar Lake and Thistle Lake. Measurements taken from seven of the viewpoint photographs were compared with maps and aerial photographs, to reveal the following:

i) A good match occurred between the model and the photographs for visible areas within 2,000 meters of the viewpoints. Areas modelled as visible that were further than 2,000 meters from the viewpoints were difficult to distinguish on the photographs, and distance measurements were not considered reliable.

ii) In several cases, distant areas modelled as visible were possibly hidden by tall subcomponents of stands, for example, towering white pine, birch, or cedar stands. The FRI stand heights are based on dominant, or working group, species only.

2.4 Identification of Potential Conflict Areas

A summary map was produced which showed areas eligible for harvest (as defined in Subsection 2.2.2), as well as those eligible areas which were visible from the global set of viewpoints. Areas both eligible and visible were considered to be potential conflict areas between fibre and visual values. These areas were quantified by working group and area (*see* Table 2) and displayed on maps (*see* Figure 3).

2.5 Detailed Analysis of Conflict Areas

With the previous analysis material, client groups can now identify actual conflict areas on a stand-by-stand basis (as defined on the FRI maps). This subset of potential conflict areas can then be addressed with more detailed analysis.

Table 2. A statistical summary of eligible and visible area by working group.

Working group[a]	Eligible (ha)	Visible (ha)	Visible (%)
wP	90.09	24.92	27.66
bS	131.94	14.20	10.76
wB	177.81	49.22	27.68
sM	62.53	20.83	33.31
Other conifers	74.35	26.77	36.00
Poplar	77.72	11.30	14.54
Total	614.44	147.24	–

[a] bS = black spruce, sM = sugar maple, wB = white birch, wP = white pine.

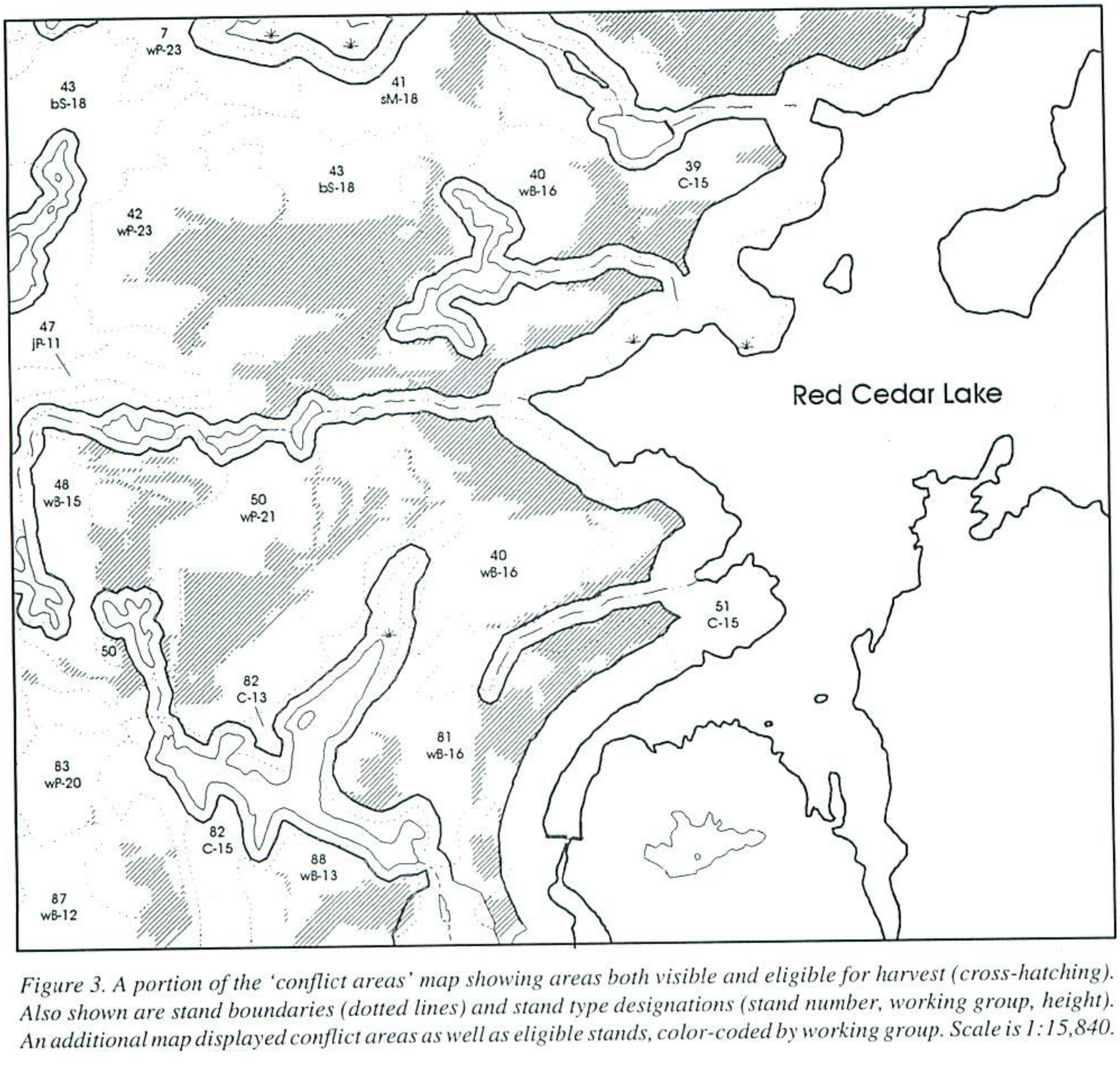

Figure 3. A portion of the 'conflict areas' map showing areas both visible and eligible for harvest (cross-hatching). Also shown are stand boundaries (dotted lines) and stand type designations (stand number, working group, height). An additional map displayed conflict areas as well as eligible stands, color-coded by working group. Scale is 1:15,840.

Typically, individual areas would be identified on the 'conflict areas' map, numbered, and ranked in order of priority, if a large number of conflict areas were identified. For the purposes of this project only one conflict area was selected to demonstrate concepts. This area (a portion of Stand 42) is shown on Figure 4 along with results of additional analysis.

A 'conflict area analysis report' was completed for this sample conflict area (*see* Table 3). Recorded were a quantitative description of the conflict area, a measure of the theoretical importance of the view from the lake, and the comparison of theoretical with actual views.

In the event that an area was visible on the photograph or in the field but not on the theoretical map (a situation that did not occur in this study), the procedure would be as follows:

i) in the field, observers record their observation position (i.e., viewpoint) and the bearing and approximate distance to the area (contour maps may assist);

ii) a technician attempts to locate the area on base maps and aerial photographs;

iii) the technician comments as to why the area is not showing up on the theoretical maps (a verification of photo-interpreted heights may be required, for example); and

iv) corrective action is taken, i.e., modify base data, rerun analysis, and proceed with the conflict resolution process.

This information provides valuable quantitative data with which resource managers and stakeholders can consider actions for conflict areas. The end result is a more focused assessment of impacts which may reduce conflict and facilitate integrated resource management solutions.

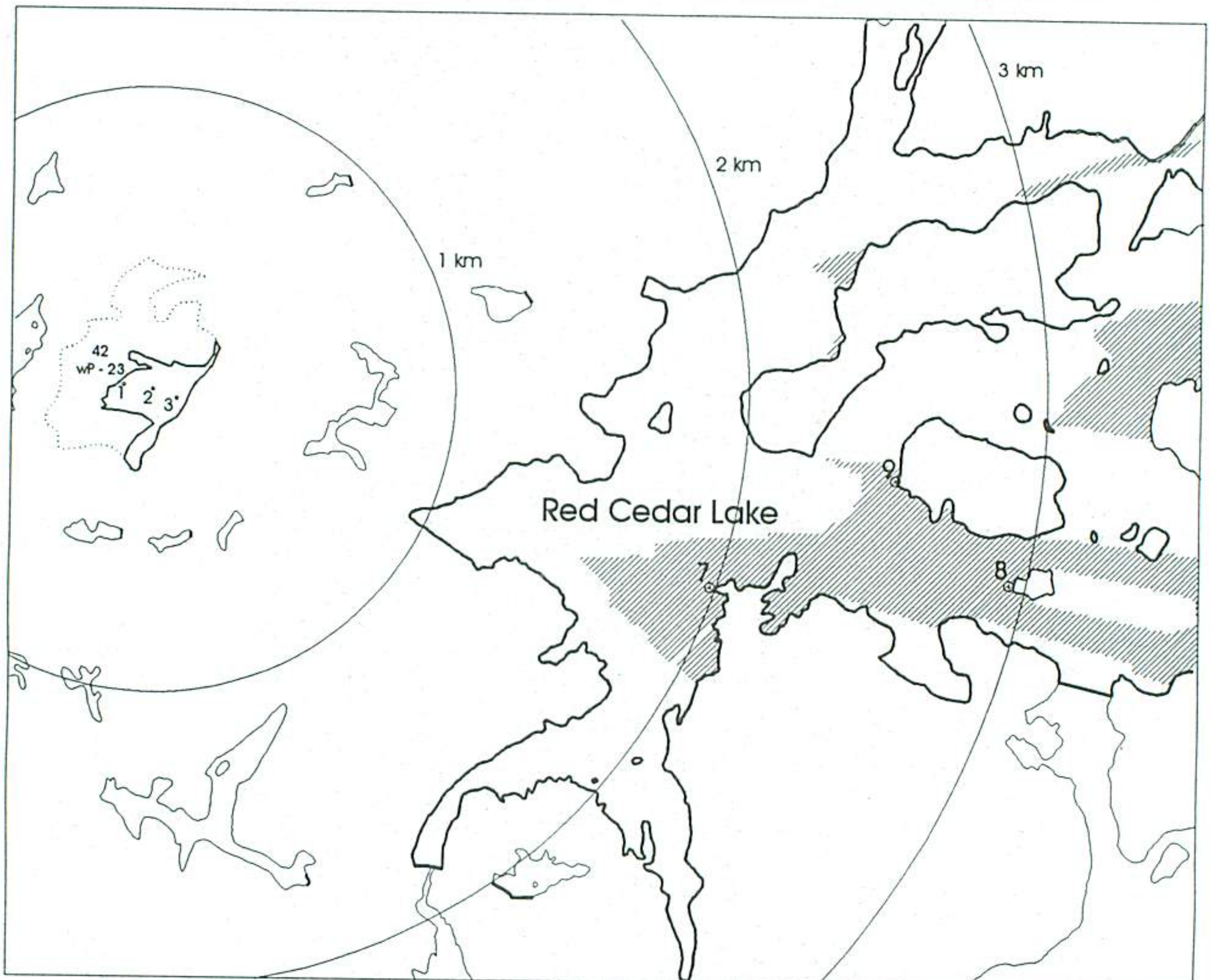

Figure 4. Conflict area analysis. Viewpoints (1, 2, 3) were placed in that portion of stand 42 determined to be visible from previous analysis (at stand height). Visibility analysis from these points provides a quantification, by distance, of lake areas theoretically 'viewing' the conflict areas; circle radii indicate 1, 2, and 3 km marks from a centre point of the conflict area. Scale is approximately 1:20,000.

3.0 SUMMARY AND RECOMMENDATIONS

The technique utilized in this study has considerable potential for identifying and providing technical support for resolving or reducing conflicts between fibre and recreation values. It also has considerable potential for expansion to better serve integrated resource management. It was enthusiastically received by stakeholders involved in the study. The technique involves four key components:

i) the use of GIS technology which enables the determination of theoretically visible areas and their spatial and quantitative comparison with other areas of interest, such as those related to fibre values;

ii) the use of field photography which allows the actual situation to be compared with theoretical results, through measurements (range and horizontal distance) and direct viewing. The latter allows a subjective assessment of the importance of the view;

iii) the participation of stakeholders, allowing them to understand the process and have meaningful input. This participation must be at an early stage (participation vs. ratification) and ongoing; and

iv) an experienced technical support group, able to match the need with the most appropriate technology and remain application- versus technology-driven.

The techniques presented in this report can be considered operational and can be readily duplicated using the methodology and techniques presented.

Areas for future effort can be broken into the following categories: streamlining the process, technology improvements, and future developments.

Table 3. Conflict area analysis report.

Description of Conflict Area

FRI stand number:	42
Working group:	wP
Age:	93
Height (m):	23
Stocking:	0.7
Species :	10% composition units (e.g., bF 1 = 10% balsam fir)

bF	wB	yB	sM	rM, siM	wP[a]
1	1	2	2	1	3

Stand area eligible for harvest (ha):	22.77
Stand area visible from viewpoints (ha):	5.89
Stand area visible from viewpoints (%):	25.87

Theoretical Visual Impact

Visible area (%) of Red Cedar Lake, by distance from conflict area centre point

Visibility of lake (%)	Distance from conflict area (km)
0	0 – 1
13.2	1 – 2
26.8	2 – 3
34.2	3 – 4
36.1	>4

Read as the % of lake surface within a given distance class which is visible from conflict area; e.g., 26.8% of the lake area within 2–3 km is visible. Note that it can be determined that conflict area is visible from viewpoints 7, 8, and 9. Photographs from viewpoints can be consulted to verify results and give an impression of visual impact.

Comparison of Theoretical Visibility (map) with Actual (photos)

Viewpoint and photo[b]	Source[c]	Horizontal extent (°)	Measured distance (m)	Comments
7–288°	map	280–290	1882–2116	
	photo	286–289	>1800	distant treetops, barely visible/measurable
8–277°	map	277–286	2845–3066	
	photo	281–283	–	distant treetops, barely visible, not measurable.
9–276°	map	275–278	2340–2626	
	photo	≈276–277	–	distant treetops, barely visible, not measurable.

[a]bF = balsam fir, rM = red maple, siM = silver maple, sM = sugar maple, wB = white birch, wP = white pine, yB = yellow birch.

[b]To conflict area.

[c]Refers to individual viewpoint maps and field photographs.

3.1 Streamlining the Process

When the methodology is applied to a larger area the effort related to the field exercise, including analysis, will be considerable. This effort can be reduced without negatively affecting results by defining potential conflict areas prior to the field exercise; i.e., determining eligible and visible areas ahead of time and restricting field work to potential conflict areas. This would include a session with stakeholders subsequent to eligibility and visibility determinations but prior to field work.

3.2 Technology Improvements

The FRI heights, as interpreted stand values, are not conducive to accuracy assessments. The visibility analysis results are not assumed to be accurate (i.e., an exact duplication of the actual situation) and this is not necessary for the undertaking. The analysis and the subsequent field verification together form a tool which can help pinpoint areas for careful consideration in the planning stage.

As discussed in Subsection 2.3.3, range determination with the existing camera system can only be considered reliable up to 1500 m and only with an experienced operator. Improvements would likely be attained with a larger format camera or a larger base. If a commitment is made to implement this process on a larger scale, research into improvements for the camera system should be considered.

Additional effort is desirable to confirm the validity of the FRI vegetation data used as the base data for the study. As we start concentrating analysis on a stand level basis we strain the suitability of the FRI. It is well known that the FRI is a macro-level base and has limitations at the stand-level. Focused interpretation in key areas to confirm species composition and height is thought to be a desirable step and is not likely to be onerous. Operational requirements should be the subject of future applied research efforts.

3.3 Future Developments

The potential exists to add to the existing methodology in several key areas, as follows:

i) additional visibility analysis at the stand level for priority conflict areas. Effort to date has focused on the visibility at canopy, or tree top, height. This should be expanded to include visibility at other heights, such as at base-of-crown height and ground level. Different parts of visible areas may be "more" visible than others. Computer analysis could support this and provide useful information for harvest planning if this is an alternative;

ii) the inclusion of temporal analysis to allow assessment of visibility not only at time of inventory but also at future periods, taking into account growth and mortality. For example, tree growth will affect visibility over time, particularly in areas which are close to viewpoints, such as shoreline buffer areas;

iii) the incorporation of other values, e.g., wildlife, culture, and access, to allow better support for integrated resource management;

iv) the technique could be expanded to investigate particular scenarios of timber harvesting. For example, harvesting a small, high-value stand near a viewpoint (e.g., near the shoreline) may expose a much larger area at further distance, thus greatly increasing the area in conflict. Several harvesting scenarios could be examined to come up with an optimal approach for a study area; and

v) FRI interpreted heights are often the only source of tree height data and, while suitable for planning purposes, have limitations for this work. For example, stream, lake, and river edges are usually not treated separately by FRI interpreters, even though riparian effects typically cause greater heights. The implication for visibility analysis is that a shorter than actual buffer may be included in the model and that more areas are theoretically visible than is the actual case. Countering this, to an unknown extent, are openings in actual stands which may provide significant views into or beyond the stands at less than stand height—that height which is used to set the height of the buffer wall in the theoretical analysis.

Each of these areas of future development will require considerable applications research effort.

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