A User Guide to Photopoint Monitoring Techniques for Riparian Areas-

Aqua-Tex Scientific Consulting Ltd. (1993)

COOPERATIVE riparian RESTORATION

A User Guide to Photopoint Monitoring Techniques for Riparian Areas-

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"Ecosystems are not only more complex than we think, they are more complex than we can think"

(Egler, 1977).

Introduction

Photopoint Monitoring is a standardized procedure, developed largely by Dr. Fred Hall of the U.S. Forest Service, for taking precisely replicable photographs of resources that require long term management (Hall, 1997). Photopoint Monitoring is both a qualitative and quantitative tool that can assist resource managers in detecting unacceptable conditions in target resources severe or irreversible changes occur, and to implement corrective actions. The technique can also be used to assess the success or failure of management decisions based on the use of clearly defined indicators and standards. The Photopoint Monitoring technique can be used as an early warning system in conjunction with other quantitative approaches or as an independent monitoring procedure.

This manual is based upon a three year trial conducted by three Environment Youth Teams, under the supervision of Aqua-Tex Scientific Consulting Ltd., followed by a 3 month intensive study of the utility of the method for the Capital Regional District (Victoria, B.C.). The purpose of that study was to determine, and field test, the range of applications of Photopoint Monitoring for riparian and ecologically sensitive areas.

The Environment Youth Team tested the application of this technique for monitoring recreation and visitor impacts in local parks, fuel loads and associated fire hazard risks in the Victoria water supply; rates of riparian restoration and recovery in channelized streams, and rates of natural and artificial disturbance recovery in burned, diseased and logged landscapes.

Benefits

The principle benefits of Photopoint Monitoring include:

- Ease of use. It requires a one-day office/field workshop to train practitioners on the procedure.
- Uses inexpensive, readily obtainable equipment.
- Provides a standardized and precisely replicable result that can be achieved by different personnel at different points in time.
- Can be easily compared to standardized results from other areas or research projects.
- Permanently marks both ends of a phototransect which enables other quantitative data collection techniques to be replicated over time (i.e. profile survey and vegetation intercept samples).

- Does not require a separate database to describe the date and location of each photopoint because all site-specific information is embedded into each photograph with a data board.
- Requires a minimum effort to repeat future photographs.
- Provides a precise method for measuring relative changes in target resource parameters over time.
- Photographs provide a long term visual permanent record of site conditions that transcend periodic changes in staff and expertise.
- Time-series photographs may be a more effective communication tool when dealing with the public and decision makers than highly quantitative charts, tables and graphs.
- Standardization of camera (35 mm with 50 mm lens), and focal point distance (10 meters) will enable newly developed quantification and analysis techniques to be applied to all photographic products.
- Historical photographs taken without a meter board can be re-shot from the same location. A meter board can then be digitally added to the historical photographs to enable quantification and analysis.

Limitations

The principle limitations of Photopoint Monitoring include:

- It cannot be used to detect quantitative changes in species composition or micro-scale soil erosion. These limitations can be overcome if additional quantitative techniques are applied along the length of the phototransect such as point intercept vegetation sampling and transect profile surveys.

- Generally, it should not be conducted by a single person due to safety considerations. Furthermore, simple tasks such as transporting equipment between sites or stabilizing a meter board or sign board during windy conditions often require a two person effort.

- It cannot be used in dense woody vegetation as branches and foliage obscure camera field of view. Extreme wind and rain also present significant challenges to the procedure.

- Over time, photopoints can become obscured by vegetation, or lost due to soil erosion or vandalism.

- Location of a phototransect is a subjective and non-random decision which depends on site configuration, experience level and monitoring objectives.

Chapter 1: Monitoring Approaches

"There is no substitute for reliable monitoring to help determine the success or failure of management actions" (Noss and Cooperrider, 1994).

Introduction

The basic purpose of a biological monitoring program is to detect and evaluate trends in resource conditions by comparing results between present, past, and baseline assessments (Haney and Power, 1996). There are four general characteristics associated with an effective biological monitoring program. First, an effective program must be able to detect deteriorating conditions severe or irreversible changes occur, and to implement corrective actions (McLain and Lee, 1996). Second, it must provide a standardized procedure for obtaining an objective record of resource conditions which transcend periodic changes in management staff and expertise. Third, the program must identify a series of indicators and associated standards in order to assess if the agency management goals are being achieved. Finally, a monitoring program must be fully integrated with management so that monitoring results affect management decisions (Noss and Cooperrider, 1994). Without an effective long term biological monitoring program, managers cannot receive feedback on how conditions change in response to management actions and cannot accurately predict how conditions may respond to new management policies.

Numerous monitoring approaches have been developed to document and evaluate trends in resource conditions over time. Qualitative assessments, such as condition-class systems, compare the conditions of a sample site to a range of descriptive classes and select the class that most closely approximates the conditions of the site (Marion, 1995; Marion and Farrell, 1996). Although this type of system is simple, expedient and inexpensive, it relies on a subjective assessment of site conditions. As a result, consistent classifications by different individuals can be difficult to achieve (Marion and Farrell, 1996). Furthermore, this system provides no quantitative measurements of specific resource conditions and classes do not usually exhibit linear relationships (e.g. class 2 is not necessarily twice as changed as class 1, nor is it half as changed as class 4).

The problems with qualitative assessments can be overcome with quantitative approaches in which targeted resources are intensively measured by field biologists (Biring 1998). Although quantitative approaches can be used to detect significant changes in ecological parameters over time, they are time consuming, knowledge intensive and costly. Significant training is also required for taxonomic identifications and for statistical analysis. As a result, field intensive quantitative monitoring programs are often the first to be eliminated during times of fiscal restraint or agency re-prioritization (Noss and Cooperrider, 1994). Based on this established pattern of elimination, it is clear that alternative monitoring approaches are required which are simple, effective, efficient, affordable, standardized, and which can provide an objective record of changing ecological parameters which transcend periodic changes in management staff and expertise.

Photopoint Monitoring is a "middle of the road" technique in which both qualitative and quantitative assessments can be made from the photographic products. It can be used either as an early warning system in conjunction with other more quantitative approaches, or independently as an exclusive monitoring procedure. Although early attempts at photographic monitoring suffered from inconsistencies in the photographic field of view and lacked standardized methods for photo quantification, identification and storage, newer approaches have overcome these difficulties. Specifically, Hall (1997) has proposed a standardized technique for ground-based photographic monitoring that could be modified and used for a variety of monitoring applications. The following sections outline Hall's (1997) standardized technique and propose some basic modifications and improvements.

Standard Ground-Based Photographic Monitoring

Hall's (1997) standardized method for ground-based photographic monitoring uses permanently marked camera locations, focal points and scale bars to achieve precise replication of photographs and to enable relative photogrammetric quantification. This technique also embeds all site information directly into each photograph to facilitate easy relocation of camera points and to ensure perpetual functionality. The standard procedure produces a single photographic product known as a photopoint photograph.

A photopoint photograph is obtained by placing a standardized scale board in the center of the camera field of view at a horizontal distance of 10 meters from the camera location. The 1 meter mark (1M) on the scale board is placed within the focal point of the camera (cross hairs) and an information board (containing site information) is placed at a maximum distance of 6 meters from the camera. Two 35 mm cameras with 50 mm lenses (set to an f-stop of 16 or 22) are used to shoot black and white prints and colour slides.

Modified Photographic Monitoring

Our modifications to the standard procedure include the following:

1. Swapping the location of the camera and scale board such that the entire 10 meter length of transect is captured on film. This procedure requires two photopoint photographs and the resulting product is called a phototransect.

2. Installing a 5 meter marker within all photopoints so that spatial scale can be determined on photographic products. The 5 meter marker also serves as a focal point for landscape photographs.

3. Obtaining a standardized landscape photograph of a phototransect which depicts how the transect fits into the overall landscape context. The landscape photograph location is also permanently marked and standardized so that it can be precisely replicated. The landscape photograph can be used to relocate the phototransect permanent markers.

4. Obtaining a non-standardized site setup photograph which depicts the location of the landscape camera location in relation to the phototransect. The site setup photograph can be used to relocate the landscape permanent marker.

5. Using colour slides, black and white prints and colour prints as the three film types. The black and white print film was selected for superior longevity, the colour print film was selected to help detail vegetation structure and composition and the colour slides were selected for presentation purposes and as back-ups to the colour prints.

6. Digitizing all photographic products and storing in an HTML-based database. The digital archive can be used as a backup to the colour photographs and also for public viewing.

Chapter 2: Photopoint Monitoring Procedures

"One picture is worth a thousand words" (Barnard, 1921).

Introduction

There are five stages to a Photopoint Monitoring project: (1) Project Planning; (2) Equipment Acquisition; (3) Photopoint Monitoring; (4) Photographic Archiving; and (5) Photographic Replication. It is essential that all stages in the following sections are implemented to ensure that the photopoint standard is maintained and that project goals and objectives are achieved.

Project Planning

Project planning is the first step in developing any long term monitoring program. The following guidelines will help to develop a work plan for a photopoint project:

1. Define the monitoring goals and the short and long term objectives of the project. If possible, determine the return monitoring frequency for all photopoints.

2. Determine the products required including: film requirements, archive requirements, computer requirements, field maps, and additional quantitative sampling needs on photopoint transects.

3. Define the boundaries of the study area and obtain permission to enter restricted areas.

4. Determine the biogeoclimatic classification of the study areas as well as other ecological parameters of interest.

5. Identify sample sites which require long term photographic monitoring.

6. Define thresholds and standards for quality control (internal audit) and quality assurance (external audit). A minimum of 12% of all sites should be randomly selected for quality control and quality assurance tests.

7. Determine a method for site relocation. Options include aerial photographs, surveyed maps and GPS. If GPS is used, ensure that each GPS unit is calibrated for both accuracy and precision (see Appendix B). Determine if UTMs or Latitude and Longitude will be used to record position.

8. Determine how photopoint products will be physically and / or digitally stored and how access will be controlled.

9. Determine if other studies have been conducted in the study area and assess their utility for the project. Obtain any photographs that have been taken by field research crews in or near the selected sample sites.

10. Determine project personnel, budget, scheduling of fieldwork, transportation logistics, and expected date of project completion. Given the nature of Photopoint Monitoring, the photopoint crew does not need to have any technical skills beyond basic camera use. The size of the crew will depend on the site conditions and additional data collection needs. Chapter 5 includes a discussion on optimal crew size and expected productivity.

11. Subsequent to the completion of the Project Planning Stage, all field equipment should be purchased or constructed. The following section outlines the standard equipment required to conduct Photopoint Monitoring.

Equipment

Standardized pieces of equipment that are required to conduct Photopoint Monitoring:

- ☐ meter board
- ☐ meter board extension
- ☐ meter board tripod
- ☐ data board
- ☐ data board tripod
- ☐ meter marker
- ☐ compass
- ☐ 50 meter fiberglass measuring tape
- ☐ 35 mm camera with 50 mm lens
- ☐ camera tripod
- ☐ shutter release cable
- ☐ pelican camera case
- ☐ black and white print film (100 ISO)
- ☐ colour slide film (100 ISO)
- ☐ colour print film (100 ISO)
- ☐ field data form
- ☐ photopoint information sheet
- ☐ landscape information sheet
- ☐ site setup information sheet
- ☐ start of roll information sheet
- ☐ panorama information sheet
- ☐ field data book
- ☐ camera location markers
- ☐ backpack or golf bag
- ☐ chalk line (optional)
- ☐ plumb bob with needle tip (optional)
- ☐ theodolite (optional)
- ☐ stadia rod (optional).

A detailed description of all required equipment is included in Appendix C. To assist future photopoint projects, a list of the expected capital costs of all field and archival equipment is also provided in Appendix C. After all field equipment has been purchased or constructed, field testing should be conducted to ensure functionality and portability.

Photopoint Monitoring Field Procedures

The Photopoint Monitoring field procedure produces three distinct types of photographic products: photopoint photographs, landscape photographs and site setup photographs. The following sub-sections outline the standard procedures used to produce each of these three products.

Photopoint Photographs

Photopoint photographs are standardized pictures that are taken of 10 meter transects containing target resources at the selected monitoring site. The prime objective is not to capture every square meter of the sample site on film, but rather to give a representative view of the site conditions and resources of management concern. All photopoint photographs contain a meter board that is placed at a standard distance of 10 meters from the camera point. When possible, the meter board is placed in the center of each picture and the focal point (cross hairs) of the camera is centered on the 1 meter mark (1M) of the meter board (in unique circumstances, the 0M and 2M are also acceptable focal points). The meter board serves three important functions:

1. to embed a standard scale within each photograph so that features in close proximity to the meter board can be measured;

2. to provide a focal point for the camera so that repeat photography can be achieved; and

3. to provide a scale for the purposes of grid sampling analysis.

Both the location of the camera and the meter board are permanently marked so that precise replication of the photopoint can be achieved provided the camera height and focal point are known. Placing the meter board at a standard distance of 10 meters from a 35 mm camera with a 50 mm lens was established by Hall (1997) to ensure at least 25% of the overall photograph height was captured by the meter board.

It is important to note that although the distance between the camera point and meter board is 10 meters, only approximately 7 meters are depicted on the resulting photograph due to optical limitations of a 35 mm camera with a 50 mm camera lens (See Chapter 4 for additional explanation). To overcome this limitation, a second photopoint is taken in which the locations of the camera and meter board are swapped. Establishing a second photopoint in the opposite direction of the first photopoint ensures that the entire 10 meter transect between the two permanent marker pins is captured on film. The contents of these photopoints can then be compared with other quantitative data collection techniques that are conducted between the two permanent marker pins (transect profiles and vegetation intercept samples).

Technique

The following guidelines outline the procedure for shooting photopoint photographs:

1. Prior to entering the field, determine day-specific field objectives, assemble appropriate field resources (maps, site locations, etc.), check weather reports and assign work positions to crew members. For a three person crew, positions include data recorder; meter board, data board and distance measurement technician; and photographer / compass operator.

2. Use maps, aerial photographs and /or GPS to locate study site. Review site monitoring objectives and conduct a site assessment to identify target resources that require monitoring.

3. Identify the location name (broad geographic area), sample site name (specific area) and sample site number. A sample site is defined as not exceeding 1 hectare in total area. Each successive sample site is sequentially numbered (provided that the location name remains constant) and named according to a distinguishable feature contained within or adjacent to the site. If a new location name is selected, site numbering reverts to 1.

4. Identify a representative 10 meter linear transect at the sample site. More than one transect may be required to capture the target resources at a specific site. When selecting an appropriate transect, consideration must also be given to accessibility based on current and future vegetation and soil conditions, and absence of such safety hazards as snags, avalanche chutes and steep slopes. Selecting a representative transect is the most challenging and subjective component of the entire photopoint process. Transect selection is significantly improved by sighting through the camera at each potential transect location. What may appear to be a good transect to the human eye, may prove inadequate when viewed through a camera lens. In general, transect selection cannot be random as the site conditions (slope and vegetation) limit where photopoints can be taken.

5. Measure the selected 10 meter linear transect with a fiberglass measuring tape or a pre-measured piece of string. The measuring tape should be leveled and held approximately 1 meter above the ground. Always ensure that the measuring tape is oriented so that the 0 meter mark is on the end point that is associated with the minimum azimuth (compass bearing value closest to 0°) and the 10 meter mark is on the end point that is associated with the maximum azimuth (bearing value closest to 360°). Orienting the transect line in this manner standardizes transect orientation and eliminates inconsistencies in labeling camera points. All azimuths are recorded to true north.

6. Center the camera tripod over the 0 meter mark of the transect line and adjust camera height until transect and target resources are in field of view. Standard camera heights range from 1 to 1.5 meters depending on site topography and configuration of target resources. Designate camera location as camera point A. When the camera and meter board locations are swapped to do the next photo for the transect, the next position of the camera will be labelled camera point B. These two photos complete one transect. If a second transect is established at the sample site, label the first camera location camera point C (0 meter mark) and the second camera point D (10 meter mark). In other words, each unique camera location is given a

unique letter. If a camera location is reused it retains its original letter. It is uncommon to install more than 4 camera points at a single sample site. Use the same camera point labeling process at each successive sample site, starting with the letter A.

7. Install a meter board at the 10 meter mark of the transect. Ensure the meter board is level and is centered in the camera field of view. The camera is always oriented in the landscape position (long axis of photo is horizontal). Select 0M, 1M or 2M as the camera focal point (1M is the preferred focal point).

8. On the 10 meter transect between the camera and the meter board, locate the 5 meter mark and place the 5 meter marker 5 cm from the transect line. The 5 meter marker provides a spatial scale within the photopoint and also serves as a focal point for landscape photographs (See Figure 1).

9. Fill out field data form and photopoint information sheet (see Appendix C).

10. Attach photopoint information sheet to data board and install data board at 5 meters from the camera (maximum distance of 6 meters if necessary due to obstacles etc.) (Figure 1). Ensure that the data board is not obscuring any of the target resources and is evenly illuminated (either total shade or total sunlight, but a mix of illumination should be avoided). The data board is placed in the camera field of view and is used to imbed site information into each photopoint photograph including: date, time, location, site name, site number, camera height, camera point, photopoint, photocode and distance / azimuth of meter board from camera location. The information contained on photopoint information sheets is for photographic identification, replication and database storage purposes. Embedding detailed site information into each photograph eliminates the need to maintain a separate site information database.

11. Check to ensure the camera aperture is set to a standardized F-stop of 16 or 22. This standardizes the depth of field to ensure that all features which are beyond the 5 meter marker are in focus. Also check to ensure that the correct ISO level (film speed) has been set.

12. Read the light meter and adjust the shutter speed accordingly. If the shutter speed cannot be set to optimize the lighting conditions, a photographic bracketing procedure may have to be used in which 3 photographs are taken over the appropriate range of shutter speeds. To bracket a photograph, select a shutter speed which represents the ideal light level according to the light meter. Take one photograph at the optimum speed, one photograph at the next highest speed and one photograph at the next lowest speed. Use a cable release at shutter speeds of 1/60 sec. or slower.

13. Focus the camera on the meter board focal point (0M, 1M or 2M) and alert the crew that camera is ready (Figure 1). It is important to note that the contents of data board will not necessarily be in focus in the view finder. If the correct f-stop has been used the data board will be in focus in the final photo. In rare circumstances, it may not be possible to capture all of the target resources in a single photopoint photograph. In such situations, 2 photopoint photographs are taken in which the meter board is first aligned on the right hand side of the

field of view, and then aligned on the left hand side. Subsequent to developing, the photographs can be overlapped along the meter board to obtain a complete image of all target resources.

14. Shoot photopoint with all three film types (depending on number of film types being used). Use quick release bases on each camera to increase speed of camera swapping on the tripod. Ensure that the field of view and focal point remain constant between cameras.

15. Install permanent marker pins at camera and meter board locations (0 meter and 10 meter marks). Use case-hardened sidewalk stakes if locations are on soil (requires sledge hammer) and use brass survey pins if locations are on bedrock (requires Hilty rock drill ™, generator and rock grout). Permanently marking the location of the camera and meter board ensures precise photopoint replication provided camera height and focal point are also recorded. In addition, the marker pins can be used for other non-photopoint purposes such as transect profile surveys and point intercept samples (Chapter 4). If the possibility exists that the permanent marking pins may be removed by a natural or human caused disturbance, it may be necessary to select a witness point to aid in camera point relocation. If a witness point is designated, then the location and azimuth of all camera points must be measured to the witness site. The witness point must also be marked with a permanent marker pin and tagged.

16. Swap the location of the camera and the meter board by placing the camera on the 10 meter mark (camera point B) and the meter board on the 0 meter mark . Adjust camera height until transect and target resources are in field of view. Ensure meter board is level and is centered in the camera field of view. Select 0m, 1m or 2m as the camera focal point. Record the true north bearing from the camera location to the meter board (should be original bearing plus 180°).

17. Add appropriate data to original field data form and create new photopoint information sheet.

18. Attach photopoint information sheet to data board and install data board at a maximum distance of 6 meters from the camera. Ensure that the data board is not obscuring any of the target resources.

19. Turn the 5 meter marker to face the camera.

20. Shoot photopoint with all three film types. The first photopoint taken at a camera location is labeled 1. Each successive photopoint taken from the same camera location is incremented by one. (e.g. A-1, A-2, A-3 designates 3 photos all taken with the camera at exactly the same location (“A”) but facing three different photopoints or targets (“1”, “2” and “3”)).

21. Confirm all necessary site data has been recorded by means of a check list and obtain a landscape photograph of the site.

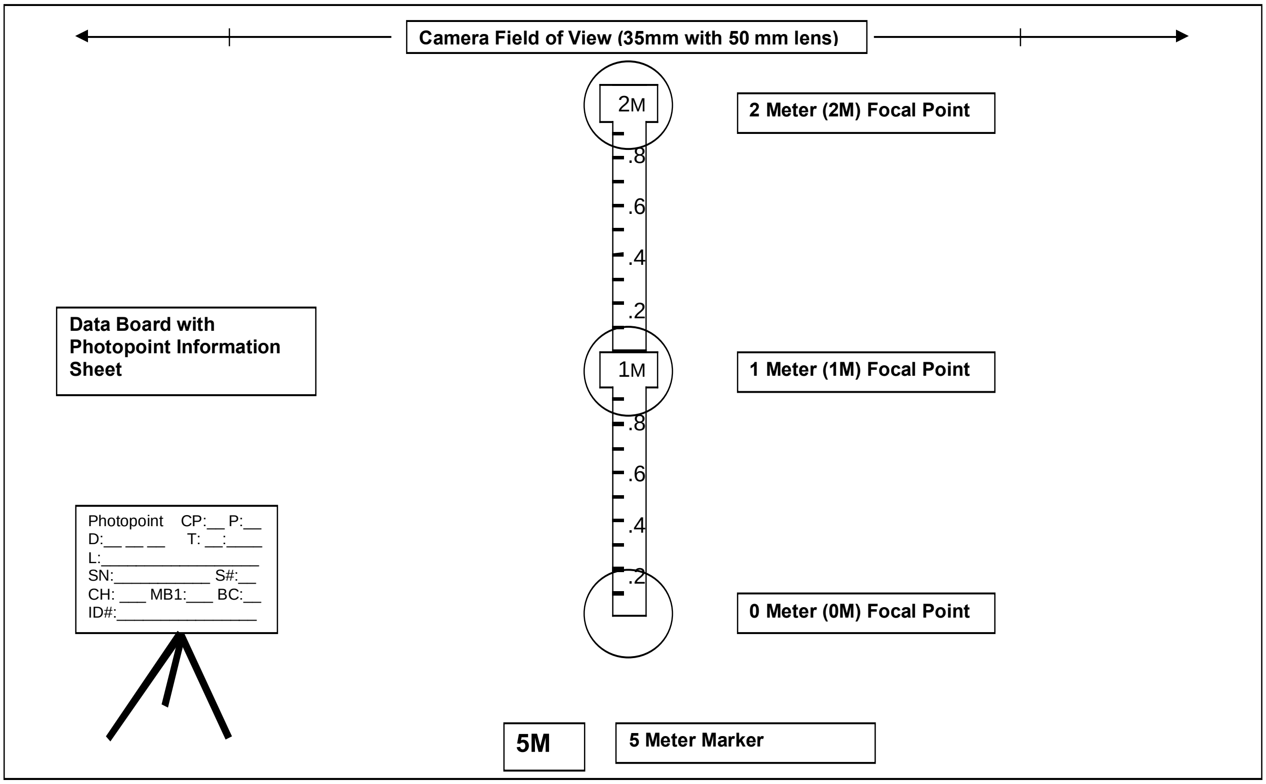

Figure 1. Schematic of meter board, data board and 5 meter marker within Photopoint Photograph. 0M, 1M and 2M focal point options are also depicted.

Landscape Photographs

The second product produced by the Photopoint Monitoring procedure is a landscape photograph. The purpose of the landscape photograph is to depict the location of the camera and meter board permanent marker pins. The landscape photograph helps to orient the user as to the location and representativeness of the photopoints, and can also be used for quantification of target resources. To achieve a standardized landscape photograph that can be precisely replicated over time, the camera focal point is aimed at the 5 meter marker (which was placed at the 5 meter mark along the 10 meter transect). By consistently using the 5 meter marker as a focal point, and by permanently marking the landscape camera location, precise replication of landscape photographs can be achieved.

Technique

1. Select a suitable location for taking an unobscured landscape photograph of the photopoint transect. The landscape location should be perpendicular or oblique to the photopoint transect and should exceed 20 meters in distance. All landscape camera locations are labeled with an L followed by a numeral. The first landscape location at a site is designated L1. If a second landscape location is used to capture a second phototransect at the same site, it is designated as L2. Use the same camera point labeling process at each successive sample site, starting with the letter L1.

2. Subsequent to the selection of a landscape location, the meter board on the 0 meter mark (camera point A) should be turned so that it is perpendicular to the camera field of view. A second meter board should then be installed on the 10 meter mark (camera point B if a transect) and also turned to face the camera. The 5 meter marker should also be reoriented to face the landscape camera location (Figure 2)

3. Adjust the focal point of the camera to contain the 5 meter marker. Obtain the azimuth from the landscape camera location to the 5 meter marker.

4. Fill out field data form and landscape information sheet (see Appendix C).

5. Attach landscape information sheet to data board and install data board at a maximum distance of 6 meters from the camera. Ensure that the data board is not obscuring any of the photopoint transect and is evenly illuminated. The data board is again used to imbed site information into each landscape photograph including: date, time, location, site name, site number, relative location and label of camera points, landscape photocode and focal point and bearing of focal point.

6. Focus camera on focal point (5 meter marker) and alert crew that camera is ready (Figure 2).

7. Shoot landscape photograph with all three film types. Ensure that the field of view and focal point remain constant between cameras.

8. Install a permanent marker pin at the landscape camera location. Use case-hardened sidewalk stakes if locations are on soil (requires sledge hammer) and use brass survey pins if locations are on bedrock (requires Hilty rock drill ™, generator and rock grout). Permanently marking the landscape camera location ensures precise photopoint replication provided camera height and focal point are also recorded.

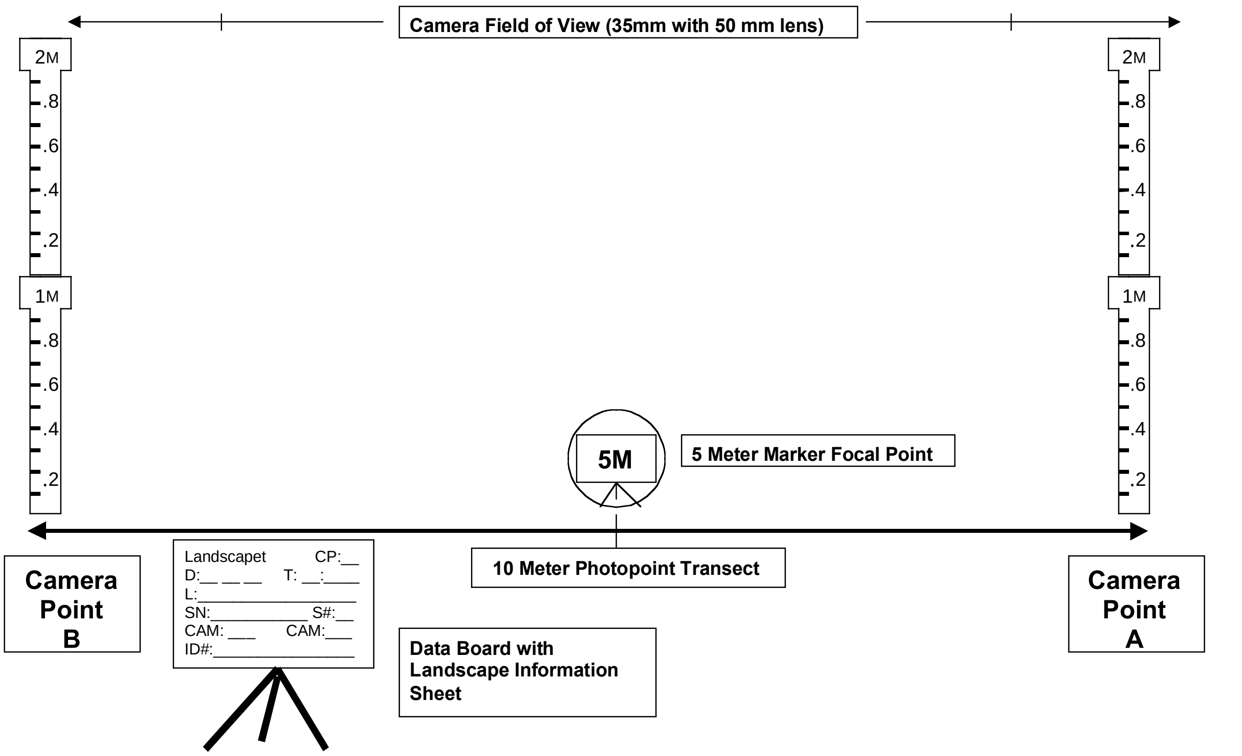

Figure 2 Schematic of meter boards (Camera Points A and B), data board and 5 meter marker focal point within Landscape Photograph (not drawn to scale).

Site-Setup Photographs

The third product of Photopoint Monitoring is a non-standardized site setup photograph which depicts the location of the landscape camera location in relation to the original photopoint. While the landscape photograph assists in the relocation of the photopoint transect and associated marker pins, the site setup photograph assists in the relocation of the landscape marker pin, and its spatial relationship to the transect marker pins.

Technique

1. Select a suitable location for taking a site setup photograph which incorporates both the landscape camera location and at least one end of the photopoint transect. Typically, the best location for shooting a site setup photograph is to take 2 steps away from the landscape pin. The site setup photograph does not need to be standardized because it is only depicting the location of the landscape pin in relation to the photopoint transect. There is a high degree of overlap between the contents of site setup and landscape photographs.

2. Fill out field data form and site setup information sheet (Appendix C).

3. Attach site setup information sheet to data board and install data board at a maximum distance of 6 meters from the camera. Ensure that the data board is not obscuring the landscape camera pin or any of the photopoint transect. The data board is again used to imbed site information into each site setup photograph including: date, time, location, site name, site number, location of landscape and transect marker pins and site setup photocode.

4. Focus camera and alert crew that camera is ready. There is no focal point used for site setup photographs because they are not standardized and not intended for replication.

5. Shoot site setup photograph with all three film types. There is no need to install a permanent marker pin at the site setup camera location.

Photographic Photocodes

Each of the three photographic products of Photopoint Monitoring is associated with a unique alpha-numeric photocode. The coding procedure is based on the date, site name and phototype:

Photopoint photographs are coded according to the following procedure:
YY MM DD - First 3 letters of site name - camera location and photopoint number.
For example, photopoint 1, taken at the site named Creek Mount, from camera point A on December 31, 1999 would be coded 99 12 31-CRE-A1.

Landscape photographs are coded according to the following procedure:
YY MM DD - First 3 letters of site name - landscape location and camera contents.
For example, the landscape photograph of camera points A and B, taken at the site named Creek Mount, on December 31, 1999 would be coded 99 12 31-CRE-L1AB. If the same landscape location was also used to produce a landscape photograph of camera points C and D, the code would be 99 12 31-CRE-L1CD. However, if a different landscape location was used to produce a landscape photograph of camera points C and D, the code would be 99 12 31-CRE-L2CD.

Site setup photographs are coded according to the following procedure:
YY MM DD - First 3 letters of site name - site setup and landscape location.
For example, the site setup photograph of the L1 landscape camera location (capturing camera location A, B, C and D), taken at the site named Creek Mount, on December 31, 1999 would be coded 99 12 31-CRE-SL1. However, if a different landscape location (L2) was used to capture camera points C and D, the code would be 99 12 31-CRE-SL2.

Data Archive Procedures

It is essential that the photographic products of Photopoint Monitoring are stored in a well organized and easy to use format. Depending on the needs of the agency, there can be up to three different storage types for photographs including photograph and negative archives (hard copy), field guides (hard copy) and digital archives (soft copy). The objective of each of these storage types is to contain all the data that other individuals will require to repeat each photographic product. The digital archive can also be used as a backup to the photo archive and published to the world wide web for public viewing. Each of the following subsections describes how to create each of the storage types that are used to organize and store photographs.

Photograph and Negative Archives (Hard Copy)

At the end of each day, the field crew submits exposed rolls of film, completed field data forms and photographic information sheets to the data manager. Film is immediately taken to a developer and processed in the following manner: a double set (2 copies of each photo) of colour prints are printed with matte finish; one set of black and white prints are printed with pearl finish; colour slides are processed according to normal standards (1 copy).

Processed film is reviewed by the data manager and project supervisor. All photographs and associated data forms which do not meet required standards are identified and given to the field crew for correction. Remaining data forms are photocopied and stored in a separate geographic location from the originals to protect against unexpected losses. Criteria for photo rejection include:

- unreadable or missing data board;
- incorrect information written on the data board;
- unreadable or lopsided meter board;
- unfocused composition; over or under exposed photographs;
- unwanted objects in the field of view; and
- failure to properly capture the monitoring objective of the site.

All photographs (both colour and black and white) and slides which conform to accepted standards are inserted into archive-quality PVC-free storage sheaths. Both the slides and slide sheaths are labeled with the appropriate photocode for easy identification using a permanent ink fine-tipped black felt pen. All storage sheaths and associated field data forms are then inserted into an oversized ring binder (11.5” by 14.5” by 2.5”) and filed according to location, site number and date.

All colour and black and white negatives are inserted into archive-quality PVC-free storage sheaths. All storage sheaths are then inserted into a separate storage binder and filed according to film roll and date of exposure. Since a variety of different locations and sites may be contained on a single roll of film, a negative information sheet is produced by the data manager to link each negative with its photograph. The negative information sheet contains the roll number and the photocode associated with each negative. Error negatives are also noted, but not discarded.

Photographic and negative archives should be stored in unique locations to minimize the chance of accidental loss or destruction. Each storage facility should provide conditions that minimize exposure to dust, light, heat and humidity. Access should be strictly controlled to prevent mishandling and theft of photographs and negatives.

Field Guide (Hard Copy)

Using the set of colour print doubles, a field guide is created using a photographic ring binder (6.5’’ by 6.5’’ by 2’’). The objective of this guide is to create a small and expendable version of the larger archive for field use. Also included is a small computer generated data sheet and site map which provides all the necessary information required to re-shoot a photopoint, landscape and site setup photograph. All of the photographs, data sheets and site maps are inserted into individual photo sleeves for protection from field conditions. Although the field guide is theoretically not necessary for photo replication (provided camera location, height and focal point are known), it is prudent to have this piece of field equipment which facilitates site relocation and ensures photographic field of view is precisely replicated.

Digital Archive (Soft Copy)

All field data and site maps are entered into a hypertext markup language (HTML) database by the data manager. The computer database is used to track project progress, produce statistics and summary tables for archival purposes, and also functions as a backup to the original field data forms. A database written in HTML is preferred because it can be accessed and updated with a simple web browser (e.g. Internet Explorer or Netscape), rather than expensive database software. Furthermore, given the prominence of the World Wide Web, and the backwards compatible nature of HTML, it is predicted that HTML-based databases will have an extended period of longevity compared to other database formats. The final advantage of an HTML database is that it requires minimal computer skills for successful operation.

Photographs and site sketches are scanned into a digital format at a resolution of 400 dots per inch (dpi). This high level of resolution is required to obtain a high level of detail in the digital photo, and to allow photographic reproductions to be printed. The 400 dpi image is saved in JPEG format with 50% compression and is named according to its unique photocode. A 400 dpi image standard allows a large number of files to be stored in a minimal space, while maintaining a high standard of detail in each of the digital photographs. If lower levels of dpi are used (e.g. 100 dpi), the digital archive cannot serve as a backup to the photo archive and data degradation in digitizing is sufficient to make the data board illegible. If higher levels of dpi are used (e.g. 1200 dpi), the picture files become too large to store efficiently. At this level of DPI and JPEG file compression, files are usually less than 1megabyte (MB) in size.

Digitized photographs and site maps are entered into the software archive and associated with the appropriate field data record. The HTML database then displays the photograph, site map and associated field data within the window of the active web browser. A web page is automatically written by the HTML code and saved to the computer's hard drive. Depending on the needs of the agency, the HTML database could be published to the internet (read-only) for public review.

Digital archive storage can either be achieved on a hard drive, Zip drive™ or CD-ROM. At the present time, the CD-ROM storage medium cannot be used if the database is to receive regular updates and maintenance.

Photopoint Replication Procedures

Prior to conducting a Photopoint Monitoring project, the frequency of return intervals should be determined. Establishing a frequency of repeat measurements provides targets for the agency and helps to ensure additional measurements will be taken. The following guidelines outline the procedure for conducting photopoint replication:

1. Using the set of photographs and site map contained in the field guide, locate the general area where the photopoint transect was established.
2. Consult the site setup photograph and the site map to determine the location of the landscape camera location marker pin. Walk to the landscape location and use a metal detector to locate the exact position of the pin.
3. Consult the landscape photograph and the site map to determine the location of the photopoint transect. Walk to the transect location and use a metal detector to locate the exact position of the photopoint transect marker pins.
4. Identify the location of camera point A and camera point B and place the camera tripod and meter board in appropriate positions. Consult the field guide to determine camera height and focal point. Adjust camera to required specifications and ensure meter board is level.
5. Install the 5 meter marker on the photopoint transect.
6. Replicate photopoint and landscape photopoints based on the procedure contained in Section 3.2.3. There is no need to replicate the site setup photograph as it is a non-standardized product that is not intended for qualitative or quantitative assessments.
7. Confirm all necessary site data has been recorded and proceed to next camera locations or sample site.
8. Archive the new photographic data set as per the procedures outlined in section 3.2.4.
9. Assess if the replicate photograph precisely overlaps with the baseline photograph by comparing points of reference. The replicate photograph is considered to be excellent if 90-100% of the field of view match, satisfactory if 80-89% of the field of view match and unsatisfactory is less than 80% of the field of view match. Although it is theoretically possible to obtain complete overlap between the baseline and the replicate, errors are introduced during the printing process. Consequently, while the negatives may alight perfectly, the prints may be offset by 5mm or less causing slight deviations in overlap (Figure 3, Figure 4 and Figure 5).

Figure 3. Excellent replication of a photopoint (90-100% overlap in field of view).

Figure 4. Satisfactory replication of a photopoint (80-90% overlap in field of view).

Figure 5. Unacceptable replication of a photopoint (<80% overlap in field of view).

Chapter 3: Applications of Photopoint Monitoring

"Clearly, Photopoint Monitoring is not a simple, cut and dried procedure, but rather a multi-faceted system covering a multitude of purposes or objectives" (Hall, 1997).

Introduction

The following sections in this chapter outline the applications of Photopoint Monitoring that were field tested during this study for CRD Parks and CRD Water. R***ecreation and visitor impacts***, ***fuel loading***, ***riparian vegetation and channel morphology***, and ***disturbance recovery*** were monitored with photopoints. The last section of this chapter outlines the methods that were developed to obtain ***repeatable multi-frame panoramic photos of landscapes and waterscapes***.

Recreation Impact Monitoring

Introduction

Recreational activities have been identified as a significant threat to the ecological integrity of park lands and protected areas (Sun and Walsh, 1998). Recreation can alter soil structure, fertility, moisture and rates of erosion (Kuss and Morgan, 1980; Kuss, 1986; Sun and Liddle, 1993; Marion and Cole, 1996); rates of vegetation growth and regeneration (Sun and Liddle, 1993); natural and exotic species composition and dispersal (Vankat and Major, 1978; Cole and Marion, 1988; Sun and Walsh, 1998); wildlife populations and foraging patterns (Helle and Sarkela, 1993); rates of large organic debris accumulation leading to changes in fire frequency (Sun and Walsh, 1998) and rates of tree mortality due to root exposure. Although there is significant variability in the response of vegetation and soil to recreation, all park and protected area management plans and decision making frameworks should include mechanisms for monitoring and assessing the impacts of recreational activities (Cole, 1995).

Currently, a variety of decision making frameworks are used to manage parks and protected areas including Recreation Opportunity Spectrum (ROS), Limits of Acceptable Change (LAC), Visitor Impact Management (VIM), Visitor Experience and Resource Protection (VERP) and the Visitor Activity Management Process (VAMP) (Nilsen and Tayler, 1997). Although different in form, the end purpose of each process is to identify a set of clear and measurable management objectives which can be periodically assessed to ensure agency compliance (Nilsen and Tayler, 1997). Each process relies on information provided by a long term systematic recreation monitoring program that is either qualitative or quantitative in nature. Depending on the needs of the resource agency and associated management objectives, Photopoint Monitoring could be used as the exclusive procedure to detect and evaluate recreation impacts. Alternatively, it could be used in conjunction with other quantitative approaches or as an early warning system to concentrate quantitative data collection in specific locations.

In its current state of development, Photopoint Monitoring can be used to detect changes in vegetation structure and regeneration, soil erosion and root exposure, trail and campsite expansion, tree damage and removal of large organic debris. It is important to note that photographic resolution and camera orientation limit the scale at which the standard Photopoint Monitoring procedure can be applied. For example, it cannot be used to detect micro-scale changes in soil structure or for taxonomic identification purposes. To achieve finer scales of monitoring resolution, additional quantitative techniques such as transect profile surveys and point intercept vegetation samples can be conducted along photopoint transects.

Given the potential benefits and limitations of Photopoint Monitoring, the purpose of this study was to field test the use of Photopoint Monitoring for assessing recreation impacts over time. Although a complete assessment of Photopoint Monitoring cannot be adequately conducted in a three month study, a series of permanently marked baseline photopoint transects have been established and will enable the utility of this procedure to be assessed over time.

In order to thoroughly test the quantitative capabilities of the Photopoint Monitoring procedure, transect profile surveys and point intercept vegetation sampling was conducted along the length of every photopoint transect. Over time, it is essential to replicate both photopoints and additional data collection techniques in order to compare photographic results with actual quantitative data. The following sections outline methods for using Photopoint Monitoring to assess recreation impacts and also include a summary of our experimental results.

Recreation Impact Monitoring With Photopoints

The Photopoint Monitoring procedure outlined in Chapter 2 can be used to monitor recreation impacts on various ecological parameters including vegetation structure and regeneration, soil erosion and root exposure, trail and campsite expansion, tree damage and removal of large organic debris. Although no additional modifications are required to use photopoints for recreation impact monitoring, the following suggestions should be taken into consideration when selecting a photopoint transect:

- Select potential monitoring sites based on input from park planners, wardens, and user groups.
- Define the specific monitoring objective of each phototransect and specify the return frequency. Replication should be conducted in different seasons to assess seasonal recreation impacts.
- Select a variety of sites with different levels of user impacts. Attempt to locate control phototransects in close proximity to high use phototransects.
- Orient phototransects to be perpendicular or oblique to hiking trails so that trail width can be monitored over time.
- Depending on the needs of the client agency, additional quantitative transect sampling procedures may be required between photopoints. The following section outlines standard methods for conducting transect profile surveys and point intercept vegetation sampling.

Quantitative Transect Sampling Procedures (Optional)

Although photopoint photographs can be used to monitor relative changes in target recreational resources over time, they cannot be used for taxonomic identification or for measuring precise transect profiles. To overcome these limitations, a transect profile survey and point-intercept vegetation sampling can be conducted between the transect permanent marker pins (camera point A, 0 meter mark and camera point B, 10 meter mark). These additional data can then be spatially related to the contents of a photopoint photograph for taxonomic or topographical identification and quantification purposes.

The following sub-sections outline the standard procedures used for transect profile surveys and point-intercept vegetation samples.

Transect Profile Survey

A transect profile survey provides data on the topographical features of the photopoint transect. The purpose of a transect profile survey is to monitor the micro-scale impacts of recreational activities on soils. If a photopoint transect is established perpendicular or oblique to a high use recreational trail, repeated monitoring should detect soil compaction or erosion over time.

The following guidelines outline the procedure for conducting a transect profile survey (Evett, 1991):

1. Position a camera tripod at each end of the photopoint transect and string a leveled chalk line between the tripods. The chalk line should be precisely marked in 50 cm intervals and should be approximately 1 meter above the ground. Place the 0 meter mark on camera point A and the 10 meter mark on camera point B.

2. Position a theodolite at the 0 meter mark of a photopoint transect and level. Measure the height of the theodolite above the 0 meter mark and shoot down the length of the transect.

3. Place a stadia rod (or meter stick) at 50 cm intervals along the length of the transect and record the associated altitude using the theodolite.

4. Subtract each measurement from the height of the theodolite and plot the transect profile.

5. To calculate the precision of this procedure, a series of replicate measurements were obtained at 4 sample sites. Using paired t-tests, no significant measurement error was detected at an alpha level of .01 ($P<.0001$).

Point-Intercept Vegetation Sampling

Point intercept vegetation samples provide data on the taxonomy, composition and diversity of plant species that are contained within the photopoint transect. The purpose of conducting point intercept vegetation samples is to compare baseline samples to subsequent samples that are taken in identical locations from year to year. Using basic statistical analysis methods, change in density, diversity or composition can be calculated and monitored over time. The standard techniques for estimating species density and composition fall into three broad categories, based on different geometric units: lines, points and quadrats. Line intercept methods assume that the proportion of area covered by a species can be estimated by dividing the length of a line intercepted by a species by the total length of the line (Floyd and Anderson, 1987). Point intercept methods assume that the probability of a point landing in a species is directly proportional to the area covered by the species (Floyd and Anderson, 1982). Finally, quadrat techniques involve rough estimation of cover by percentage classes (Floyd and Anderson, 1987). A difficulty arises in attempting to select the most accurate and precise sampling method as the absolute density, composition and diversity of plants in the study area is unknown. However, numerous authors have attempted to compare the results obtained by each of the three methods. Significant similarities have been found between line and point intercept methods (similar results by different individuals), whereas quadrat methods have yielded poor results due to the subjectivity involved in estimating cover class percentage (Floyd and Anderson, 1987). Moreover, given the linear nature of a photopoint transect, either line intercept or point intercept methods would be more suitable for conducting vegetation sampling than quadrats.

Given the methods used to conduct transect profile surveys, the point intercept method was preferred to the line intercept method, because both vegetation sampling and profile surveying could be conducted simultaneously. Furthermore, the “all-contacts” point intercept method (all vegetation intercepts are recorded) was selected over the “basal contact” point intercept method (only the ground vegetation intercept is recorded) because it is more effective in indicating the presence of different species (Whitman and Siggeirsson, 1954).

The following guidelines outline the procedure for conducting point intercept sampling along a photopoint transect:

1. Position a camera tripod at each end of the photopoint transect and string a leveled chalk line between the tripods. The chalk line should be precisely marked in 50 cm intervals and should be approximately 1 meter above the ground. Place the 0 meter mark on camera point A and the 10 meter mark on camera point B.

2. At each 50 cm interval along the length of the transect, slowly lower a needle-tipped plumb bob and record all vegetation that is intercepted. Identify the species and record impact status. Note interception with soil, woody debris and rock, including type and diameter.

3. To facilitate temporal comparisons, future point intercept samples are taken at the identical location along the phototransect. Baseline and subsequent samples are entered into a spreadsheet with date as column heading and measurement interval as row heading. Since the samples are not independent, non-parametric analysis must be conducted to determine if significant differences exist. A variety of statistical tests can be conducted depending on the needs of the client agency. McNemar’s statistic can be used to compare ground cover loss over time (Cooper 1987).

4. To calculate the precision of this procedure, a series of replicate measurements were obtained at 4 sample sites. No differences in taxonomic identifications were recorded.

Recreation Impact Monitoring Results

A total of eleven baseline phototransects were established by this study for recreation impact monitoring. Seven phototransects were installed on Mt. Braden, two were installed at Jack Reservoir and 2 were installed at Mavis Reservoir. A total of seven phototransects were replicated for quality control purposes. 70% of the replicated transects were given an overlap score of excellent, 15% were given a score of satisfactory and 15% were given a score of unsatisfactory (See Table 1 and 2, Section 4.7). A random selection of 2 successfully replicated photopoints and 1 successfully replicated landscape photograph have been included in Figure 6, Figure 7 and Figure 8 for general reference and comparison purposes.

Figure 6. Baseline (990628-ROC-C1) and replicated (990813-ROC-C1) recreation impact photopoints on Mt. Braden.

Figure 7. Baseline (990713-MID-B1) and replicated (990817-MID-B1) recreation impact photopoints on Mt. Braden.

Figure 8. Baseline (990628-ROC-L2CD) and replicated (990813-ROC-L2CD) recreation impact landscape photographs on Mt. Braden.

Fuel Load Monitoring

Introduction

Fuel loading refers to the accumulation of wood residue in managed forests which are subjected to fire suppression (Primack, 1993). Although some wood residues are ecologically beneficial for such purposes as moisture retention, soil protection, wildlife cover and nutrient cycling, excessive residues create a significant fire hazard (Maxwell and Ward, 1976). Consequently, methods are required to monitor fuel loads in managed forests and to identify loading levels that are associated with a significant fire risk. Photographs have been extensively used to provide fast, easy and inexpensive quantification of fuel loads that are sufficient for most management needs (Maxwell and Ward, 1976). Species specific fuel load photographs are contained in a photo series which depicts various fuel loading levels and their associated fuel ratings. Quantified data is also provided for site characteristics that are depicted within the photograph including residue size classes, average residue depth and ground area covered. The photo series eliminates the need to re-measure fuel loads at random sample sites as users can obtain average measurements by simply selecting the photograph that most closely approximates the conditions of the sample site. If the fuel loading characteristics of a site are not depicted in any of the photo series, users can interpolate between photos to obtain reasonably accurate estimates (Maxwell and Ward, 1976).

The photo series approach to fuel load assessments is a modified condition class system in which a subjective class type is assigned to a sample site based on a number of site characteristics. The current procedure for generating a fuel load photo series does not include methods for photographic replication or for photogrammetric quantification from photographic products. These limitations could be overcome by using the standardized Photopoint Monitoring system to generate a fuel load photo series. Therefore, the purpose of this study was to field test the use of Photopoint Monitoring for generating fuel load photo series and for monitoring fuel loads over time. Although a complete assessment of Photopoint Monitoring cannot be adequately conducted in a three month study, a series of permanently marked baseline photopoint transects has been established and will enable the utility of this procedure to be assessed over time.

Fuel Load Monitoring With Photopoints

The standard Photopoint Monitoring procedure outlined in Chapter 2 can be used to generate a standard fuel load photo series. Based on the results of this study, we suggest the following guidelines for using photopoints to generate fuel load photo series and to monitor fuel loads over time:

1. Identify forest type and size class which contain high, low and intermediate levels of fuel loads.

2. Photograph on overcast days to avoid sharp contrasts caused by bright sunlight.

3. Low lighting conditions can be successfully photographed using a combination of 100 ISO film, a camera tripod, shutter release and manual shutter control. The following technique is used to obtained photographs in low light: If the light meter registers insufficient light at a shutter speed of 1 second on a F-stop aperture of 16, then adjust the f-stop until sufficient light is obtained. Count the number of f-stop settings to the new position and then return the F-stop to the F-16 position. The number of settings between the F-16 position and the setting which provided sufficient light determines the required shutter speed. The geometric relationship between f-stop setting and exposure time is as follows: 1 setting requires 2 second exposure time, 2 settings requires 4 second exposure time, 3 settings requires 8 second exposure time, 4 settings requires 16 second exposure time etc. Once shutter speed is determined, set the camera to manual and use a stop watch to count exposure time.

4. Follow standard procedures contained in Maxwell and Ward (1976) for measuring site-specific fuel load characteristics.

5. Use the procedures contained in Chapter 4 to conduct photogrammetric measurements of items contained within photographs.

Fuel Load Monitoring Results

A total of five baseline phototransects were established by this study for fuel load monitoring. Two phototransects were installed at the Sooke Lake Fire Vantage Point on recently logged sites and three phototransects were installed at Mile 3 Kapour, Rithet Creek Weir and Jack Main junction in mature forests with different fuel load characteristics. All five phototransects were replicated for quality control purposes. 80% of the replicated transects were given an overlap score of excellent and 20% were given a score of satisfactory (See Table 1 and 2). A random selection of 3 successfully replicated photopoints have been included in Figure 9, Figure 10 and Figure 11 for general references and comparison purposes.

Figure 9. Baseline (990714-ROA-B1) and replicated (990819-ROA-B1) fuel load photopoints near Sooke Lake Fire Vantage Point.

Figure 10. Baseline (990729-TER-B1) and replicated (990811-TER-B1) fuel load photopoints taken near Sooke Lake Fire Vantage Point.

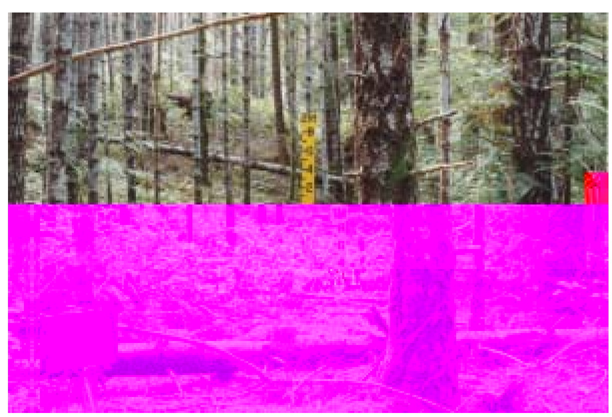

Figure 11. Baseline (990723-CRE-A1) and replicated (990803-CRE-A1) fuel load photopoints taken near Kapoor Mile 3 (disregard white pages on lefthand photo).

Riparian Vegetation and Stream Channel Monitoring

Introduction

The management goal of the Capital Regional District Water Department is to maintain an optimal standard of drinking water quality for its ten municipal clients. To achieve this goal, a variety of management interventions are employed which require long term biological monitoring. Although a detailed monitoring program has been implemented to monitor the chemical and biological properties of raw water, a management need exists to monitor projects involving stream restoration and rehabilitation. Specifically, numerous streams in the Goldstream and Sooke watersheds have been channelized to control flows and prevent flooding. Subsequent to the channelization process, concerns arose regarding the potential effects of riparian vegetation removal on water quality. A number of possible effects were identified including increased stream temperatures, increased sedimentation rates, decreased nitrogen, phosphorus and carbon inputs in the form of leaf litter and insects, and decreased supply and recruitment of large woody debris. The decreased supply of large woody debris was identified as one of the most important functions of riparian vegetation, as large woody debris stabilizes channel banks; encourages sinuosity; reduces water velocity; increases the availability of dissolved oxygen; increases the retention of organic matter; significantly influences the composition of aquatic communities; and contributes to the filtration of sediment (Dose and Roper, 1994; Richards and Host, 1994; Evans ., 1993; Bilby and Ward, 1989; Hicks ., 1991; Crispin ., 1993; Castelle . 1994).

Given the importance of riparian vegetation, the channelized stream banks and flood plains were replanted and are being rehabilitated in an effort to re-establish riparian canopy closure. Photopoint Monitoring has been identified as a technique that could successfully monitor the restoration and recovery process. In addition, Photopoint Monitoring could be used to monitor stream channel morphology and the erosion or deposition of bed load. Consequently, the purpose of this study was to field test the use of Photopoint Monitoring for monitoring riparian restoration and recovery as well as channel morphology. Although a complete assessment of Photopoint Monitoring cannot be adequately conducted in a three month study, a series of permanently marked baseline photopoint transects has been established and will enable the utility of this procedure to be assessed over time.

In order to thoroughly test the quantitative capabilities of the Photopoint Monitoring procedure, stream cross sections and bed load samples were conducted between parallel camera points located on both banks. Over time, it is essential to replicate both photopoints and additional data collection techniques in order to compare photographic results with actual quantitative data. The following sections outline methods for the use of photopoint techniques to monitor riparian restoration, channel morphology and bed load movement.

Riparian Vegetation and Stream Channel Monitoring with Photopoints

The Photopoint Monitoring procedure outlined in Chapter 2 can be used to monitor the restoration and recovery of riparian vegetation as well as stream channel morphology and bed load movement. However, application of the procedure presents unique challenges in the riparian environment. In order to successfully implement a program of Photopoint Monitoring of riparian vegetation and stream morphology, minor modifications were made to the standard procedures. The technique developed requires up to fourteen baseline photopoint photographs to completely document a single site. The photopoints are broken down into four categories: parallel shots, perpendicular shots, oblique shots, and in-stream shots. Each shot is designed to capture different aspects and characteristics of the riparian zone and stream channel, and the sum of these parts can be used to monitor a site. A detailed explanation of the procedure follows.

Camera Setup and Site Selection

1. Select a suitable sample site in which two parallel phototransects can be installed on opposite banks of the stream.

2. Face upstream and select a camera location on the right-hand bank. Label as camera point A. Ensure the camera point will not be lost to bank erosion and will not be obscured by riparian vegetation (Figure 12).

3. Locate camera point B 10m upstream of camera point A. This location creates a standardized phototransect between the two camera points (A:B).

4. Move to the opposite bank (left) and location camera point C so that it is perpendicular to camera point A.

5. Locate camera point D 10m upstream from camera point C, along a line parallel to the A:B phototransect. If correctly implemented, camera points B and D should lie perpendicular to each other, along a parallel line to A:C.

6. Install case-hardened side walk stakes at each of the camera locations.

7. If conditions permit, the four permanently marked camera locations can be used to establish two additional in-stream camera locations. Camera point E can be established at a location within the stream channel that is equidistant from camera points A and C and along the A:C transect. Similarly, camera point F can be established within the stream channel at a location that is equidistant from camera points B and D, and along the B:D transect. If correctly implemented, camera point E should be 10m away from camera point F, and parallel to the A:B and C:D phototransects (Figure 12). Given the nature of the stream bed, camera points E and F cannot be permanently marked. However, they can be precisely relocated provided that camera points A:B:C:D can be found.

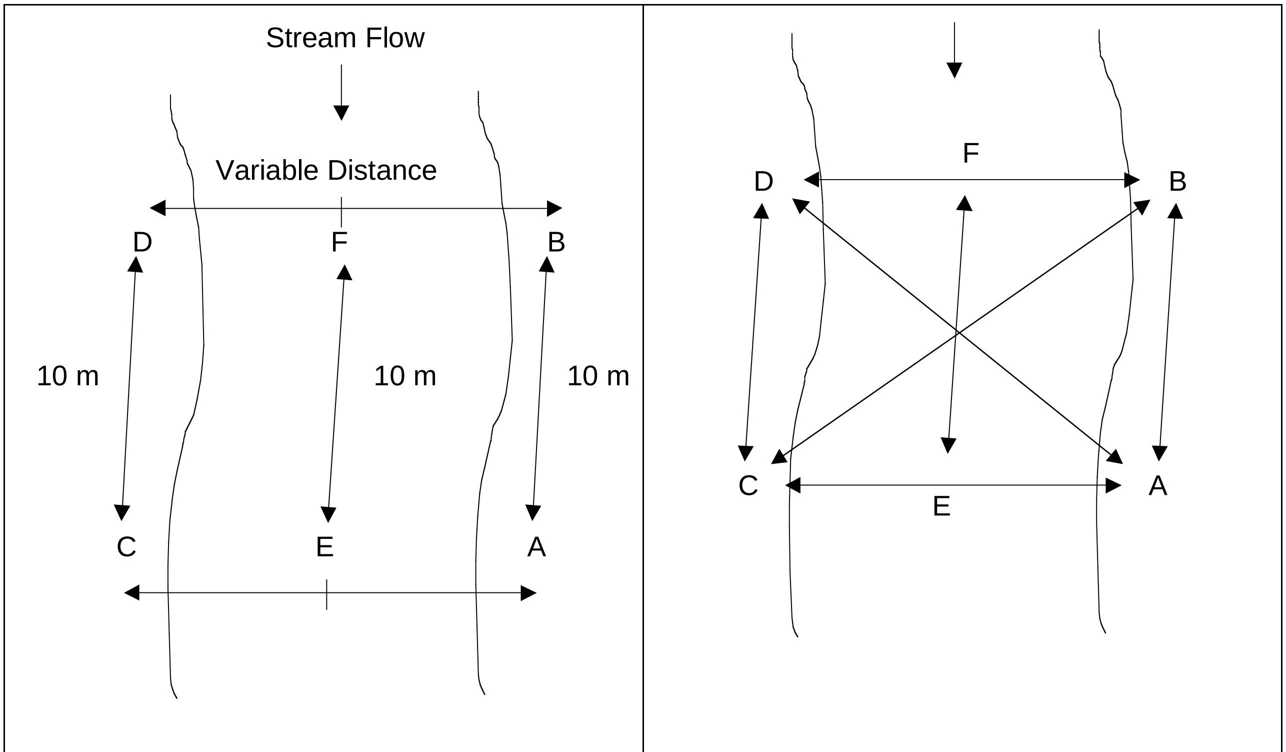

Figure 12. The frame on the left depicts the location of 6 alphabetically labelled camera points. The frame on the right depicts the direction of photopoints that are taken at each camera point (parallel, perpendicular, oblique and in-stream).

Subsequent to the establishment of the camera grid, the following shots are taken:

Parallel Shots (A:B, B:A, C:D, D:C)

Parallel shots are taken parallel to the stream flow designed to capture the restoration and recovery of riparian vegetation as well as the channel profile. Parallel shots are most useful in the early stages of the recovery process, before the camera's line of site is obscured by vegetation. Overtime, it is expected that parallel shots will loose functionality as vegetation re-growth obscures the line of site between the A:B and C:D camera locations. Parallel shots are always labelled by camera point and the numeral 1 (Figure 12, Figure 13 and Figure 14).

Perpendicular Shots (A:C, C:A, B:D, D:B)

Perpendicular shots are taken perpendicular to the stream flow and are designed to capture water height, bank erosion and deposition and riparian vegetation on the opposite bank. The distance between camera locations is non-standardized as it is dependent on channel width. Over time, perpendicular shots should retain their functionality as riparian vegetation should not obscured the line of site between camera points A:C and B:D. Perpendicular shots are always labelled by camera point and the numeral 2 (Figure 12, Figure 15 and Figure 16).

Oblique Shots (A:D, D:A, B:C, C:B)

Oblique shots are taken oblique to the stream flow and are designed to capture the relationship between channel bottom, channel bank and riparian vegetation. The distance between camera locations is non-standardized as it is also dependent on channel width. Oblique shots compliment the parallel and oblique shots by capturing a different perspective than is captured in parallel or perpendicular shots. Furthermore, as with the perpendicular shots, oblique shots face minimal obscuring from future riparian vegetation growth, as the creek represents the majority of the foreground. Oblique shots are always labelled by camera point and the numeral 3 (Figure 12 and Figure 17).

In-Stream Shots (E:F, F:E)

One of the problems encountered with Photopoint Monitoring in streams was the occasional inability to capture the stream bed in any of the aforementioned shots. In the event of severe down-cutting of the stream channel, the stream bed could be absent from the camera field of view, even in the oblique shots. Consequently, a new shot was introduced - the in-stream shot - to help monitor the stream bed from within the channel (Figure 12). While this may not always be possible to accomplish, these shots ensure that all aspects of the stream and riparian zone are captured on film. Should the stream's width be too large to capture in a single shot, two photographs may be necessary to capture the necessary bank to bank information. The first shot should have the meter board flush with the right edge of the shot, while the second shot should have the meter board flush with the left edge of the shot. In such a manner, the meter board will serve as the overlap point of the two shots, creating a miniature panorama shot within the stream channel). Since in-stream shots are special cases of parallel shots, they are always labelled by camera point and the numeral 1 (Figure 12 and Figure 18).

Quantitative Transect Sampling Procedures (Optional)

Depending on the needs of the client agency, additional quantitative transect sampling procedures may be required along photopoint transects. The following section outlines standard methods for conducting stream cross sections and bed load sampling.

Stream Cross Sections

Position a camera tripod over camera point A and a second tripod over camera point C (opposite camera points).

String a leveled chalk line between the two camera tripods. The chalk line should be precisely marked in 50 cm intervals and should be approximately 1 meter above the estimated bank full conditions. Place the 0 meter mark on camera point A.

At each 50 cm interval along the length of the transect, measure the distance to the channel bottom. If possible, also measure the distance from the chalk line to the surface of the water (Platts, 1987).

Repeat procedure between camera point B and camera point D.

To calculate the precision of this procedure, a series of replicate measurements were obtained at 4 sample sites. Using paired t-tests, no significant measurement error was detected at an alpha level of .01 (P<.0001).

Bed Load Sampling

The following guidelines outline the procedure for conducting bed load sampling between permanently marked camera locations on opposite banks:

1. Position a camera tripod over camera point A and a second tripod over camera point C (opposite camera points).

2. String a leveled chalk line between the two camera tripods. The chalk line should be precisely marked in 50 cm intervals and should be approximately 1 meter above the estimated bank-full conditions. Place the 0 meter mark on camera point A.

3. At each 50 cm interval along the length of the transect, slowly release a needle-tipped plum bob and record the dimensions of the x, y and z axis of the rock that is intercepted (replace rock when measurements are complete).

4. Repeat procedure between camera point B and camera point D.

5. To calculate the precision of this procedure, a series of replicate measurements were obtained at 4 sample sites. Using paired t-tests, no significant measurement error was detected at an alpha level of .05 (P<.0001).

Riparian Vegetation, Stream Channel and Bed Load Monitoring Results

A total of thirty six baseline phototransects were established by this study for riparian vegetation and stream channel load monitoring. Six phototransects were installed along Judge Creek, sixteen were installed along Rithet Creek and fourteen were installed along 17S creek. A total of twenty-four phototransects were replicated for quality control purposes. 88% of the replicated transects were given an overlap score of excellent, 8% were given a score of satisfactory and 4% were given a score of unsatisfactory (See Table 1 and 2, Section 4.7). A random selection of 3 successfully replicated photopoints have been included in Figure 13-Figure 18 for general reference and comparison purposes.

Figure 13.Baseline (990712-OVE-B1) and replicated (990805-OVE-B1) photopoint (parallel shot) taken on 17S creek.

Figure 14. Baseline (990712-OVE-C1) and replicated (990805-OVE-C1) photopoint (parallel shot) taken on 17S creek..

Figure 15. Baseline (990706-LOW-C2) and replicated (990804-LOW-C2) photopoint (perpendicular shot) taken on Rithet Creek.

Figure 16. Baseline (990712-OVE-B2) and replicated (990805-OVE-B2) photopoint (perpendicular shot) taken on 17S creek.

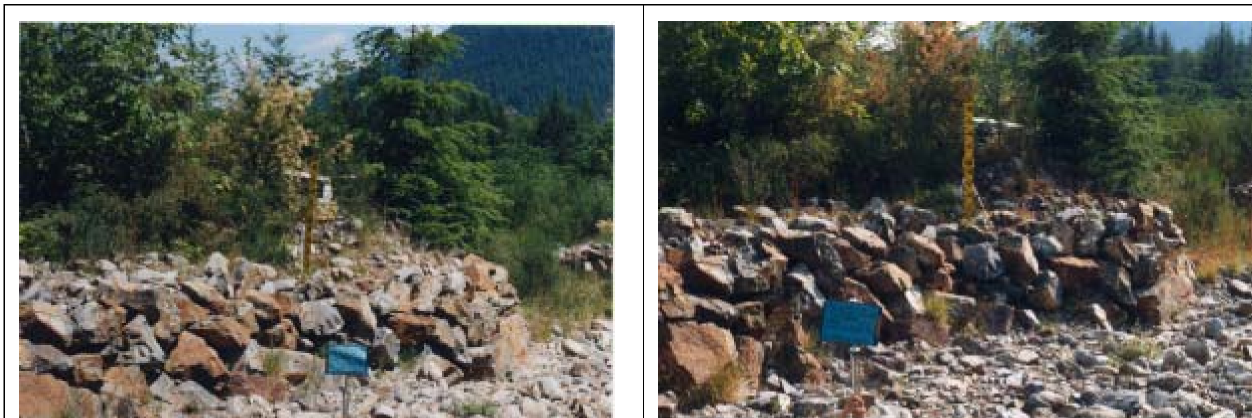

Figure 17. Baseline (990708-FAN-D3) and replicated (990805-FAN-D3) photopoint (oblique shot) taken on 17S Creek (replication unsatisfactory due to use of incorrect focal point).

Figure 18. Baseline (990805-FAN-F1) and replicated (990816-FAN-F1) photopoint (in-stream shot) taken on 17S creek.

Disturbance Recovery Monitoring

Introduction

Temperate rain forests are dynamic and complex ecosystems which are subject to stochastic physical disturbance events including fire, wind storms, drought, avalanches, landslides, and floods as well as biological disturbance events including tree falls, disease epidemics and animal burrowing, trampling and grazing. The severity, size, frequency, scale and seasonality of disturbance events affects both the range of successional stages and habitats as well as the composition of forest biological diversity (Primack, 1993). Forest harvesting strategies have recently been designed to mimic patterns of natural disturbance in an attempt to minimize the adverse impacts of tree removal. Disturbance ecology is an emerging discipline that seeks to predict and understand the effects of natural and anthropogenic disturbances as well as the process of ecosystem recovery. Photopoint Monitoring has been identified as a technique that could be used to monitor rates of recovery and structural succession in naturally and anthropogenically disturbed forest ecosystems.

In its current state of development, Photopoint Monitoring can be used to detect changes in a variety of macro-scale ecological parameters. It is important to note that photographic resolution and camera orientation limit the scale at which the standard Photopoint Monitoring procedure can be applied. For example, it cannot be used to detect micro-scale changes in soil structure or for taxonomic identification purposes. To achieve finer scales of monitoring resolution, additional quantitative techniques such as transect profile surveys and point intercept vegetation samples can be conducted along photopoint transects. Given the potential benefits and limitations of Photopoint Monitoring, the purpose of this study was to field test the use of photopoint techniques to monitor disturbance recovery over time. Although a complete assessment of Photopoint Monitoring cannot be adequately conducted in a three month study, a series of permanently marked baseline photopoint transects has been established and will enable the utility of this procedure to be assessed over time.

Disturbance Recovery Monitoring With Photopoints

The Photopoint Monitoring procedure outlined in Chapter 2 can be used to monitor disturbance spread and recovery rates of various ecological parameters including vegetation structure and regeneration, soil erosion and root exposure, tree damage and removal of large organic debris. No additional modifications are required to use photopoints for disturbance recovery monitoring. Many of the photopoints obtained for monitoring recreation impacts, fuel loads and riparian restoration can be used simultaneously for monitoring the disturbance recovery process.

Results

A total of eight baseline phototransects were established by this study for disturbance recovery monitoring. One phototransect was established at the Borrow Pit near the base of Mt. Braden, two were established at the Sooke Lake Fire Vantage Point, four were established on Mt. Wells Regional Park and a final phototransect was established near the Goldstream Gate gate. A total of three phototransects were replicated for quality control purposes. 83% of the replicated phototransects were given an overlap score of excellent and 17% were given a score of satisfactory (See Table 1 and 2, Section 4.7). A random selection of 2 successfully replicated photopoints and 2 baseline photopoints have been included in Figure 19- Figure 22 for general reference and comparison purposes.


Figure 19.Baseline (990714-ROA-B1) and replicated (990819-ROA-B1) disturbance recovery photopoints near Sooke Lake Fire Vantage Point.


Figure 20.Baseline (990720-BOR-A1) and replicated (990806-BOR-A1) disturbance recovery photopoints at the Borrow Pit near the base of Mt. Braden.

Figure 21. Baseline (990811-DIS-A1) photopoint of diseased trees taken near Goldstream Gate.

Figure 22. Baseline (990809-BUR-B1) photopoint of recent fire on Mt. Wells

Landscape and Waterscape Panoramic Monitoring

Introduction

The need for panoramic photography arose to help monitor macro level changes in the environment that could not be captured by standard photopoint and landscape photographs. For example, ecological phenomena such as disease outbreaks or fire are much larger than the field of view of a standard 50 mm lens and pose a significant challenge for photographic monitoring. Human built structures such as reservoirs are also difficult to monitor with the standard Photopoint procedure. Consequently, the following standardized multi-frame panoramic monitoring procedure was developed to monitor macro-level changes in landscapes and waterscapes over time from a single camera location. Although the following procedures utilizes most of the same equipment as the Photopoint Monitoring procedure, it is essential that the camera tripod is equipped with vertical and horizontal levels, a 360° rotating head and a compass marked in 15° or 30° increments.

Landscape and Waterscape Panoramic Monitoring with Photopoints

1. Select a suitable location for taking an unobscured panoramic photograph and determine panorama objectives. Panoramic camera locations are always designated with a P.

2. Use a compass to determine the total number of degrees that require photographing and divide by 30 to estimate the total number of photo frames in the panorama photo series (each frame in the panorama represents 30° using a 35 mm camera with a 50 mm lens).

3. Select a focal point for the panorama which will not change over the next century. Common focal points include human built structures (e.g. dam, building, or tower) and natural geographic features such as mountain peaks. If one of these features is not available in the landscape or waterscape of interest, then a meter board can be placed at a maximum distance of 40 meters from the camera point and used as a surrogate focal point. The location of the meter board must be permanently marked to enable relocation. Typically, the permanent structure or meter board will serve as the focal point for the first frame in the panoramic series (P1). Subsequent frames in the photo series are obtained by rotating the camera tripod 30° in a clockwise direction. The focal point of all subsequent frames are referenced to the starting focal point. For example, the second frame (P2), which is rotated 30 degrees clockwise from P1, will have a focal point of P1+30°. Similarly, the third frame (P3) will have a focal point of P1+60° and the fourth frame (P4) will have a focal point of P1 + 90°. In rare cases, the permanent structure or meter board cannot be used as the first frame in the photo series and must be used at some intermediate point in the panoramic rotation. For example, if the permanent marker appeared in frame P3, then P2 would have a focal point of P3-30° and P1 would have a focal point of P3-60°. Similarly, P4 would have a focal point of P3+30° and P5 would have a focal point of P3 + 60°.

4. Level the camera and adjust height until focal point (permanent structure or meter board) can be centered in the field of view. It is imperative that the camera remains level in a complete 360° rotation in order to achieve precise panoramic replication.

5. Measure the bearing to the focal point.

6. Orient the tripod compass so that the 0° mark is directed towards the focal point. This will enable precise 30° rotations of the camera.

7. Fill out field data form and panorama information sheets (see Appendix C). The required number of panorama information sheets is equal to the number of photo frames that were determined in Step 2.

8. Attach appropriate panoramic information sheet to data board and install data board at a maximum distance of 6 meters from the camera. It is important to note that the signboard should be placed in the bottom right hand corner of the photograph. This is to ensure that when the photos are joined together, the signboard data is not accidentally lost due to the minimal overlap created during the re-construction of the panoramic shot. Depending on the configuration of the site, it may be necessary to attach the panoramic information sheets to a plastic extension arm (e.g. paint roller extension), rather than the data board. The data board or extension is used to imbed site information into each panoramic photograph including: date, time, location, site name, site number, photo frame number, camera height, focal point, bearing of focal point and photocode (See Appendix C).

9. Focus camera on focal point (permanent marker or meter board) and alert crew that camera is ready.

10. Shoot the first frame of the panoramic photo series and then rotate the camera 30° in the appropriate direction based on information determined in Step 3. Install a new panoramic information sheet in each successive frame and complete the panoramic photo series with a single film type. After the complete panoramic arc is shot, a new camera can be mounted on the tripod and the processes can be repeated.

11. Install a permanent marker pin at the panorama camera location. Use case-hardened sidewalk stakes if locations are on soil (requires sledge hammer) and use brass survey pins if locations are on bedrock (requires Hilty rock drill ™, generator and rock grout). Permanently marking the panorama camera location ensures precise panoramic replication provided camera height and focal point are also recorded.

Results

A total of thirteen baseline panoramas were established by this study for monitoring change in landscape and waterscapes. Three panorama sites were installed at Humpback Reservoir, two sites were installed at Jack Reservoir, one site was installed at Mavis Reservoir, one was installed at the Sooke Lake Fire Vantage Point, two were installed at Sooke Lake Reservoir, one was installed near the Goldstream Gate entrance, one was installed on 17S creek and one was installed on Mt. Wells. A total of seven panoramas were replicated for quality control purposes. 14% received an overlap score of excellent, 14% received a score of satisfactory and 72% received a score of unsatisfactory (See Table 1 and 2, Section 4.7). All baseline and replicate panoramas are located in Appendices F and G which have been submitted to the CRD as separate volumes. The successfully replicated panorama and 4 additional baseline panoramas have been included in Figure 23- Figure 27 for general references and comparison purposes.

Although these results may appear to indicate significant problems associated with the panoramic procedure, three specific causes have been identified. The first was determined to be swapping cameras at each frame, rather than using a single camera to shoot the entire panoramic arc. Field tests demonstrated that swapping cameras after each frame increased the likelihood of altering the tripod level and alignment and significantly reducing the overlap quality of the resulting panorama. Consequently, it is essential that all frames in a panoramic photo series are taken from each camera, rather than swapping cameras at every interval of the panoramic shot. If this new procedure is used to produce panoramic baselines and replicates, it is anticipated that a greater level of replication precision should be achieved. The second cause for the high level of unsatisfactory replications relates to inconsistent and improper placement of the data board. For example, in some replicates, the data board was obscuring significant items of interest or was placed in a location that was inappropriate when frames were assembled. Consequently, it is essential to place the data board at a consistent distance from the camera and in a consistent location within the field of view so that target resources are not obscured. The final problem encountered during the replication of panoramas relates to significant inconsistencies in exposure quality, leading to multiple under or over exposed frames in the panoramas. Additional research revealed that there is no photographic method currently available to obtain perfectly consistent exposure levels within each of the frames of the panorama. The only solution is to purchase a panoramic lens (9mm) which will capture the entire landscape or waterscape in a single frame.

Figure 23. Baseline (990811-TOP-P, top photo) and replicate (990819-TOP-P, bottom photo) landscape panorama taken at the Sooke Lake Fire Vantage Point.

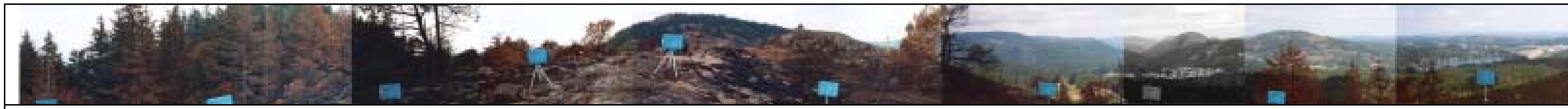

Figure 24. Baseline (990809-BUR-P) landscape panorama at the Mt. Wells burn site.

Figure 25. Baseline (99 08 16-PUM-P) waterscape panorama taken from Sooke Lake tower.

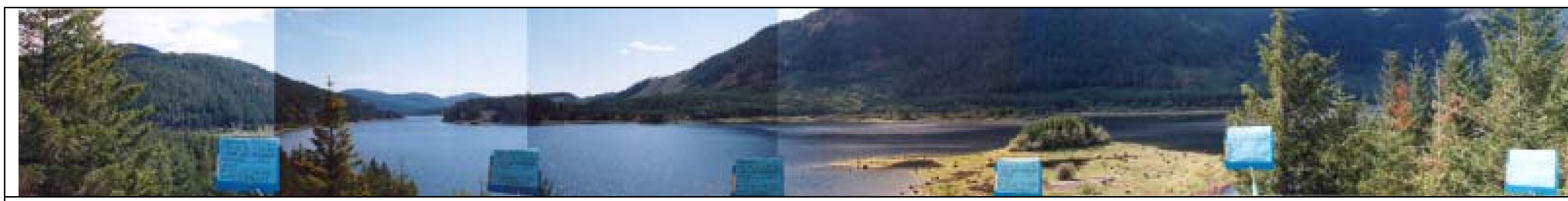

Figure 26. Baseline (99 08 19-BLU-P) waterscape panorama taken from rock bluff opposite to Sooke Lake tower.

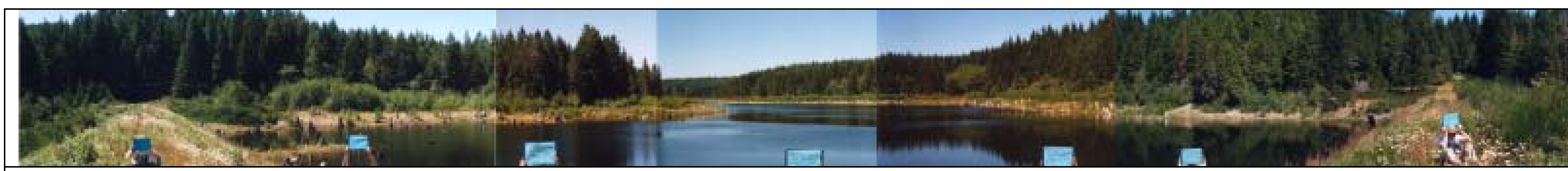

Figure 27. Baseline (990726-DAM-P) waterscape panorama taken from the Jack Reservoir dam.

Conclusions

This study installed a total of 58 baseline phototransects (116 photopoints) in order to assess the application of photopoint monitoring for recreation impacts, fuel loading, riparian restoration, and disturbance recovery (Table 1). A total of 25 phototransects (50 photopoints) were replicated for quality control (internal audit) purposes and ranked according to amount of overlap with baseline photographs. 82% of the replicates received a score of excellent (90-100% overlap), 13% received a score of satisfactory (80-89% overlap), and 5% received a score of unsatisfactory (<80% overlap). These results indicate that the standardized Photopoint Monitoring procedure can precisely replicate (80-100% overlap) baseline photographs approximately 95 times out of 100 (Table 2). Unfortunately, quality assurance (external audit) tests could not be conducted due to budgetary constraints.

A total of 13 panorama camera points were also installed to monitor macro-level changes in landscape and waterscapes (Table 1). A total of 7 panoramas were replicated for quality control purposes and ranked according to the amount of overlap with baseline panoramas. 14% received a score of excellent, 14% received a score of satisfactory and 72% received a score of unsatisfactory (Table 2). Although these results may appear to indicate significant problems associated with the panoramic procedure, the cause has since been determined and eliminated. Consequently, future attempts at panoramic replication should achieve a greater level of replication precision.

Table 1. Summary of baseline and replicated phototransects and panoramas. Monitoring purposes include: recreation impacts (RI), disturbance recovery (DR), fuel loading (FL), riparian zone (RZ) landscapes (LS) and waterscapes (WS).

Location	Site	Purpose	Baseline Photo-transects	Replicated Photo-transects	Baseline Panoramas	Replicated Panoramas
Mt. Braden	6	RI	7	7	0	0
Borrow Pit	1	DR	1	1	0	0
Jack Reservoir	2	RI/WS	2	0	2	2
Mavis Reservoir	2	RI/WS	2	0	1	0
Humpback Reservoir	3	WS	0	0	3	0
Judge Creek	2	RZ/LS	6	4	2	0
Rithet Creek	5	RZ	16	4	0	0
17S Creek	2	RZ/LS	14	4	1	0
Sooke Lake Reservoir	1	WS	0	0	1	2
Sooke Lake Bluff	1	WS	0	0	1	1
Mt. Wells	1	DR/LS	4	0	1	0
Fire Vantage Point	2	DR/FL/LS	2	2	1	2
Fuel loading	3	FL	3	3	0	0
Diseased Tree	1	DR	1	0	0	0
TOTALS	**32**		**58**	**25**	**13**	**7**

Table 2. Summary of replication score for each application of Photopoint Monitoring.

Application	**Excellent Replication Score**	**Satisfactory Replication Score**	**Unsatisfactory Replication Score**
Recreation Impact Monitoring	71% (10/14 photopoints)	14.5% (2/14 photopoints)	14.5% (2/14 photopoints)
Fuel Load Monitoring	80% (8/10 photopoints)	20% (2/10 photopoints)	0
Riparian Vegetation and Channel Morph.	88% (21/24 photopoints)	8% (2/24 photopoints)	4% (1/24 photopoints)
Disturbance Recovery	83% (5/6 photopoints)	17% (1/6 photopoints)	0
Landscape and Waterscape Panoramas	14% (1/7 panoramas)	14% (1/7 panoramas)	72% (5/7 panoramas)
Photopoint Totals	**82%**	**13%**	**5%**
Panorama Totals	**14%**	**14%**	**72%**

Chapter 4: Relative and Absolute Terrestrial Photogrammetric Quantification Techniques

"The greatest challenge presented by photopoint photographs is obtaining absolute measurements of a 3-dimensional space from a 2-dimensional image" (Jensen, 1998).

Introduction

One of the key strengths of the Photopoint Monitoring technique is the application of photogrammetric methods to obtain relative measurements of target resources from photographic products. This characteristic allows relative changes in target resources to be monitored over time, and facilitates detection of deteriorating and/or unacceptable resource conditions. In all cases, change over time will be reported in a percentage such as X grew by 25% from 1989 to 1990. Currently, absolute measurements of target resources can only be obtained if they are in close proximity to the meter board (<2 meters). However, based on preliminary field experiments, a great potential also exists for photogrammetric methods to be developed that will enable absolute measurements to be obtained of any items within the photographic field of view. If developed, this characteristic will reduce the need to obtain costly and time-consuming field measurements and will also minimize subjectivity in resource condition assessments.

Currently, the standard method for conducting photogrammetric analysis of photopoint photographs utilizes a procedure called Photo Grid Analysis (Hall, 1997). This technique requires that a standardized scale reference be present in the photograph (i.e. a meter board) at a standardized (or known) distance from the camera. A transparent grid is then adjusted to match the decimeter markings on the meter board and is laid over the photograph. Such a grid allows the client to obtain absolute measurements in close proximity to the meter board (i.e. <2m) and relative measurements at various distances beyond the meter board. As stated previously, procedures for obtaining absolute measurements of any object in the field of view are currently being developed. The following section outlines standard methods for conducting Photo Grid Analysis.

Materials and Methods for Photo-Grid Analysis

Grid Analysis Requirements

To accurately apply Photo Grid Analysis to time series photographs, three requirements must be meet. First, the field of view contained within each photograph must be precisely replicated. This requires that both the camera and meter board locations are permanently marked and located at a standardized distance from one another. This standardized distance should be such that the scale reference, or meter board, has a height in the photograph that represents at least 25% of the overall photograph height, with an optimum height of 35 % (Hall, 1997). Hall (1997) calculated that this minimum height requirement translates into a single meter board maximum distance of 10 horizontal meters (using a 50 mm lens on a 35mm camera) or a maximum distance of 20 meters with a double meter board (2 meters in length). The second requirement for the application of Photo Grid Analysis is the use of a consistent camera height and focal point based on the 1M, 2M or 0M markings on the meter board. This ensures that the angle of the camera remains constant and facilities precise re-orientation in subsequent replication attempts (Hall, 1997). A third and final requirement is that at least 80% of the meter board must be clearly visible in the photograph to allow for maximum precision. The use of double meter boards, as was used in this study, allows a one meter section of the scale reference to be clearly visible in most cases. Once these criterion are met and the photographs have been developed, grid analysis can be applied. Although photo-grid analysis can be applied in a variety of contexts (e.g. fuel loading, recreation impact monitoring, disturbance recovery monitoring) only one application of this technique, vegetation monitoring will be described based on Hall (1997).

Photo Grid Analysis Procedure

The following guidelines outline the procedure for conducting Photo Grid Analysis (Hall, 1997):

1. All photographs to be analyzed should be enlarged to at least 6.5" X 10" to provide easy identification and a reasonable working scale. A fast and relatively inexpensive substitute for actual photographic enlargement is to enlarge the photograph on a colour laser copier to a size of 8.5" X 11".
2. Create a master grid (as shown in Figure 28) which is relatively close to the grid size required for the enlarged photograph.
3. Measure the height of the meter board (or visible portion) in the enlarged photograph to the nearest half mm (Figure 29).
4. Measure the height of the meter board (or visible portion) on the master grid in grid units (e.g. Eight decimeters of the meter board is visible therefore measure the height of eight units on the master grid) to the nearest half mm (**Figure 30**).

5. Determine the adjustment factor required for the master grid (i.e. how much to enlarge or reduce the master grid) by dividing the meter board height in the enlarged photograph by the master grid meter board height (e.g. (XXmm/ YYmm) x 100 = ZZ% therefore reduce/enlarge by ZZ%).
6. Reduce or enlarge the master grid by the adjustment factor determined in Step 5 onto plain paper using a photocopier.
7. Compare the adjusted grid to the meter board in the enlarged photograph. If the grid lines do not match up with the decimeter markings on the meter board, change the adjustment factor as required. This process may require a few trials.
8. Once the grid has been adjusted to exactly match the decimeter markings on the meter board in the enlarged photograph, copy the adjusted grid onto a transparency.
9. Align the horizontal grid lines with the decimeter markings on the meter board in the enlarged photograph.
10. Align the vertical grid lines with the left edge of the meter board in the enlarged photograph.
11. Tape the top two corners of the transparent grid to the enlarged photograph to allow lifting of the transparency for close inspection of the photograph.
12. Copy the necessary information from the sign board in the photograph to the transparency in order to identify the transparency if it is separated from the photograph.
13. Create a photogrid analysis data sheet.
14. Mark, in the initial photograph of the series, each shrub in its center using a single letter code. Begin with the shrubs in the foreground of the photograph and work back in the photograph (Figure 31).
15. Outline each shrub, beginning in the foreground of the photograph, marking directly on the outline of the shrub (not outside of the shrub's outline) as accurately as possible (Figure 31).
16. Shrubs that overlap should be given different letters and outlined in a different colour (if different colours are not feasible, use solid and dashed lined to differentiate between the overlapping shrubs) (Figure 31).
17. Record for each shrub the sum of the grid intersects inside the outline that has been drawn.
18. Sum all of the intersects.
19. Continue the analysis on each of the subsequent photograph in the series. If a shrub is missing, then omit the one letter code, if a new shrub appears, add a new one letter code.
20. Tally the intersects for each of the subsequent photographs and compare the series using various statistical or modeling techniques.

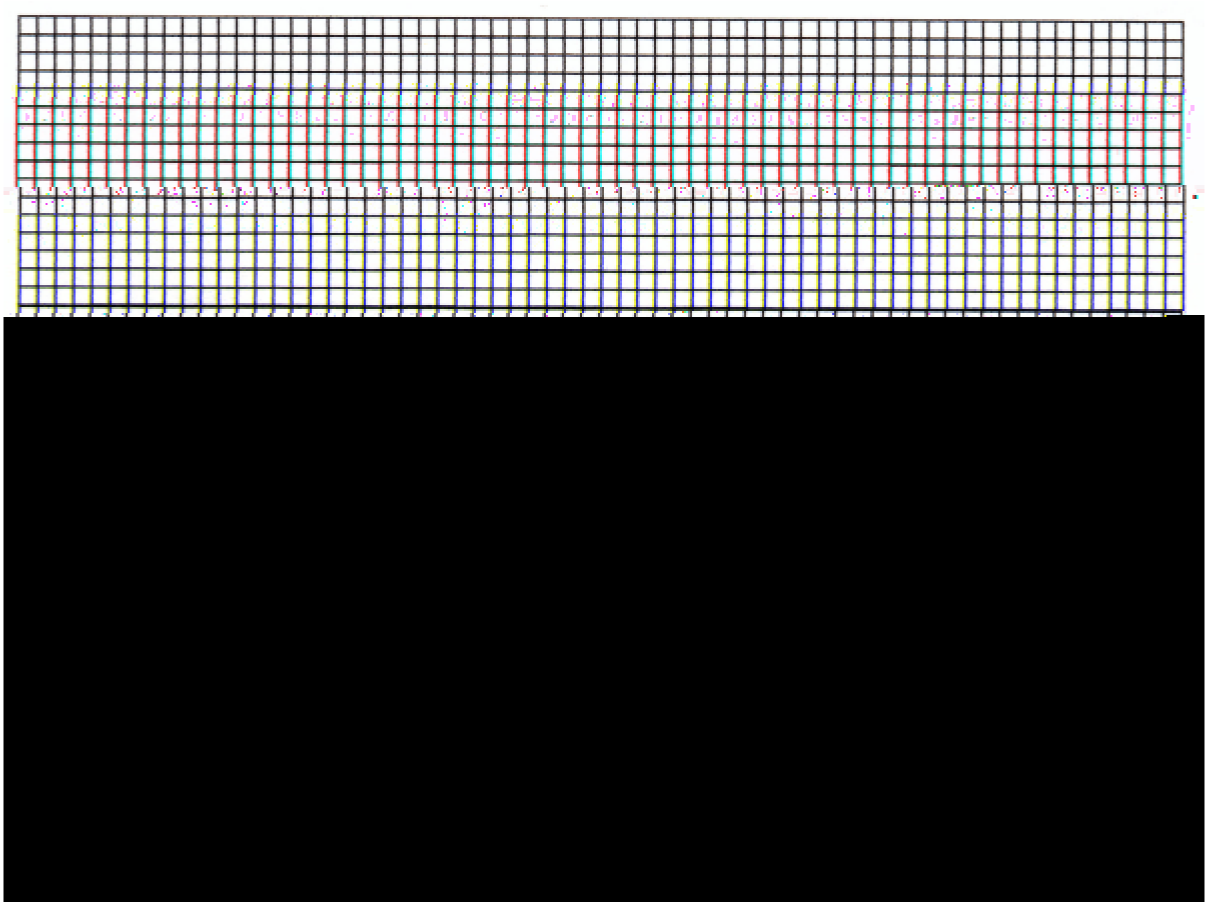

Figure 28. Master grid for Photo Grid Analysis of photopoint photographs.

Figure 29. Height of the meter board (mm) for determining the adjustment factor for the master grid. The first clear decimeter marking is the 2 dm. The height of the meter board from the 2 dm to the top is 43mm (Photo Code: 990805-FAN-F1).

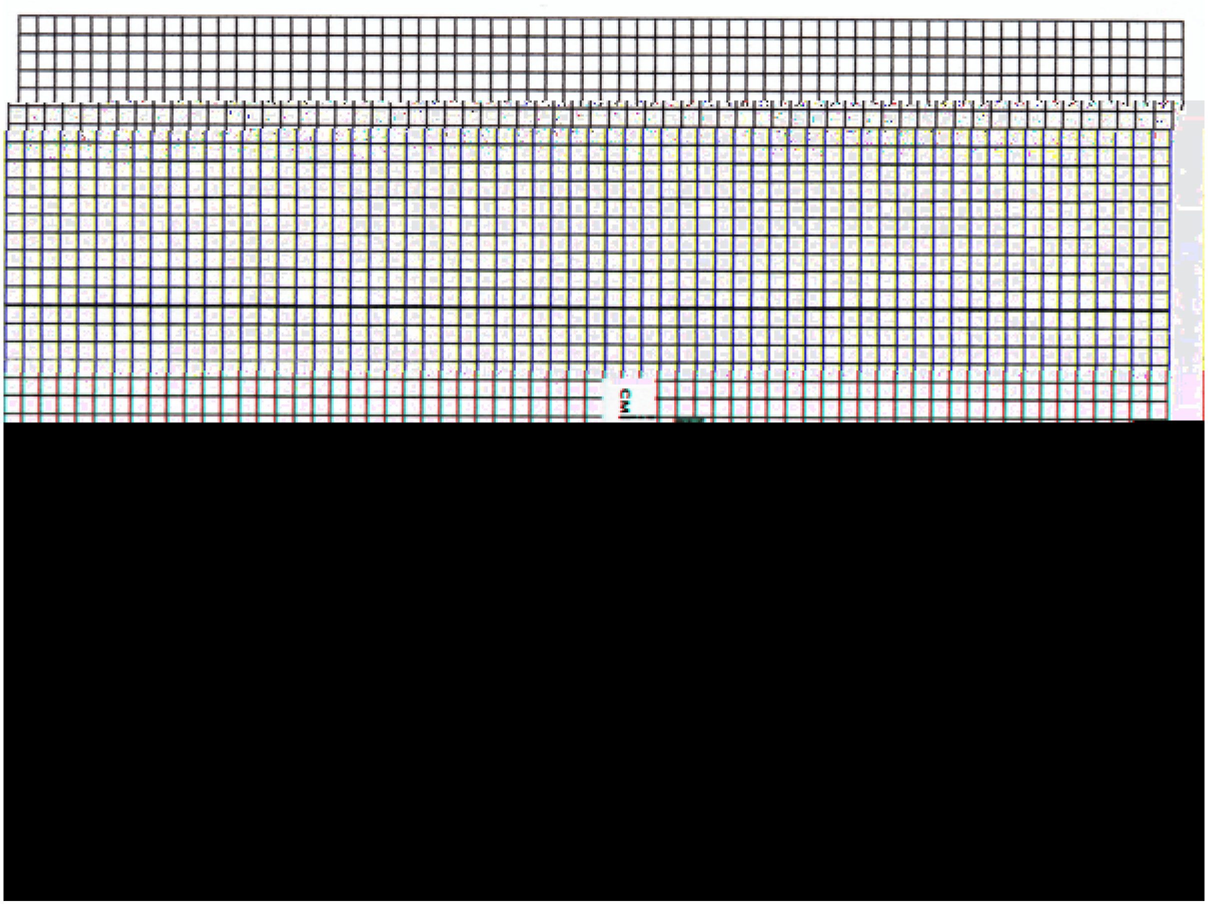

Figure 30. Height of the meter board in grid units (i.e. 18 dm of visible meter board represents 18 grid units). The height of 18 grid units is 45mm.

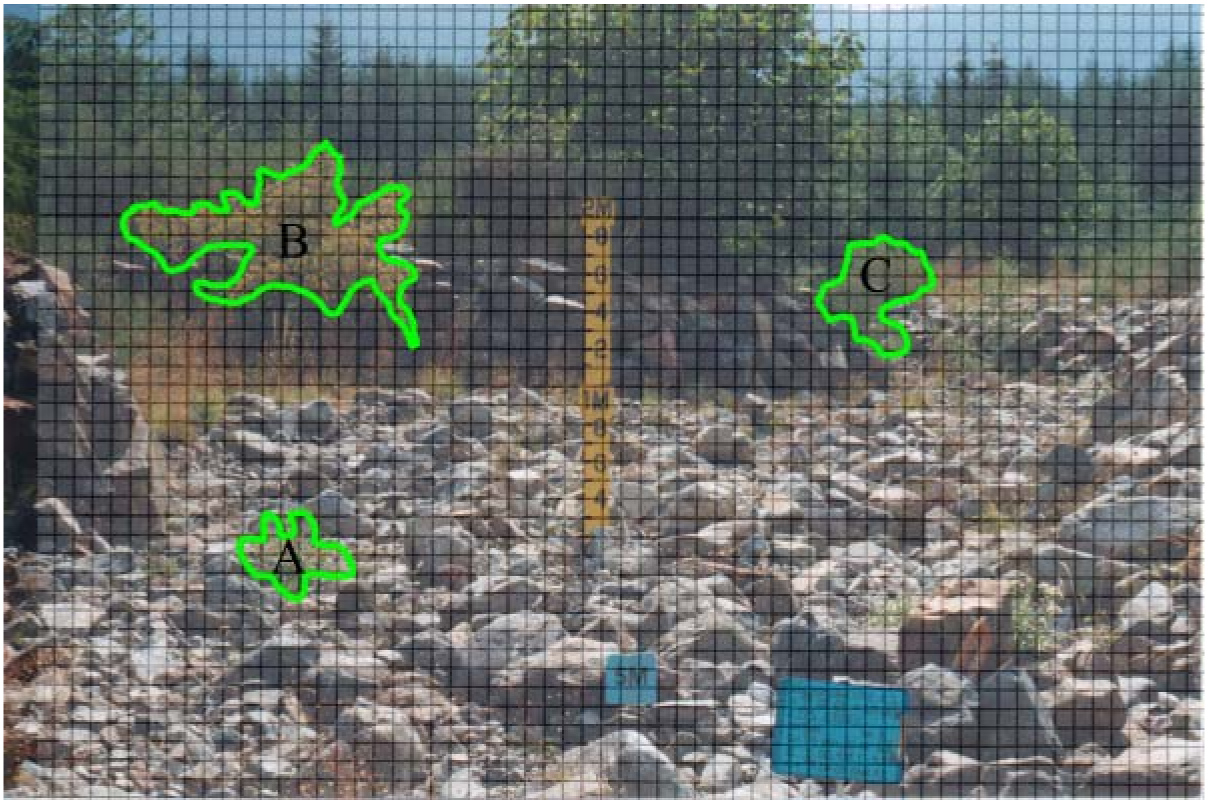

Figure 31. An in-stream photograph of 17S Creek with a properly adjusted grid on which the profile of several (but not all) shrubs have been outlined. Each shrub is given a unique one letter code to identify it. It should be noted that this picture is not enlarged to the standard as recommended by Hall (1997) for presentation purposes.

Photo-Grid Analysis Results

As this study only represents the initial baseline of a Photopoint Monitoring program, no significant changes in size or area of the target resources was observed. As a result, Photo Grid Analysis cannot be applied to any of the photopoints generated by this study. It is possible, however, to digitally alter photopoint photographs in order to demonstrate the Photo Grid Analysis technique. Consequently, two examples of photopoint photographs have been subjected to digital manipulation. It should be noted that these digital manipulations are only an artistic rendition of changes that could occur over time and are solely for the purpose of demonstrating the application of Photo Grid Analysis for measuring relative change. The first example (Figure 32) is designed to demonstrate the potential effects of increased recreational activity on a trail on Mt. Braden (990628-ROC-B1). The application of Photo Grid Analysis to Figure 32 reveals that the width of the trail has increased from 199 grid units to 257 grid units, representing a relative increase of 116%. The second example (Figure 33) is designed to mimic the spread of disease through a stand of Douglas Fir trees (*Pseudotsuga menziesii*) near Sooke Lake reservoir (990814-DIS-A1). The application of Photo Grid Analysis to Figure 33 reveals that the area of diseased trees has increased from 89 grid units to 138 grid units, representing a relative increase of 55%.

Discussion

The digitally manipulated results demonstrate the application of Photo Grid Analysis in measuring relative changes in target resources contained with photopoint photographs. Depending on the needs of the client agency, monitoring relative changes in target resources may be adequate to assess the effectiveness of management decisions and to detect deteriorating conditions. If relative measurements are not sufficient to meet the monitoring needs of the client agency, absolute measurements can be made of objects that are in close proximity to the meter board (<2m). For any objects beyond this maximum distance of 2m, there are no methods currently available for making absolute measurements. Although one of the secondary objectives of this study was to develop standard procedures for obtaining absolute measurements of any objects contained within the photographic field of view, budgetary constraints prevented the attainment of this goal. Preliminary calculations and field tests were conducted, but additional research and development is necessary before an accurate and precise technique can be proposed. However upon completion, our methods will be published to the appropriate scientific journal for peer review.

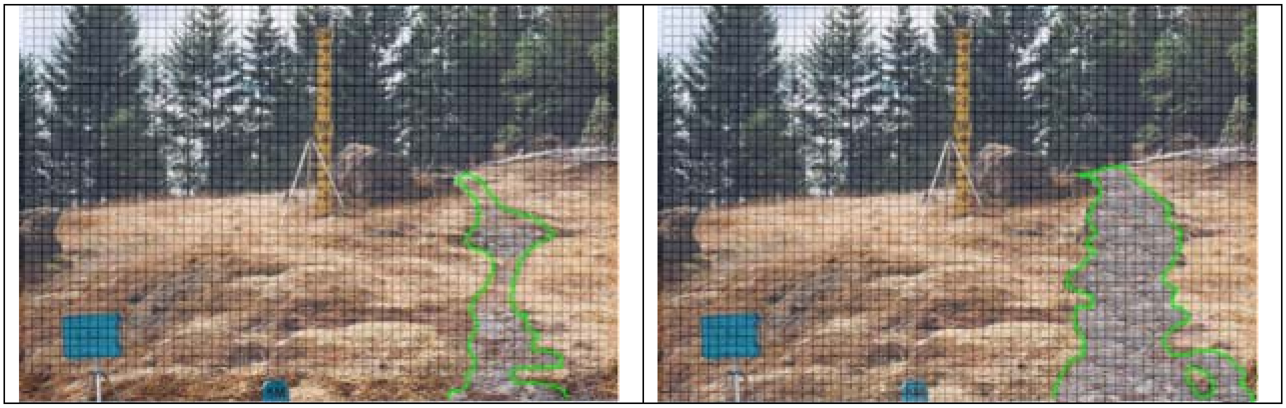

Figure 32. Depicted on the left is a trail on Mt. Braden (Photo Code: 990628-ROC-B1). The trail currently occupies an area of 119 grid units. Depicted on the right is the Mt. Braden trail after digital modification to mimic trail widening as a result of increased recreational use. The trail now occupies an area of 257 grid units, representing an increase of 116%.

Figure 33. Depicted on the left is an area of diseased Douglas Fir trees (*Pseudotsuga menziesii*) near Sooke Reservoir (Photo Code: 990814-DIS-A1). The diseased trees currently occupy an area of 89 grid units. Depicted on the right is the diseased tree patch after digital modification to mimic the spread of the disease. The diseased trees now cover an area of 138 grid units, representing a 55% increase.

Chapter 5: Assessment of Photopoint Monitoring

Benefits of Photopoint Monitoring

1. Basic photopoint monitoring is simple to use and requires a 1 day office/field workshop to train practitioners on the procedure. Advanced techniques can be added as crews become more proficient with the technique.

2. Uses inexpensive, readily obtainable equipment.

3. Provides a standardized and precisely replicable result that can be achieved by different personnel at different points in time.

4. Can be easily compared to standardized results from other areas or research projects.

5. Permanently marks both ends of a phototransect which enables other quantitative data collection techniques to be replicated over time (i.e. profile survey and vegetation intercept samples).

6. Does not require a separate database to describe the date and location of each photopoint because all site-specific information is embedded into each photograph with a data board.

7. Requires a minimum effort to repeat future photographs.

8. Provides a precise method for measuring relative changes in target resource parameters over time.

9. Photographs provide a long term visual permanent record of site conditions that transcend periodic changes in staff and expertise.

10. Time-series photographs may be a more effective communication tool when dealing with the public and decision makers than highly quantitative charts, tables and graphs.

11. Standardization of camera (35 mm with 50 mm lens), and focal point distance (10 meters) will enable newly developed quantification and analysis techniques to be applied to all photographic products.

12. Historical photographs taken without a meter board can be re-shot from the same location. A meter board can then be digitally added to the historical photographs to enable quantification and analysis.

Limitations of Photopoint Monitoring

In its present state of development, Photopoint Monitoring also has a number of serious limitations that must be recognized. These limitations:

1. It cannot be used to detect quantitative changes in species composition or micro-scale soil erosion. These limitations can be overcome if additional quantitative techniques are applied along the length of the phototransect such as point intercept vegetation sampling and transect profile surveys.

2. Generally, it should not be conducted by a single person due to safety considerations. Furthermore, simple tasks such as transporting equipment between sites or stabilizing a meter board or sign board during windy conditions often require a two person effort.

3. It cannot be used in dense woody vegetation as branches and foliage obscure camera field of view. Extreme wind and rain also present significant challenges to the procedure.

4. Over time, photopoints can become obscured by vegetation, or lost due to soil erosion or vandalism.

5. Location of a phototransect is a subjective and non-random decision which depends on site configuration, experience level and monitoring objectives.

Crew Size

While it is technically possible for the standard Photopoint Monitoring procedure to be carried out by one person, it is neither efficient, nor safe or practical to do so. The logistics of a one-person crew introduce a variety of inefficiencies and technical difficulties that significantly limit productivity and project feasibility. For example, simple tasks such as transporting equipment between sites or stabilizing a meter board or data board during windy conditions often require a two person effort. Furthermore, The ***British Columbia Workers Compensation Board (WCB) occupational health and safety regulations recommend a minimum crew size of two when working in remote wilderness conditions***. However, while a two-person crew represents the *minimum* crew size required to conduct the Photopoint Monitoring procedure, it does not represent the most efficient crew size. A three-person crew offers a high degree of efficiency and maximum productivity. On a three person crew, one member is designated the photographer / compass operator, one member is responsible for the placement of the meter board and data board and for all distance measurements, and one member completes all photographic information sheets and field data forms (data recorder). If transect profile surveys and point intercept vegetation samples are conducted along the photopoint transect, then one crew member is responsible for sighting the theodolite, one member is responsible for vegetation sampling, taxonomy and for holding the stadia rod to determine terrain height, while the final member is responsible for recording all data.

The only identified disadvantage of a three person crew arises in the event of an accident in which one crew member must stay with the injured party, while the other crew member must hike out alone to seek aid. In the unlikely event that the aid-seeker should injure themselves, the entire crew could be placed at an unacceptable level of risk. As a result, if a Photopoint Monitoring project is being conducted in wilderness conditions, a crew size of four should be given serious consideration to ensure crew safety. With a four person crew, two members could safely hike out of the study area to obtain medical assistance for the injured crew member.

On a four person crew, one member is designated the photographer / compass operator, one member is responsible for the placement of the meter aner .n crw6rd anerfor all distance measurements, one member is responsible for completing the photographic information sheets anerthe final member is responsible for completing all fieler .n cforms.

Table 3. The productivity, benefits aner isadvantages associated with 5r ifferent crew sizes.

Crew Size	Site Completion Time (hours)	Benefits	Disadvantages
1	3	low cost	inefficient rate of site completion, potential safety haz6rd, simple tasks cannot be performed
2	2	low cost	inefficient rate of site completion, potential safety haz6rd
3	1.5	moderate cost, highly efficient, highly productive	potential safety haz6rd
4	1.5	highly efficient, highly productive, high degree of crew safety	high cost, some position redundancy
5	1.75	higher level of combined crew experience, allows advance site scouting if crew is divided	high cost, inefficient rate of site completion, unavoidable crew idleness

Crew Productivity

When first establishing a Photopoint Monitoring transect, it should be recognized that the time to setup anermonitor an individual site decreases with the level of crew experience. For inexperienced crews, at least 45 minutes of iscussion time are required for the crew to determine the ideal location of a photopoint transect, reg6rdless of crew size. As the crew gains confidence in their site selection skills, iscussion time could be reduced to as little as 20 minutes. Since locating a representative photopoint transect is the most important component of the entire photopoint procedure, the decision should not be rushed. Once the photopoint transect has been selected, an inexperienced 3 or 4-person crew should be able to complete 4 photographs (2 photopoint, 1 lanescape aner1 site setup) in approximately 1.5 hours. Conducting a transect profile survey anerpoint intercept vegetation samples adds approximately 1 hour to the estimate completion time. Consequently, for an inexperienced crew of 3 or 4, a single photopoint transect and all associated photographs and vegetation and profile samples will take approximately 3 to 3.25 hours to complete.

As a photopoint crew grows proficient in Photopoint Monitoring and in identifying common vegetation, it may be possible to reduce the total site completion time to 2 to 2.25 hours. Based on a 3-person crew, this represents a total investment of 6.0 – 6.75 person-hours to fully monitor a site (8-9 person hours for a 4 person crew with no significant gains in productivity). Consequently, once the crew is fully trained, a 3 man crew becomes more efficient and cost effective than a 4 person crew. Approximately 15-20 field days are required to reach the maximum level of productivity.

Depending on the proximity of sample sites, on the terrain of the study area, and on the field mobility skills of the crew members, it is reasonable to expect an experienced 3 or 4 person crew to complete 3-4 sites per day. Unfortunately, steep terrain, poor weather, wildlife and human error may significantly reduce this level of productivity.

The time to replicate a photopoint transect and to complete profile and vegetation samples is the same as it takes to establish and complete a baseline site. This can be attributed to time spent in relocating camera permanent marker pins with metal detectors.

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McLain, R.J. and R.G. Lee. 1996. Adaptive Management: Promises and Pitfalls. *Environmental Management*. Vol. 20(4): 437-448.

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Appendix A: Glossary

5 meter marker: an instrument that is used to mark 5 meters between the camera location and the meter board.

Aligned-left shot (or flush left): to indicate that a photograph is taken with the meter board located on the far left edge of the frame.

Aligned-right shot (or flush right): to indicate that a photograph is taken with the meter board located on the far right edge of the frame.

Azimuth: "The direction of lines may be expressed as bearings and azimuths. Both are measured in terms of degrees minutes and seconds of arc from a selected line of reference or meridian. Azimuths are measured clockwise through 360°, staring from the reference meridian. They may be referred to as either north or south, but never both on the same survey. Bearings are measured either clockwise or counterclockwise in quadrants and never exceed 90°" (Wetzel and Likens, 2000).

Black and white print film: 100 ISO, 36 exposures, used for archival photo documentation due to longevity of negatives.

Camera Location Markers: 36 inch, case hardened side walk stakes (or rebar) can be used to permanently mark all camera and meter board locations which occur over soil (sledge hammer required). Brass survey pins can be used to permanently mark locations which occur over bedrock (Hilty rock drill and generator required).

Camera point: the precisely located point at which each photopoint photograph is taken.

Camera tripod: adjustable to a height of 1.5 m with a quick release base, used to standardize camera height and to increase stability of camera.

Camera: 35 mm manual reflex camera with 50 mm lens and a minimum f-stop of 16. Three cameras are required to obtain colour prints, black and white prints and colour slides. A fourth camera should also be carried for backup purposes.

Chalk Line (Optional): marked with 50 cm increments and used for point intercept vegetation and bed load sampling, transect profile surveys and stream cross-sections.

Colour print film: 100 ISO, 36 exposures used for archival photo documentation, and quantification.

Colour slide film: 100 ISO, 36 exposures, used for presentation purposes and as a back-up for colour prints.

Compass: used to measure true north bearing between camera location and meter board.

Data board: an instrument that is used to hold photographic information sheets. A data board is constructed using a camera tripod with extendible legs and a 21 cm by 27.5 cm aluminum clip board.

Field data book: 1.5 inch three ring plastic binder used by field crew to hold all field data forms and photographic information sheets.

Field data form: Used to record site sketch and other photopoint information including: location name, site name, site number, date, time, photograph type, meter board alignment, camera height, focal point, distance and bearing between the camera location, and meter board(s), film roll number, film type and speed, and frame number on camera.

ISO: denoting the film type used for photographs. As ISO. value increases, film quality decreases, while amount of light required for proper exposure decreases.

Landscape Information sheet: 8 1/2 by 11 inch cobalt blue sheet that is placed on the data board and used to imbed site information into each landscape photograph including: date, time, location, site name, site number, focal point, focal bearing, location of camera points and photocode.

Line level: used to ensure chalk line is horizontally level.

Meter board alignment: the location of the meter board within the field of view (frame). The meter board can either be aligned in the center of the frame or flush with the right or left hand side of the frame.

Meter board extension: a 1 m tall, 15 cm wide measurement board which is attached to the top of a meter board to extend the height to 2 meters. Meter board extensions are painted emergency yellow and decimeters are marked with black 5 cm linear markings. Ten centimeter lettering is used to denote .2, .4, .6, .8 and 2 meter marks. Meter board extensions are attached to meter boards with bolts, wing nuts and brackets.

Meter board: a 1 m tall, 15 cm wide free standing measurement board. The meter board is painted emergency yellow for contrast, and decimeters are marked with black 5 cm linear markings. 10 cm tall black lettering is used to denote .2, .4, .6, .8 and 1 meter marks. This device is placed within each standardized photopoint and serves three functions: 1) to embed a standard scale within each photograph so that features in close proximity to the meter board can be measured; 2) to provide a focal point for the camera so that repeat photography can be achieved; and 3) to provide a scale for the purposes of grid sampling analysis. Meter boards are constructed from a single piece of _ inch plywood or anodized aluminum. A metal camera tripod can be attached to the meter board at the 80 cm mark to achieve free standing status. A level is attached to the back of the meter board to ensure placement is always plumb.

Meter tape: 60 meter long fiberglass measuring tape used to measure ground distance between camera location and meter board.

Pelican camera case: A durable, padded, waterproof case that is used to protect and carry cameras and film between locations.

Photopoint Information Sheet: 8 _ by 11 inch cobalt blue sheet that is placed on the data board and used to imbed site information into each photopoint photograph including: date, time, location, site name, site number, camera height, camera point, photopoint, photocode and distance / bearing of meter board from camera location. Photopoint Information Sheets must be printed on cobalt blue paper for maximum photographic readability.

Plumb with needle tip: dropped from a level chalk line and used for point intercept vegetation sampling.

Shutter release cable: Used to prevent camera shake during long shutter speeds (>.25 seconds).

Sidewalk stake: a 1/2” thick, hard cased steel stakes measuring 36” in length. Used to mark camera, meter board, landscape, and panorama points for ease of future relocation.

Site Setup Information Sheet: 8 _ by 11 inch cobalt blue sheet that is placed on the data board and used to embed site information into each site setup photograph including: date, time, location, site name, site number, location of landscape pin and photocode.

Start of Roll Information Sheet: 8 _ by 11 inch cobalt blue sheet that photographed at the beginning of each film roll and is used to embed all abbreviations used on Photographic Information Sheets photopoint, Landscape and Site Setup Information Sheets within negative stripes.

Theodolite: optical instrument used for a number of purposes in surveying (e.g. transect profile surveys). It consists of a telescope fitted with a spirit level and mounted on a tripod so that it is free to rotate about its vertical and horizontal axes.

Witness point: a semi-permanent human-built structure which can be relocated in the future. In the absence of human-built structures, a natural witness point, such as a tree, can be used.

Appendix B: GPS Calibration Methods

Introduction

Re-locating biological monitoring sites can be accomplished with a combination of maps, compass bearings and extensive field directions. Although this technique has been used by field research scientists for decades, its accuracy is limited by map scale and errors are introduced by temporal changes in magnetic declination as well as ecological succession and disturbance. Fortunately, the advent of the Global Positioning System (GPS) has significantly improved the ability of research scientists to relocate biological monitoring sites in both urban, rural and backcountry wilderness settings. The purpose of this appendix is to outline the procedure used to determine the accuracy of three commercially available GPS units: a Magellan GPS 2000 (4 channel), a Trimble Scoutmaster GPS (8 channel) and a Garmin GPS II Plus (12 channel) with a Garmin GBR 21 DGPS beacon receiver. The results of these tests were used to determine the suitability of the GPS units for the Photopoint Monitoring E-Team project.

GPS Background Information

NAVSTAR, the Global Positioning System, is a satellite based navigation system that was originally developed to meet the navigation needs of the U.S. Military. The first four prototype satellites were launched in 1978 and since that time the system has expanded to include twenty-four orbiting GPS satellites (Parkinson *et al*., 1996). Although GPS is currently capable of precision measurements to the millimeter, most commercially available units are limited to a 100m precision capability for U.S. Military security reasons. This results in a GPS signal degradation called Selective Availability (SA). Fortunately, the error introduced by SA can be significantly reduced through the use of Differential GPS (DGPS). DGPS is a commercially developed system which involves local, ground-based corrections to GPS signals in order to improve the precision of locations to within +/- 10m (Parkinson *et al*., 1996).

GPS may be useful for Photopoint Monitoring projects as it greatly facilitates the relocation of camera points and associated sample sites. However, prior to relying solely on GPS for camera point relocation, the accuracy of potential units must be determined.

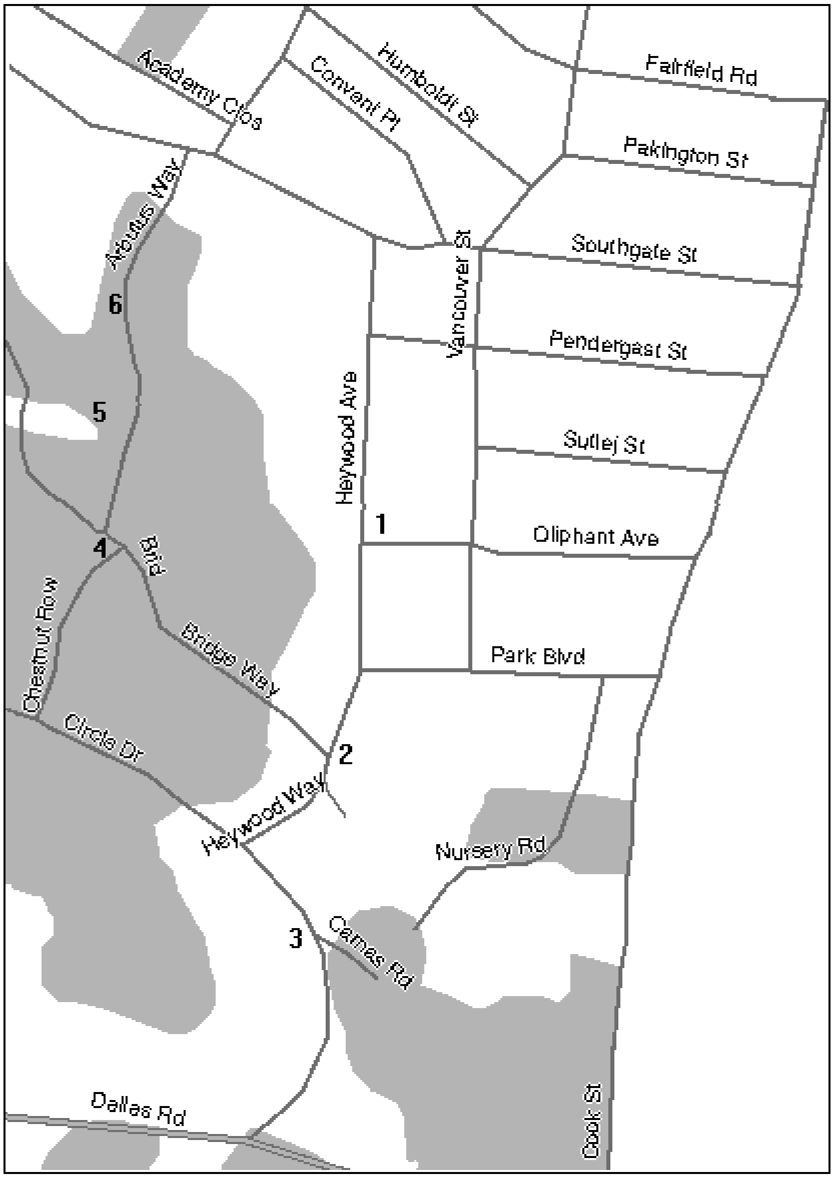
Materials and Methods

To determine the accuracy of hand-held GPS units, the precise location (+/- 8 mm) of six survey monuments found in Beacon Hill Park, Victoria was obtained from Geographic Data British Columbia (Geodata BC). Three survey monuments were selected which had direct site-lines to satellites, while the other three were situated beneath dense coniferous and deciduous canopy to simulate field conditions (Figure C1). Each of the GPS units was activated over each of the survey monuments at a height of 1.2 meters. Location readings were obtained from each unit at intervals of 1, 5, and 10.

The readings were converted from a format of degrees and minutes with three decimal places to degrees, minutes, and seconds with two decimal places. This ratio calculation was based on the assumption that a second represents one sixtieth of a minute.

Latitude and longitude locations were converted to the Universal Transverse Mercator (UTM) values using a web-based conversion utility provided by Geographicdata B.C. (www.pwccanada.com:8001/mascot/util3a.html). The UTM system is a collection of two-dimensional, metric grids that approximate a globe rather than the curved latitude and longitude model. UTM location is given in Northing and Easting, which can be compared directly to the known figures for the survey monuments.

To calculate the error of each GPS unit, the observed Northing and Easting were subtracted from the known Northing and Easting. Since these two distances are at right angles to each other, the actual difference between the two locations can be calculated by using the Pythagorean Theorem to find the hypotenuse (Figure C2). Finally, the errors were averaged and the summary statistics calculated for each instrument.



SURVEY MONUMENT LEGEND

1 = Tablet 4-4, GCM 906602
Latitude: 48 24 46.41770 dms
Longitude: 123 21 37.87315 dms
Northing: 5362256.090 m
Easting: 473322.119 m

2 = Tablet 4-67, GCM 736116
Latitude: 48 24 43.06883 dms
Longitude: 123 21 39.66155 dms
Northing: 5362152.864 m
Easting: 473284.872 m

3 = Tablet 4-65, GCM 634824
Latitude: 48 24 36.83936 dms
Longitude: 123 21 39.57303 dms
Northing: 5361960.514 m
Easting: 473285.785 m

4 = Tablet 8-89, GCM 420281
Latitude: 48 24 50.19255 dms
Longitude: 123 21 50.07543 dms
Northing: 5362373.829 m
Easting: 473071.855 m

5 = Tablet 8-91, GCM 807305
Latitude: 48 24 54.35509 dms
Longitude: 123 21 47.78457 dms
Northing: 5362502.128 m
Easting: 473119.552 m

6 = Tablet 8-92, GCM 82685
Latitude: 48 24 59.73414 dms
Longitude: 123 21 47.68681 dms
Northing: 5362668.202 m
Easting: 473122.349 m

Figure C1. Locations of survey monuments used to calibrate GPS units. Sites 1, 2 and 3 have direct site-lines to satellites while sites 4, 5 and 6 are obstructed by forest canopy.

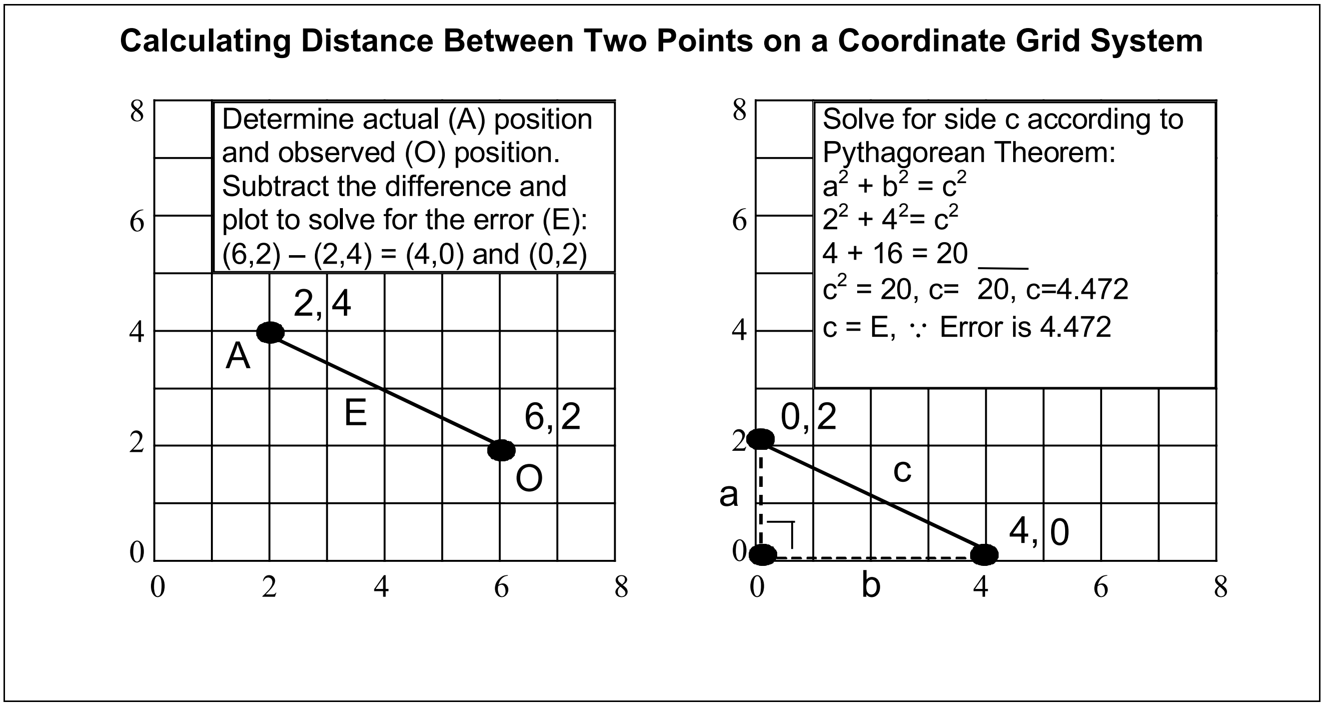


Figure C2. Application of Pythagorean Theorem to solve for the GPS error (E) between the actual (A) and observed (O) position. The same approach is applied to Northing and Easting coordinates on a UTM grid.

Results

Error calculations indicate that the Garmin DGPS, Magellen and Trimble units are associated with an average error rate of 14.95m, 161.42m and 83.53m respectively (Table C1).

Table 1. Calculated error of each GPS unit.

Survey Monument	DGPS Error (m)	Magellan Error (m)	Trimble Error (m)
1 (Tablet 4-4)	3.66	50.73	182.13
2 (Tablet 4-67)	3.96	47.58	342.03
3 (Tablet 4-65)	1.92	467.08	156.05
4 (Tablet 8-89)	5.61	163.58	111.63
5 (Tablet 8-91)	21.60	61.70	139.80
6 (Tablet 8-92)	50.08	112.25	137.83
Average Error (m)	**14.95**	**150.48**	**178.24**
Standard Deviation	**18.88**	**161.42**	**83.53**

Discussion

Based on the results of this calibration study, the Garmin DGPS unit was determined to be the most accurate unit. As a result, the Garmin DGPS was used to determine the location of all camera points.

Appendix C: Photopoint Monitoring Equipment Specifications and Costs

Equipment Specifications for Photopoint Monitoring:

Meter board: a 1 m tall, 15 cm wide free standing measurement board (Figures C1.1 and C2.1). The meter board is painted emergency yellow for contrast, and decimeters are marked with black 5 cm linear markings. 10 cm tall black lettering is used to denote .2, .4, .6, .8 and 1 meter marks. The enlarged top portion is 20 cm wide. This device is placed within each standardized photopoint and serves three functions: 1) to embed a standard scale within each photograph so that features in close proximity to the meter board can be measured; 2) to provide a focal point for the camera so that repeat photography can be achieved; and 3) to provide a scale for the purposes of grid sampling analysis. Meter boards are constructed from a single piece of 1/8 inch plywood or anodized aluminum. A metal camera tripod can be attached to the meter board at the 80 cm mark to achieve free standing status (Figure C3.2). A level is attached to the back of the meter board to ensure placement is always perpendicular to the ground (a perfect 90° angle) (Figure C3.1).

Meter board extension: a 1 m tall, 15 cm wide measurement board which is attached to the top of a meter board to extend the height to 2 meters (Figures C1.2 and C2.1). Meter board extensions are painted emergency yellow and decimeters are marked with black 5 cm linear markings. Ten centimeter lettering is used to denote .2, .4, .6, .8 and 2 meter marks. Meter board extensions are attached to meter boards with wing nuts and brackets.

Data board: an instrument that is used to hold photographic information sheets. A data board is constructed using a camera tripod with extendible legs and a 21 cm by 27.5 cm aluminum clip board (Figure C4.2).

5 meter marker: an instrument that is used to mark 5 meters between the camera location and the meter board (Figure C5.2).

Compass: used to measure true north bearing between camera location and meter board (Figure C6.6).

Meter tape: 60 meter long fiberglass measuring tape used to measure ground distance between camera location and meter board (Figure C6.1).

Cameras: 35 mm manual reflex camera with 50 mm lens and a minimum f-stop of 16. Three cameras are required to obtain colour prints, black and white prints and colour slides. A fourth camera should also be carried for backup purposes (Figure C6.5).

Camera Tripod: adjustable to a height of 1.5 m with a quick release base, used to standardize camera height and to increase stability of camera. A tripod is absolutely essential when shooting in low light levels with shutter speeds in excess of 0.25 seconds (Figure C4.1).

Shutter release cable: Used to prevent camera shake during long shutter speeds (>.25 seconds) (Figure C6.2).

Pelican camera case: A durable, padded, waterproof case that is used to protect and carry cameras and film between locations (Figure C6.4).

Black and white print film: 100 ISO, 36 exposures, used for archival photo documentation due to longevity of negatives.

Colour slide film: 100 ISO, 36 exposures, used for presentation purposes and as a back-up for colour prints.

Colour print film: 100 ISO, 36 exposures used for archival photo documentation, and quantification.

Field data book: 1.5 inch three ring plastic binder used by field crew to hold all field data forms and photographic information sheets (Figure C7.1)

Camera Location Markers: 36 inch, case hardened side walk stakes (or rebar) can be used to permanently mark all camera and meter board locations which occur over soil (sledge hammer required) (Figure C4.3 and C4.4). Brass survey pins can be used to permanently mark locations which occur over bedrock (Hilty™ rock drill and generator required) (Figure C5.5).

Backpack/Golf Bag: Used to carry equipment between locations (Figure C7.2).

Chalk Line and (Optional): marked with 50 cm increments and used for point intercept vegetation sampling (Figure C5.4).

Plumb with needle tip (Optional): dropped from a level chalk line and used for point intercept vegetation sampling.

Theodolite (Optional): used for conducting transect profile surveys.

Field data form: Used to record site sketch and other photopoint information including: location name, site name, site number, date, time, photograph type, meter board alignment, camera height, focal point, distance and bearing between the camera location, and meter board(s), film roll number, film type and speed, and frame number on camera (Figure C9).

Quantitative data form: Used to record quantitative data such as point-intercept vegetation samples, bed load samples, stream cross sections and transect profile surveys (Figure C10).

Photopoint Information Sheet: 8 1/2 by 11 inch cobalt blue sheet that is placed on the data board and used to imbed site information into each photopoint photograph including: date, time, location, site name, site number, camera height, camera point, photopoint, photocode and distance / bearing of meter board from camera location. Photopoint Information Sheets must be printed on cobalt blue paper for maximum photographic readability (Figure C11).

Landscape Information sheet: 8 1/2 by 11 inch cobalt blue sheet that is placed on the data board and used to imbed site information into each landscape photograph including: date, time, location, site name, site number, focal point, focal bearing, location of camera points and photocode (Figure C12).

Site Setup Information Sheet: 8 1/2 by 11 inch cobalt blue sheet that is placed on the data board and used to embed site information into each site setup photograph including: date, time, location, site name, site number, location of landscape pin and photocode (Figure C13).

Start of Roll Information Sheet: 8 1/2 by 11 inch cobalt blue sheet that is photographed at the beginning of each film roll and is used to embed all abbreviations used on Photographic Information Sheets (Figure C14).

Panoramic Information Sheet: 8 1/2 by 11 inch cobalt blue sheet that is placed on the data board and used to imbed site information into each panoramic photograph including: date, time, location, site name, site number, camera height, azimuth to focal point and photocode (Figure C15).

Figure C1 (1-3): Depicts meter board (1), meter board extension (2) and meter board tripod (3).

Figure C2 (1): Depicts front and back sides of completed meter board assemblage.

Figure C3 (1-2): Depicts meter board leveling mechanism (1) and meter board attachment mechanism (2).

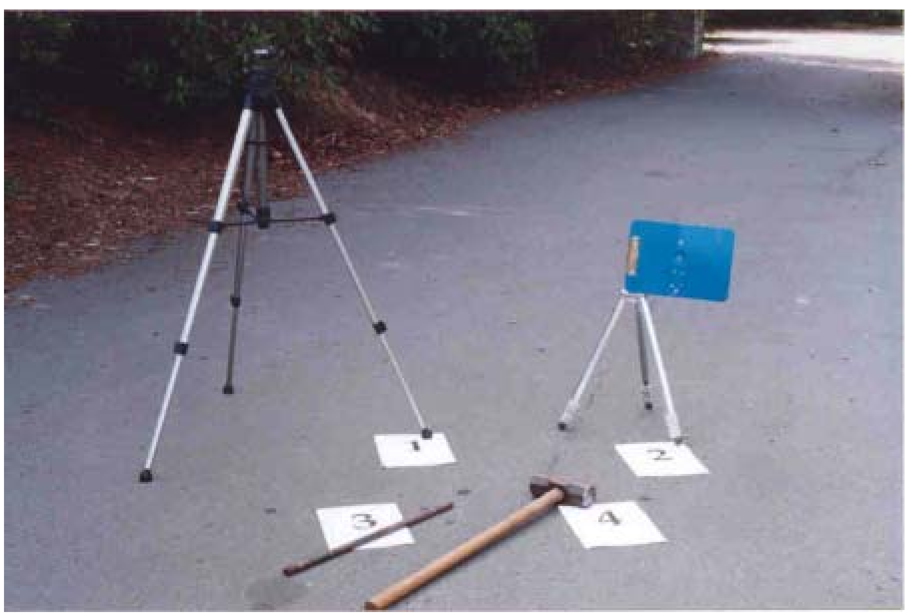


Figure C4 (1-4): Depicts camera tripod (1), data board (2), case-hardened side walk stake (3) and sledge hammer (4).

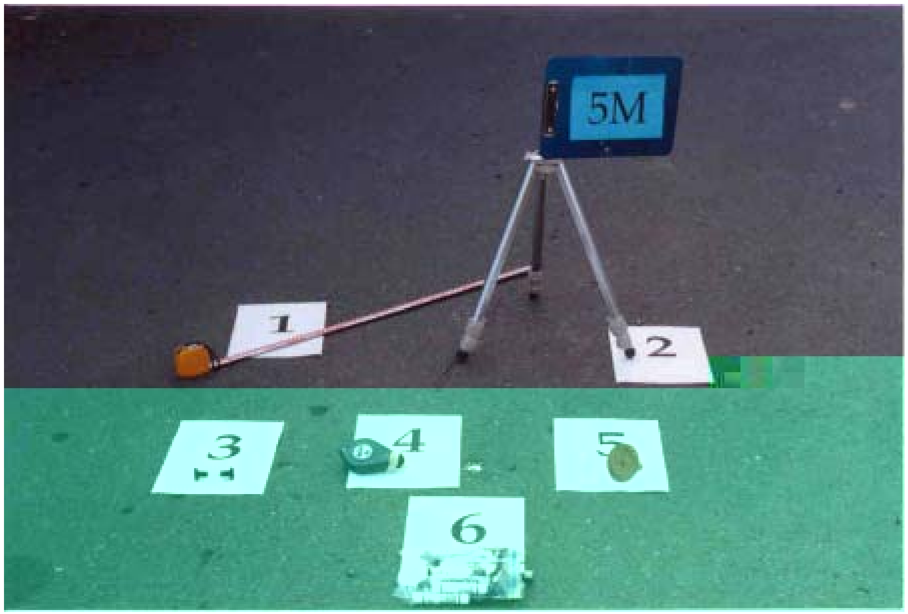


Figure C5 (1-6): Depicts mini-rod (1), 5 meter marker (2), line level (3), chalk line (4), brass marker pin (5) and marking pens (6).

Figure C6 (1-6): Depicts fiberglass measuring tape (1), shutter release (2), camera mount (3), pelican case (4), 35 mm camera with 50 mm lens (5) and compass (6).

Figure C9: Field data form used to record reach sketch and other photo information: stream name, reach name, reach number, photograph type, meter board alignment, camera height, photograph number, stream direction, description of witness point and the distance and bearing data between the camera location, witness point and meter board(s), date, film roll number, film type and speed, frame number on camera.

Location: ______________________________ Site Name: ______________________________ Site #: ________________

Lat./ Long. or UTM: ____

Date (YYYY/MM/DD)_____________________ Time (HH:MM) _____________ Data Recorder: ______________________

SLD#: ________________

BW#: ________________

CLR#: ________________

Map Checklist:

- O North Arrow
- O Camera Locations (A H)
- O Landscape Location (L)
- O Site Setup Location (S)
- O Veg. Plot Locations (V)
- O Meter Boards (MB)
- O Direction of Trail
- O Transect
- O Predominant Veg.
- O Landmarks

PHOTO INFORMATION

CAM LOC	PHOTO POINT#	SLD #	B/W F#	CLR F#	CH (M)	FOCAL POINT

DISTANCE (M)

CAM TO MB1	WIT TO CAM

Bearing (True North –19.35°E in Victoria)

CAM TO MB1	CAM TO MB2	FOCAL BEARING	WIT TO CAM

Figure C10: Quantitative data form used to record quantitative data such as point-intercept vegetation samples, bed load samples, stream cross sections and transect profile surveys.

Location: ______________________________ Date (YYYY/MM/DD): ____________________

Site Name: ______________________________ Time (HH:MM): _________________________

Site #: ______________________________ Lat./Long. Or UTM: ______________________

Camera Location: ____________ Distance to MB 1 (M): _________ Bearing to MB 1: _______

Data Recorded: _____________ Photographer: _______________ Crew: _______________

Distance From Camera to MB	Height	Point-Intercept Vegetation Sample/ Stream Cross Section Bedload Sample

Figure C11: Photopoint Information Sheet, used to imbed site information into each photopoint photograph including: date, time, location, site name, site number, camera height, camera point, photopoint, photocode and distance / bearing of meter board from camera location. Photopoint Information Sheets must be printed on cobalt blue paper for maximum photographic readability.

PHOTOPOINT CP ______ P ___

D ___ ____ ______ T ____ : ______

YEAR (YY) MONTH (MM) DAY (DD) HOUR(HH) MINUTE (MM)

L ______________________________

SN __________________ S# _______

CH ______ MB1 ____ BC° _____

____ : ___ ____ : ____ ___ : ___

ID #

Figure C12: Landscape Information sheet, used to imbed site information into each landscape photograph including: date, time, location, site name, site number, focal point, focal bearing, location of camera points and photocode.

LANDSCAPE CP____

D__ ____ _____ T____:______
YEAR (YY) MONTH (MM) DAY (DD) HOUR(HH) MINUTE (MM)

L ______________________________

SN ________________ S#______

CAM ____ :____ CAM ____ :____

FP__________ FB° ___________

ID #

Figure C13: Site Setup Information Sheet, used to embed site information into each site setup photograph including: date, time, location, site name, site number, location of landscape pin and photocode.

SITE SETUP

D________ ________ ________ T________ : ________

YEAR (YY) MONTH (MM) DAY (DD) HOUR(HH) MINUTE (MM)

L ________________________________

SN ____________________ S#________

CAM _______ : ____________________

WIT______________________________

ID #

Start of Roll Information Sheet, used to embed all abbreviations used on Photographic Information Sheets.

FILM INFORMATION

ROLL: ______ ISO/ASA: ___

DATE (Y/M/D): __ __ __

CP= CAMERA POINT　　D= DATE (Y/M/D)
P=PHOTOPOINT #　　T=TIME
L=LOCATION NAME　　SN=SITE NAME
CH=CAMERA HEIGHT　　S#=SITE NUMBER
MB1/MB2= 1ST/2ND METER BOARD DISTANCE
MB°= METER BOARD BEARING
C/L/R= CENTER/LEFT/RIGHT POSITION
FB= FOCAL BEARING　　FP=FOCAL POINT
ID= PHOTOGRAPH IDENTIFICATION NUMBER

Figure C15: Panoramic Information Sheet, used to imbed site information into each panoramic photograph including: date, time, location, site name, site number, camera height, azimuth to focal point and photocode.

Equipment Costs for Photopoint Monitoring:

Table C1. Expected costs of standard photopoint monitoring field equipment.

Equipment	Unit Cost	Local Supplier
Meter board	$100	Requires Construction
Meter board extension	$100	Requires Construction
Meter board connecting brackets	$7	Capital Iron
Meter board tripod with metal camera base (used)	$50	Various second hand stores
Aluminum clip board for data board	$12	Canadian Tire
Data board tripod with metal camera base (used)	$50	Various second hand stores
35 mm reflex camera with 55 mm lens (used)	$250	Lens and Shutter
Camera tripod with quick release camera base	$100	Lens and Shutter
Kodak black and white print film (100 ISO 36 EXP)	$17	Lens and Shutter
Kodak colour print film (100 ISO 36 EXP)	$14	Lens and Shutter
Kodak colour slide film (100 ISO 36 EXP)	$10	Lens and Shutter
Cobalt blue information sheet paper (letter size)	$12	Staples
Permanent ink felt pen	$2	Staples
White paper for data forms (letter size)	$8	Staples
Laser ink cartridge	$100	Access West Recycling
Transport vehicle (8 person Chevy Astro van)	$1300/month	Budget
Vehicle insurance	$120/month	ICBC
Fuel	$10/100 kms	Various
Cell Phone	$120 / month	BC Tel Mobility
First aid kit	$30	St. John Ambulance
Case hardened side walk stakes (marking soil)	$3	National Concrete Accessories
Sledge hammer (6 lbs)	$30	Canadian Tire
Tapered brass survey pins (marking bedrock)	$10	CRD Water Department
Hilty Rock Drill	$35	Old Country Rentals
Portable Honda Generator (1 kilowatt)	$30/day	Old Country Rentals
Fiberglass measuring tape (60 m)	$50	Canadian Tire
Magnetic compass	$100	Goertz Limited
Write in the Rain field notebook	$6	Goertz Limited
Global Positioning System (GPS)	$300	Goertz Limited
Differential GPS unit		Rotec Communications
AA Batteries for GPS / Radios	$8/pack of 6	Various
Chalk line	$20	Goertz Limited
Plumb	$5	Goertz Limited
Theodolite	$40	Old Country Rentals
Printfile print archive sheaths	$15	Lens and Shutter
Printfile slide archive sheaths	$12	Lens and Shutter
Printfile negative archive sheaths	$12	Lens and Shutter
Printfile archive binder	$18	Lens and Shutter