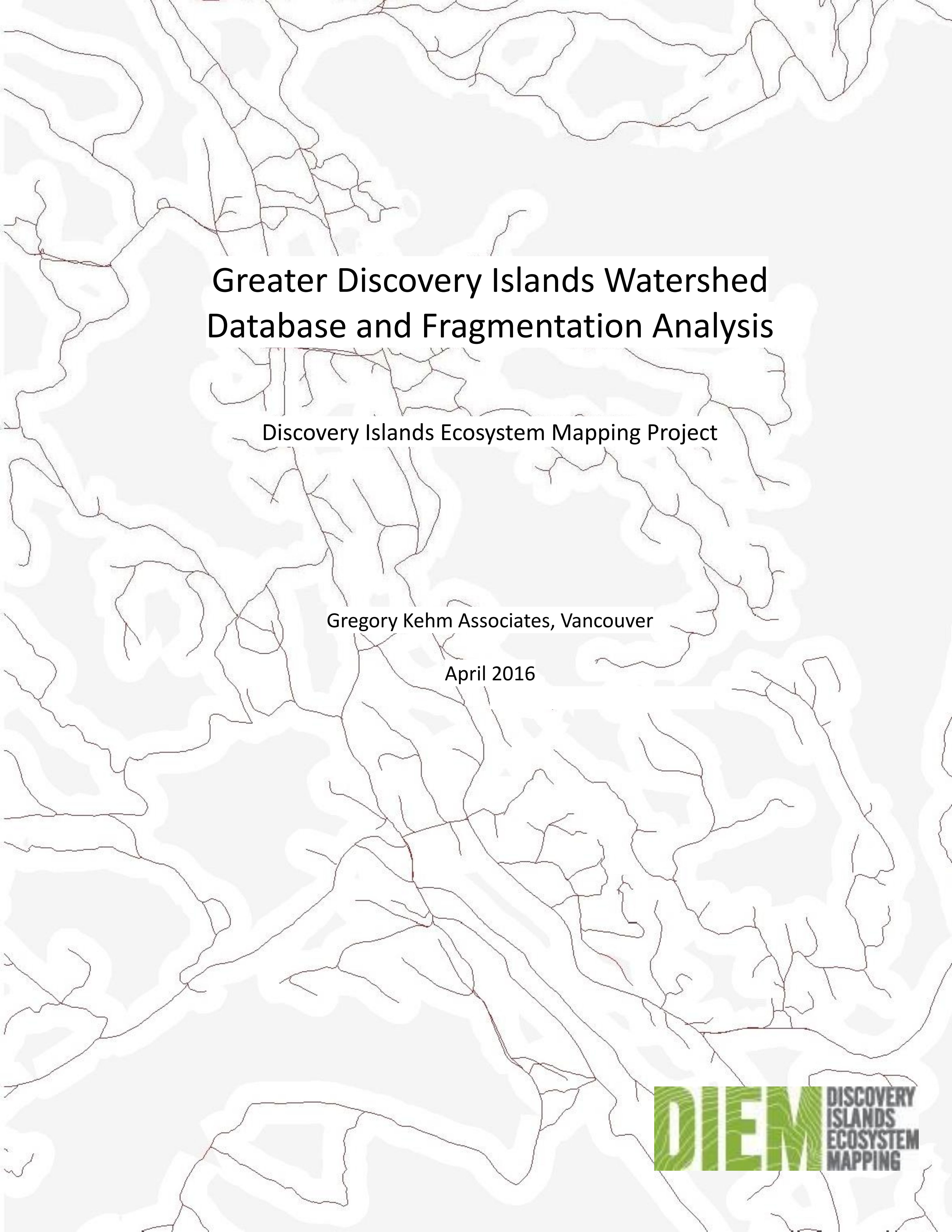

Greater Discovery Islands Watershed Database and Fragmentation Analysis

Discovery Islands Ecosystem Mapping Project

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DIEM DISCOVERY ISLANDS ECOSYSTEM MAPPING

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Overview

Over the last few years, the Discovery Islands Ecosystem Mapping Project (DIEM) has collected unique data to fill identified information gaps in the provincial knowledge base about the Discovery Islands and a portion of the adjacent mainland, and to enhance the public information available to promote long term, intelligent land use decision making. Two examples of DIEM's work include a complete sensitive ecosystems inventory (SEI) for the Discovery Islands that fills a critical knowledge gap in forestry planning, and identifies enduring features that quantify the physical characteristics that underpin the biological diversity of the Islands' ecosystems. The latter work was completed for select physiographic areas, including the Discovery Islands.

This watershed project was developed in 2013. It examines a larger perspective than single data sets or themes of interest. The project describes and compares watersheds:

1) to create a baseline of watershed information to track changes over time (fragmentation by roads or forest harvest);
2) to understand what makes them similar or unique; and
3) to assess current human pressure on the landscapes within the watersheds in order to indicate how much human activity has taken place over the past decades.

The project results can display many views of the Discovery Islands – all through the lens of watersheds to show forest harvest history, wetlands and lakes, SEI, intact landscapes, road density, and more.

The results are dynamic. This has been a straightforward exercise to add new descriptions to the watersheds or update existing ones, making the database and its mapping potential a powerful temporal tool. The data can support a community planning process to identify priority watersheds and specific landscapes within them that need active stewardship.

Alternatively, the data can help assess individual proposals for land conversion activities by evaluating the specific impacts of a proposal and how they may contribute to cumulative impacts from past land conversion activities. For example, if a watershed is highly fragmented by roads but has one remaining intact forest area and if there is a proposal to harvest the remaining intact area, it can be proactively identified, quantified, and assessed to place the proposal within a wider cumulative impact context.

Broad influences of human activity extend beyond the Discovery Islands. The project study area includes significant mainland geography extending past Bute Inlet.

1.0 Introduction

In this project, "watershed fragmentation" is defined as the permanent or maintained linear disruption of natural land cover by human-built features, such as roads, transmission lines, and pipelines. The degree of watershed fragmentation is measured by the extent of human-built linear features as measured by total length and density within a watershed. A description of the list of fragmenting features and their data sources is included as Table 1 in the appendix to this project summary.

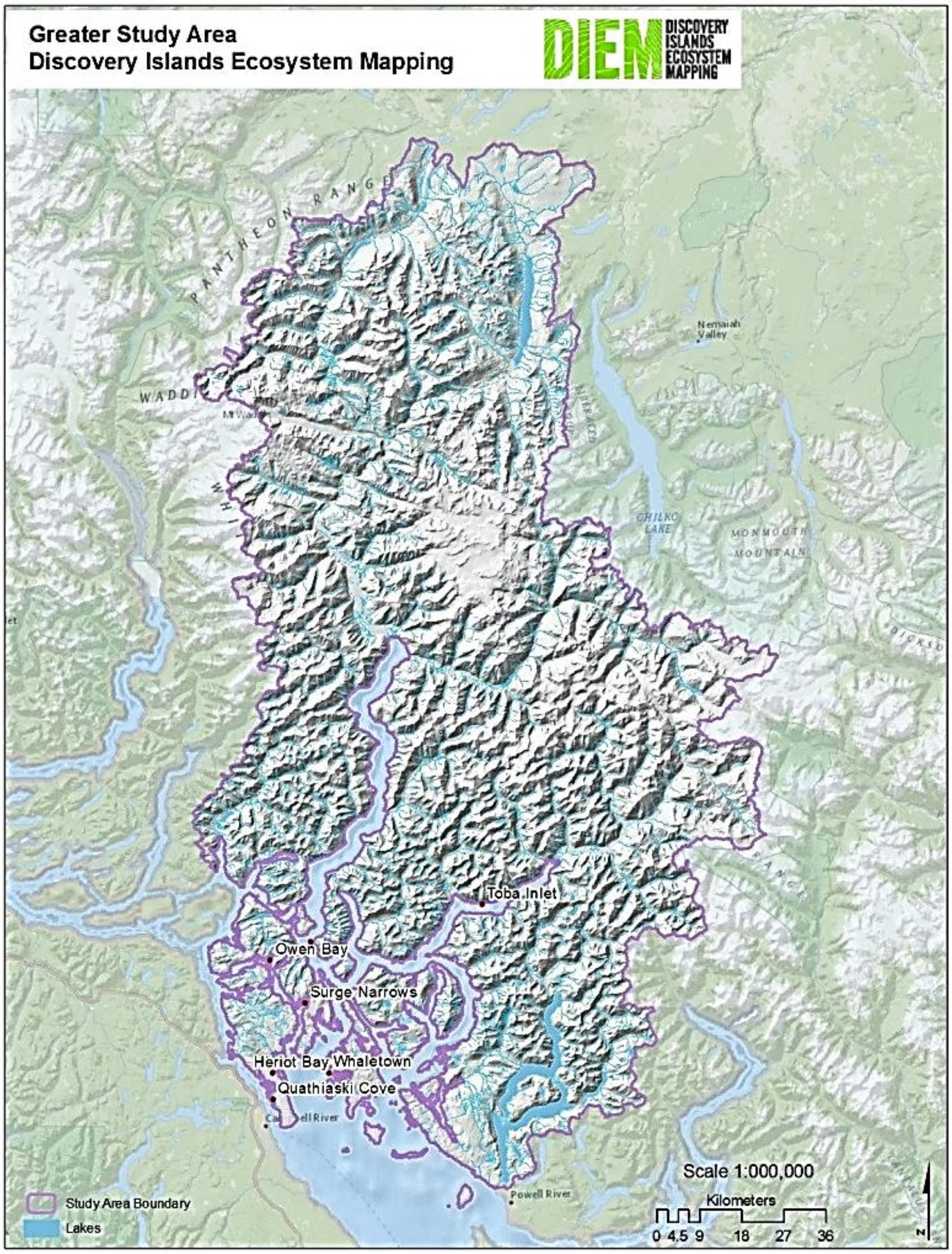

Figure 1. Greater Discovery Islands Study Area.

This goal of this project was to understand the condition of watersheds across the Discovery Islands and a portion of Bute Inlet on the mainland (See Figure 1). Further, we sought to create a baseline of documentation in order to measure changes in human activity over time and to identify watersheds having relatively low known human impacts.

Analysis of the findings yields an important planning tool and may support the future identification of priority watersheds based on a variety of key ecological, cultural, and economic values.

The project did not seek to identify watershed priorities, although it is possible to identify patterns of use and non-use through the maps and to begin to generally discern levels of importance within watersheds.

Measuring human linear fragmenting features offers an excellent surrogate, or proxy, to assessing human pressure on the land (Figure 2). For example, roads are always built for a purpose; in this study, area they have largely been built to gain access for forest harvesting activities.

Roads persist on the landscape and are conduits for additional uses, including motorised recreational access and other forms of land conversion, such as mining or residential development. Roads also exert direct impacts on ecological systems in a variety of ways, including road-stream crossings that increase sediment load directly into streams, channel alterations that impact fish habitat, improved access to remote areas by humans and predators, and engine noise that can affect fish and wildlife behaviour.

2.0 Definition and Measurement of Watershed Integrity

In this study, we have defined the integrity of a watershed by its current condition expressed as a percentage of the watershed having no linear disturbance from current human-caused fragmentation, and the size of areas in hectares (ha) that contain “dead-end” roads within them. Landscape areas containing no linear disturbances have the highest integrity and are referred to as “intact landscapes.” Watersheds can be entirely intact or can contain one or more intact landscapes within them.

Intact landscapes play an important role in maintaining the ecological values that characterise well-functioning watershed ecosystems: clean plentiful water, healthy forests, diverse wildlife, and opportunities for adaptation to an increasing rate of climate change. The intact areas are also good surrogates, or proxies, for capturing finer scale ecological attributes that support watershed integrity. For example, an intact landscape might contain wetlands, lakes, stream segments, and small patches of terrestrial habitat (e.g., old forest) that, together, function to sustain the plants, fish, and wildlife endemic to the area.

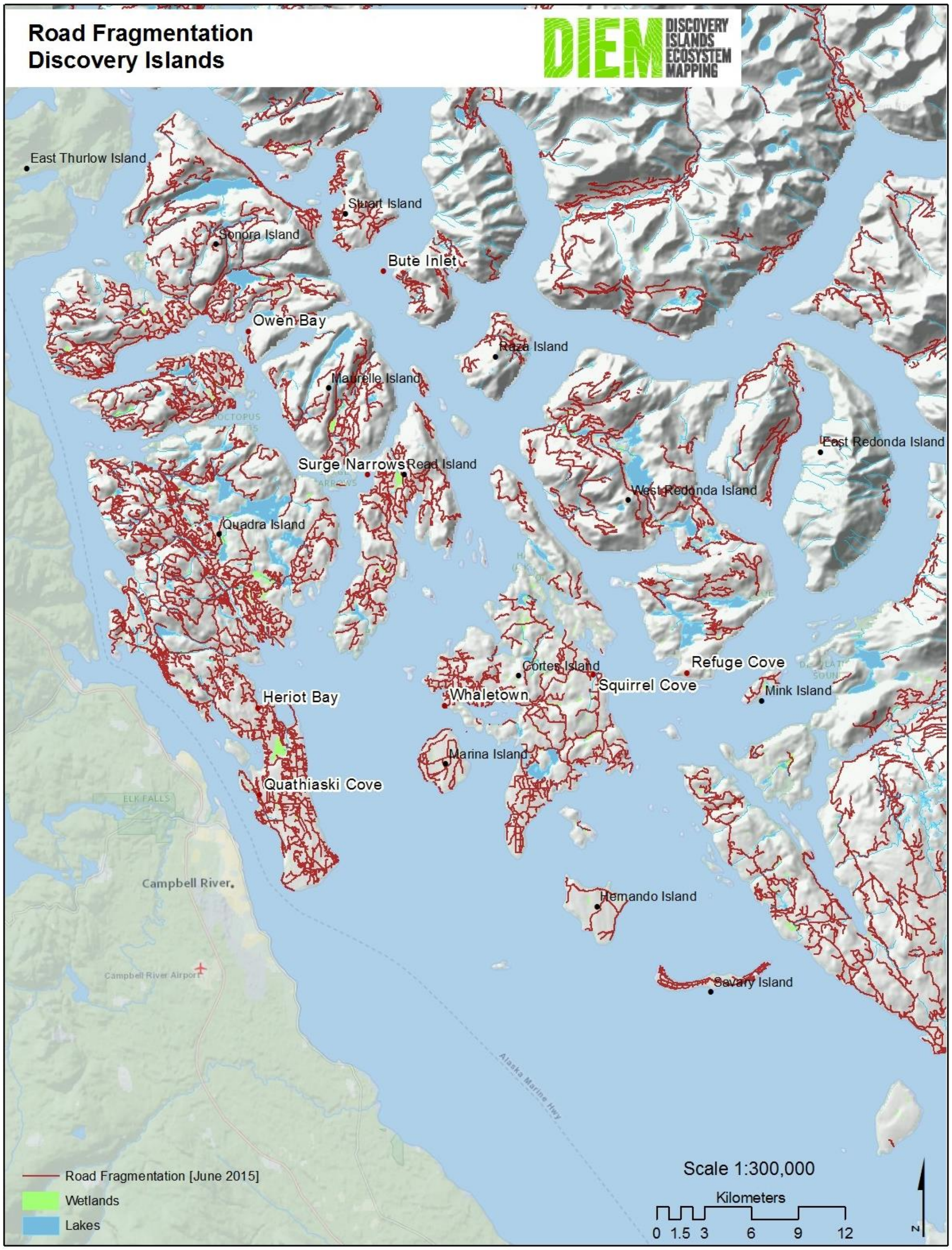

Figure 2. Discovery Islands transportation network primarily comprising resource roads (circa 2015).

Every linear human-caused fragmenting feature within an otherwise intact area is buffered by a distance of 100 meters. Any landscape beyond the buffered distance is without roads, etc. (see Figure 3). The buffer distance could be calibrated, or expanded or contracted, to better represent different road types and concomitant impacts on the natural environment and wildlife. A resource road and a highway are different in the type, frequency, and volume of vehicles they are designed to carry. For example, a gravel resource road is very likely to have seasonal usage, whereas a paved highway has year-round use.

Figure 3. Intact landscapes without roads in the Discovery Islands

Noise, pollution, lighting, and physical barriers to wildlife movement affect the surrounding landscapes in various ways that extend well beyond the edge of the road or other fragmenting feature. A more involved study, including broader and more detailed ecological and human values, could apply customised buffer distances to different transportation, utility, and pipeline features and generate a further defined set of intact areas. This study selected a reasonable middle-buffer distance as a general cover for all features equally.

3.0 Descriptions of the Watersheds

In addition to identifying where intact portions of watersheds are located and their percentage of the watershed area, the project analyzed select ecological and current human pressure statistics to support further watershed level descriptions (See Appendix Table 1). Additional attributes can be included in future work based on specific questions related to planning or evaluation. Two provincial watershed scales were used in the study area: Watershed Atlas 1:50,000 for mainland portion, and Freshwater Atlas 1:20,000 for the Discovery Islands.

A. Ecological attributes:

These include the watershed area and unique ID, lakes, wetlands, lake classification, old and mature forest, parks and protected areas, ecological reserves, elevation range, a variety of enduring features and geological classes, and the sensitive ecosystem inventory.

B. Human pressure attributes:

These identify the road class, density [km/sq km], and groundwater wells. The recent forest harvest map (Figure 4) shows watersheds themed by the percent of intact landscape contained within them. Generally, there is a higher number of intact watersheds in the eastern half of the Discovery Islands than in the western half. This pattern could be driven by ownership and/or forest licensee tenures. A map of recent forest harvest between January and October 2015 (Figure 5) also shows activity on the western half, with focused intensity on a few specific watersheds. Said differently, the harvest activity within a majority of the watersheds accounted for more than 20% of the watershed area, with one watershed showing greater than 50% of the area harvested. Many ecological and other values can be identified and mapped to support an understanding of both the similarities and the differences among watersheds and to describe the ongoing human pressures placed upon them.

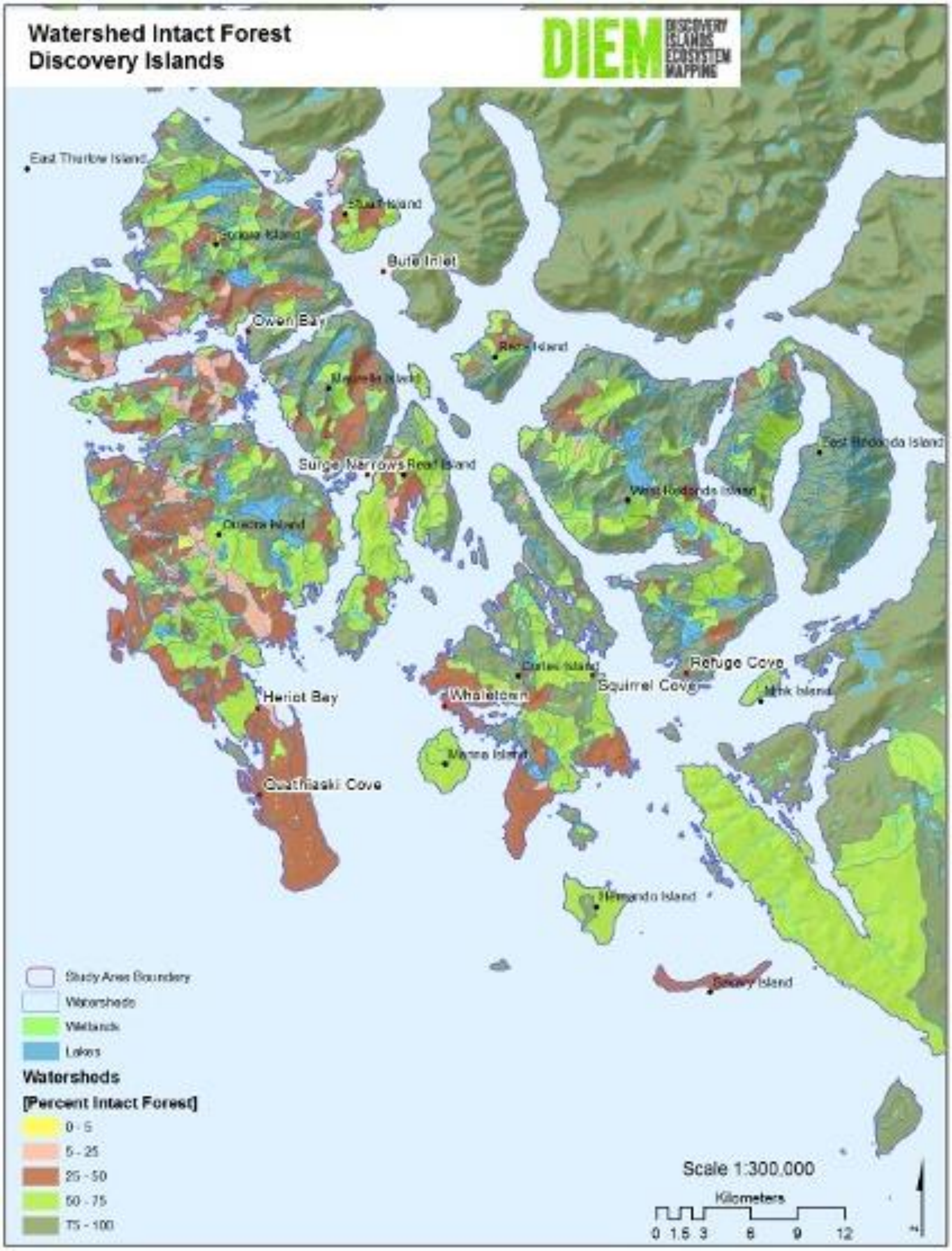

Figure 4. Watersheds themed by the percent of intact landscapes

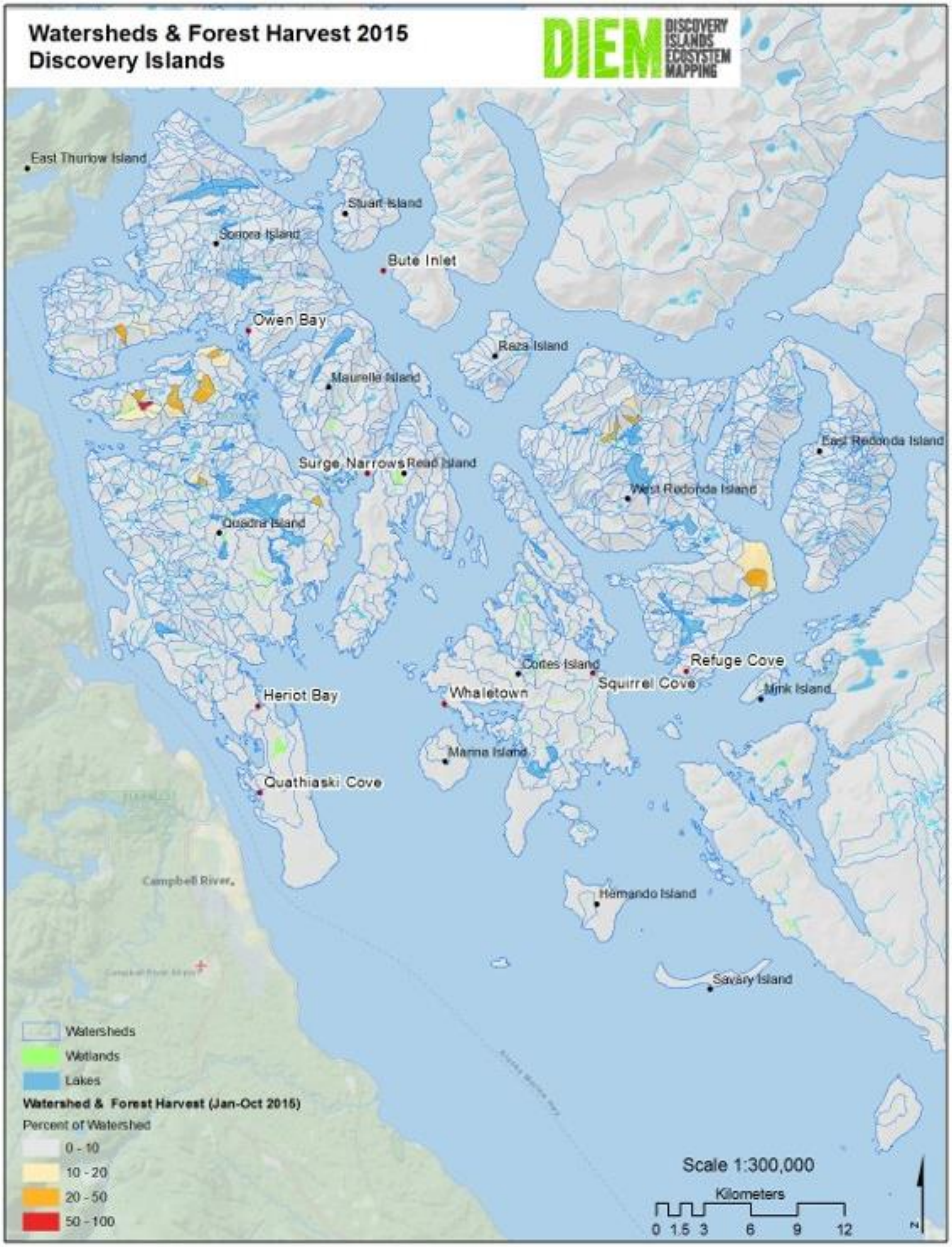

Figure 5. Watersheds themed by the percent of recent forest harvest activity between January and October 2015

C. Cultural attributes

Cultural features collected from community science "bio-blitzes" or cultural mapping exercises can be included in the database. Examples of these features include popular hiking trails, gathering or solo spiritual areas, scenic quality, biological inventories, etc., and represent specific cultural or recreational values important to the Discovery Islands communities that are or may potentially be at risk by proposed land conversions.

Over time, as these data are collected, they can be easily brought into the watershed database and maps to display cultural values associated with specific watersheds, as well as cultural values cross-queried with ecological or other attributes (e.g., solitude areas and intact forest).

4.0 Methodology for watershed visual interpretation and fragmentation (integrity) analysis

A visual validation method was developed to check the completeness and current state of the fragmenting features and analysis results. This method relies upon current satellite imagery that is freely accessible, 90% or greater cloud free, and less than 15 metre ground resolution. These criteria describe the conditions necessary to be able to see gaps in the data from ground feature signatures (e.g., new resource road development), and to enable digitisation. As a side note, Google services, such as Google Earth and Google Maps, provided current good quality imagery warehouses, although their user license agreement prohibits digitising from these services. A web mapping service (WMS) was used that met most of the above criteria. The imagery dates are different by satellite scene and image resolution. The 1 metre resolution data are generally circa 2012, or approximately four years old. Overall, 120 kilometres (117 new fragmenting features) were digitised almost entirely to complete resource roads. All features collected from authoritative provincial data were retained unless duplicates were found. This was often the problem in the provincial resource road spatial data and required significant clean-up by editing for single accurate road networks.

The approach taken for visually interpreting the fragmenting features included the following steps:

1. Identify the satellite imagery source for use in the validation. The ESRI web map service is located at http://goto.arcgisonline.com/maps/World_Imagery
2. Overlay a 1:50,000 index grid over the study area to organise visual inspection across the entire study area. Each index grid was further divided into digitising quadrants to provide a scale of approximately 1:5,000 to digitise additional fragmentation lines.
3. Visually review and screen-digitise new vector lines using ArcGIS following the centreline of the features and attribute with a numeric code indicating the type of fragmenting feature.

Editing, completing, and creating new road network data followed these basic steps:

1. Data

Two provincial spatial data layers were used for the transportation review. These were the best available public, no-cost, and provincial spatial data available at the time of the analysis. While it is possible TRIM data would have provided greater accuracy of road features (1:20,000), it is not known whether additional roads would have been captured. TRIM data are available for purchase from the province:

- Digital Road Atlas (DRA) - Master Partially-Attributed Roads
- Forest Tenure Road Section Lines (FTEN) - Resource Roads

2. Approach

The two data layers were spatially compared to determine the extent of overlap and to confirm road classes (the type of road). Each layer was reviewed for completeness by overlaying on a current satellite or aerial photo image. Progress was organised by 1:20,000 index tile, reviewing one tile at a time. The road features visual examination is at a scale range of approximately 1:5,000 to 1:15,000. Road edits and additions were made on-screen and attributed with a new project fragmentation identifier to distinguish the general class of road, e.g., local paved, or resource road/dirt, gravel.

3. Evaluation

The FTEN resource roads layer required significant time and effort to review and revise. Four problems with the data were identified:

- <u>Currency</u>: The data are outdated as many roads on the imagery were absent in the spatial data (see figures 6 and 7).
- <u>Error</u>: Many road segments in the spatial data did not appear on the imagery or within the signatures associated with a harvest area. Road fragments abound. These were small disconnected fragments.
- <u>Completeness</u>: The resource road network was often incomplete. For example, road segments are missing leaving gaps in the network. Orphaned road segments were found. These are in isolation of any surrounding road network. Numerous roads were absent from the data layer yet visible on high resolution imagery.
- <u>Redundancy</u>: Many duplicate features existed, including identical road networks slightly offset in their spatial location. Parallel road networks sometimes traced slightly different routes (see Figure 8). Due to project time constraints, not all redundancy could be corrected in the data.

Figure 6. Unedited road network on Quadra and Maurelle Islands

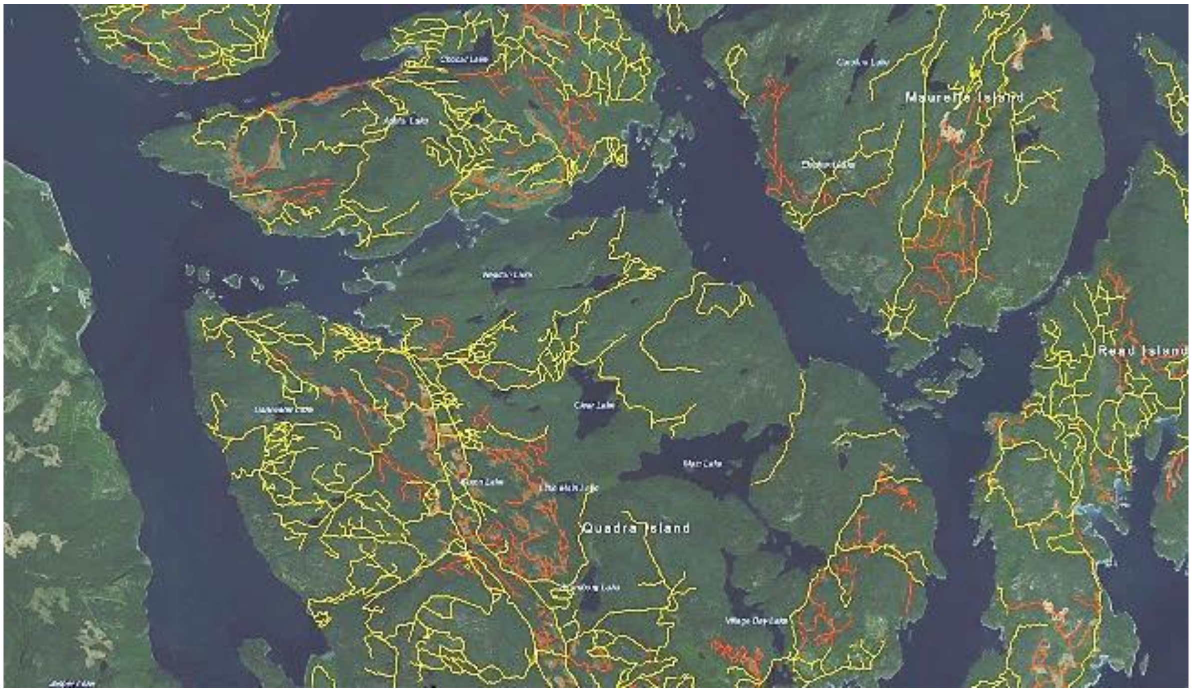

Figure 7. Missing roads digitised (in red) from satellite imagery

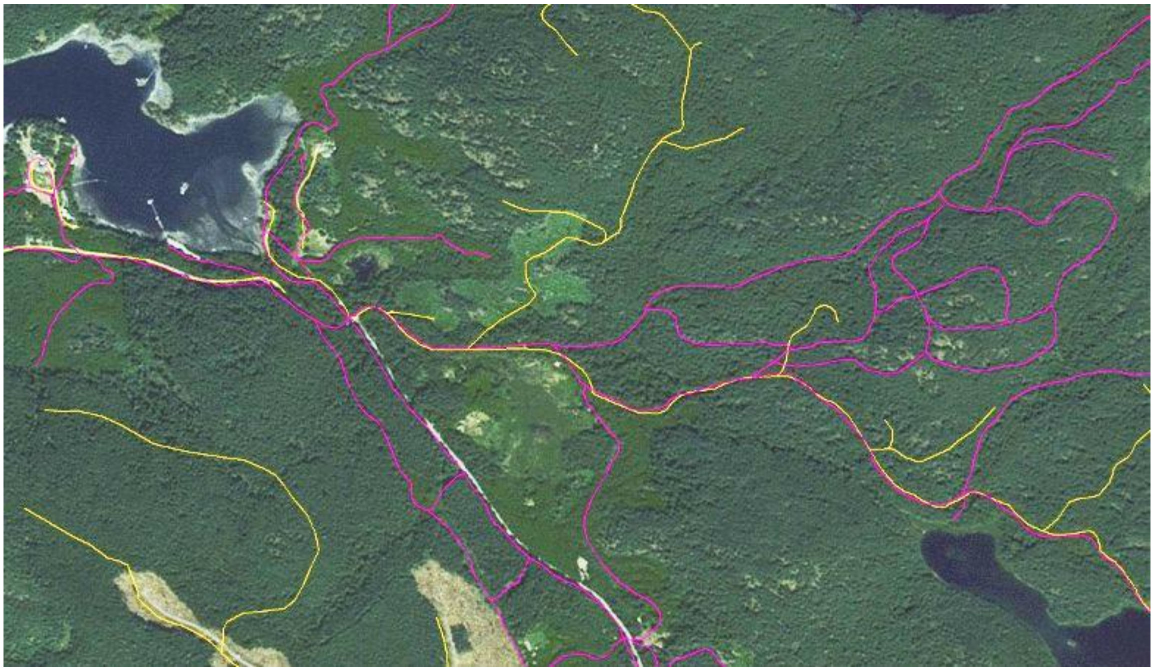

Figure 8. Overlapping and offset roads on Quadra Island from two different data layers: provincial forest tenure resource roads (yellow) and provincial digital road atlas roads (purple).

Watershed integrity, meaning the amount of intact, unfragmented landscape within the watershed boundary, was evaluated using the following approach:

1. Within each watershed landscape, areas without roads were identified by running an analysis to create polygons between road lines across the entire study area. Said differently, any area between road segments was enclosed and joined together so that it was entirely bounded by roads without any intrusions or bisections. This is referred to as an intact landscape area. To generally represent the impacts roads have along their corridor areas (sound, pollution, edge effects, etc.), we included a 50 metre buffer on either side of the road centreline and removed this buffer area from the intact areas, reducing their size. Different road types have different impacts on the surrounding landscape (paved *vs* dirt, single lane *vs* multiple lanes) and it would be possible in the future to refine the buffer distance based on road type. In this study, a single buffer distance seemed reasonable based on the predominance and characteristics of the resource road type. Watersheds were populated with statistics measuring the percent and area of intact landscape within.
2. The density of road networks within each watershed was calculated to provide a relative comparison between watersheds to enable an understanding of where human pressures have been greater or smaller. The road density unit is measured in kilometres of road per square kilometre (km/km sq).

5.0 Conclusions

Compiling, editing, and completing a current transportation network data theme provides a powerful, multi-purpose information base with which to quantify and document the state of the watersheds within the Greater Discovery Islands ecosystem. Roads are a useful proxy to determine the extent of human pressure in terms of current and future land conversions and it is possible to identify the landscape areas that are currently in an intact, and possibly undisturbed, condition.

Intact areas of a watershed are important for maintaining ecosystem processes, including nutrient recycling, hydrologic regulation and filtering, and resilience to stressors, such as disease and natural disturbance events. These functions increase in their importance to watershed health when the lens of a rapidly changing and unpredictable future climate is overlaid on our contemporary interpretation of the condition of watersheds and landscapes.

Mapping watersheds and their characteristics can benefit planning exercises by assisting in identifying those watersheds that could be highlighted for special management or to plan for the amount of human pressure (e.g., forest harvest) that could be placed on them. These pressures can be understood as the number of individual proposals for land conversion AND the cumulative impacts of all land conversions up to the present and proposed for the future. An understanding of cumulative impacts from individual activities prompts an important conversation about how much human pressure is sustainable when weighed against other values in the landscape (i.e., recreation, visual, spiritual, cultural, economic, etc.).

This project creates a baseline year (2015) that can be compared against future years to document temporal variety and change for several ecological, human use, and cultural values. For example, the road network can be easily reviewed to calculate the change in road density for a period of time, or the area of forests harvested can be shown by watershed; this can highlight specific parts of the landscape in the study area having more, or less, human pressure. Conversely, those watersheds where land conversions are concentrated may be identified and monitored more closely.

As rapid climate change becomes our new norm and disrupts historic patterns of seasonality, moisture, species movement, heat, and natural disturbance events, we need more tools and more conservative approaches in our planning and actions to maintain biodiversity health. A precautionary approach is recommended; where large areas of intact ecosystems are better than small patches, and networks enabling latitudinal and altitudinal connectivity enable unhindered movement of species. This project has created tools and data to achieve these primary goals and to assist in creating a farsighted approach to the future by visualising and quantifying changes to watersheds over time. By rationalising the compounding impacts of human-caused land conversion activities, we see a larger story of cumulative impacts on our landscapes that can inform our responses and knowledge about when and how our own well-being is at risk.

Appendix 1

The study area includes over 2,500 watersheds. Each watershed is populated with a select set of ecological and human pressure attributes that may be updated over time and added to as specific needs arise.

In the snapshot below, those watersheds provided with a name by the provincial gazetteer are listed in the column "Watershed Name." The size of the watershed is listed next, using hectares (ha).

Intact landscapes, or those areas without road fragmentation, are described by both the size of the areas in hectares and the percent of the overall watershed. In this selected set, almost all of the watersheds are nearly completely without roads.

The Theodosia River watershed (mainland east of East Redonda Island) stands out in this sample with 76% intact landscape, 6% old growth forest, and a very small amount (1 %) protected. Between January and October 2015, approximately 3% of the area had forest harvest activity.

Table 1 Example of select attributes describing each watershed.

Watershed Name	Watershed Area [ha.]	Intact Area [ha.]	Intact [%]	Protected [%]	Old Forest Area [ha.]	Old Forest [%]	Harvest Jan-Oct 2015 [%]
Jewakwa River	27,521	27,207	99	0	3,425	12	0
Heakamie River	23,558	22,875	97	0	2,822	12	0
Brew Creek	19,671	19,063	97	0	5,480	28	0
Whitemantle Creek	15,730	15,575	99	0	4,073	26	0
Falcon Creek	15,175	15,175	100	2	4,616	30	0
Tiedemann	14,653	14,653	100	7	5,707	39	0
Razor Creek	13,972	13,972	100	0	2,851	20	0
Scar Creek	14,881	13,607	91	0	8,187	55	0
Valleau Creek	13,346	12,962	97	0	5,716	43	0
Hell Raving Creek	10,172	10,166	100	0	418	4	0
Cumsack Creek	5,163	4,880	95	0	4,733	92	1
Theodosia River	10,504	7,940	76	1	631	6	3
Nude Creek	19,880	19,880	100	1	1,438	7	0
Fossil Creek	900	872	97	0	574	64	0
Paradise River	26,252	25,064	96	0	23,936	91	0