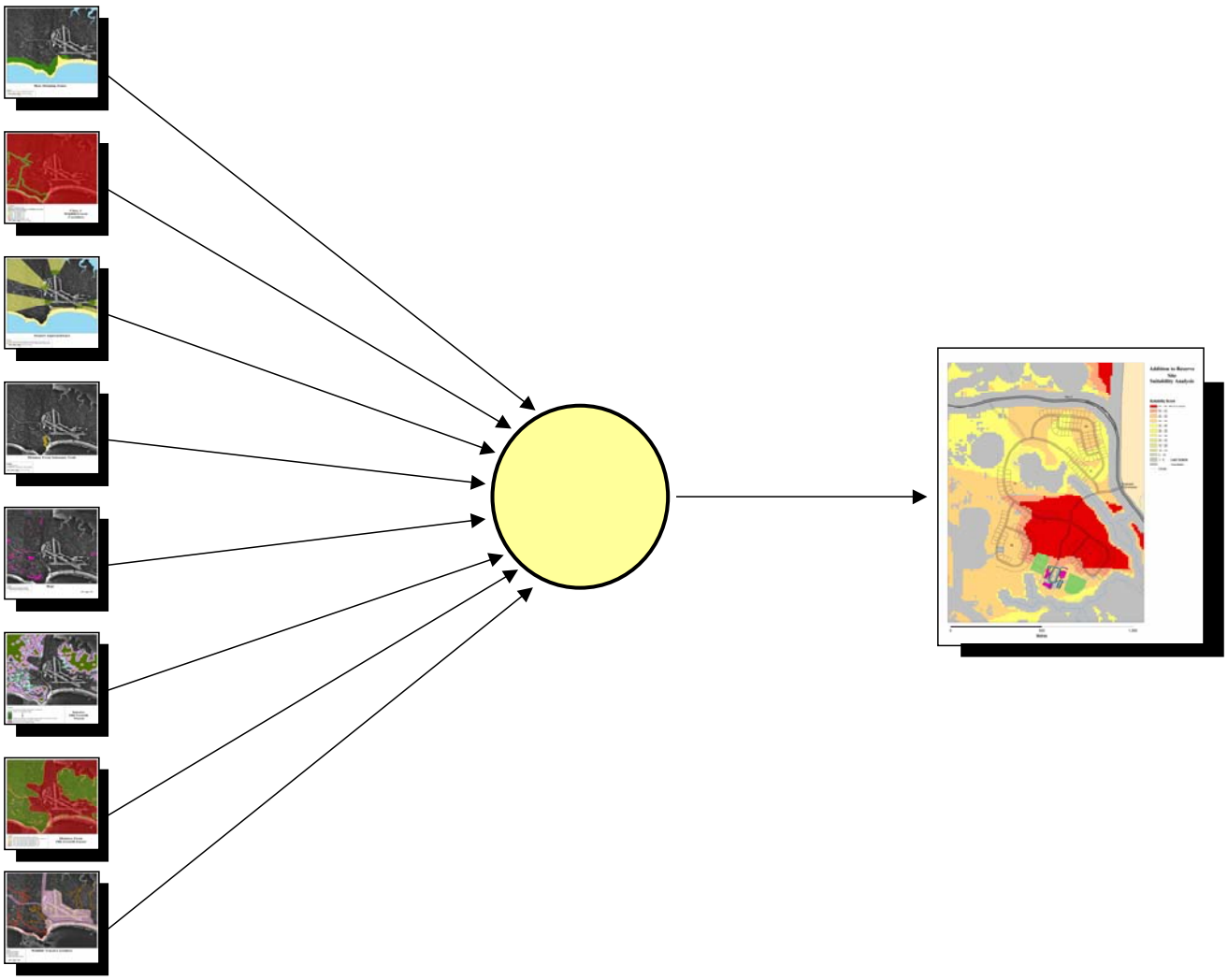
GIS SITE SELECTION ANALYSIS

for the Removal of Lands from Within
Pacific Rim National Park Reserve of Canada
for An Addition To
Esowista Reserve (IR # 3)



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1. Introduction:

This document explains the site selection process referred to in Step 4, Section A of the *Strategic Environmental Assessment for the Reversion of Lands From Pacific Rim National Park Reserve To the Tla-o-qui-aht First Nation* . It describes a process that used a Geographic Information System (GIS) to find a site that would result in relatively less damage to the ecological integrity of the Park Reserve.

Rationale for Using a Rule-Based Site Selection Analysis:

The process of finding the best location for the addition to reserve needed to address many ecological integrity and social concerns. The ecological integrity concerns considered both immediate loss of ecological resources when the land is developed, and longer term cross-boundary effects on remaining park lands. Parks Canada also needed to ensure that the "visitor experience" of the National Park Reserve was not degraded. Social concerns included size and shape requirements for community layout, and proximity to the existing Esowista Reserve (IR 3).

Eventually, a community boundary had to be drawn on a map. One approach could have to been to draw a community boundary, then try to manage the resulting damage to ecological integrity. Instead, Parks Canada used a GIS analysis which produced a map showing areas that could be developed with relatively less environmental impact. (See Figure A-1). Once the map was produced, a community boundary was drawn that conformed to the most suitable areas. This boundary is shown on the map in Figure A-2.

The analysis used a set of "rules" that addressed various ecological and social concerns. The rules arose from the judgement of experienced park staff; field observations and data; peer-reviewed literature; and standards developed by the *Scientific Panel for Sustainable Forest Practices in Clayoquot Sound*. This rules-based system provided an unbiased site selection that was transparent and focused on important issues. As rules were changed, or as data about what is on the ground improved (e.g. a better stream map was acquired), the analysis was re-run and within a few minutes, an updated site suitability map produced. If the results of the analysis were too restrictive (i.e. community needs could not be met), the rules were discussed and adjusted until a workable solution was found. A by-product of this type of a decision system was the ability to determine the ecological cost of developing any site in the landscape.

Information required by the analysis came from a number of different sources including satellite imagery, interpreted air-photos, field data, Global Positioning Systems, and different base-maps. All needed to be organized by the GIS in a systematic way that controlled error.

Much of the information that helped to select the site could be produced only by GIS analysis. Some of the rules used to find a suitable site required maps that relied on

calculations of distance to the nearest stream, or the identification of interior old-growth forest. The analysis divided the area of interest into 10 metre squares (for a total of 375 000 squares), and evaluated each square for ecological or impact or effects on the quality of visitor experience in the Park. Each run of the analysis took the computer fifteen seconds to perform.

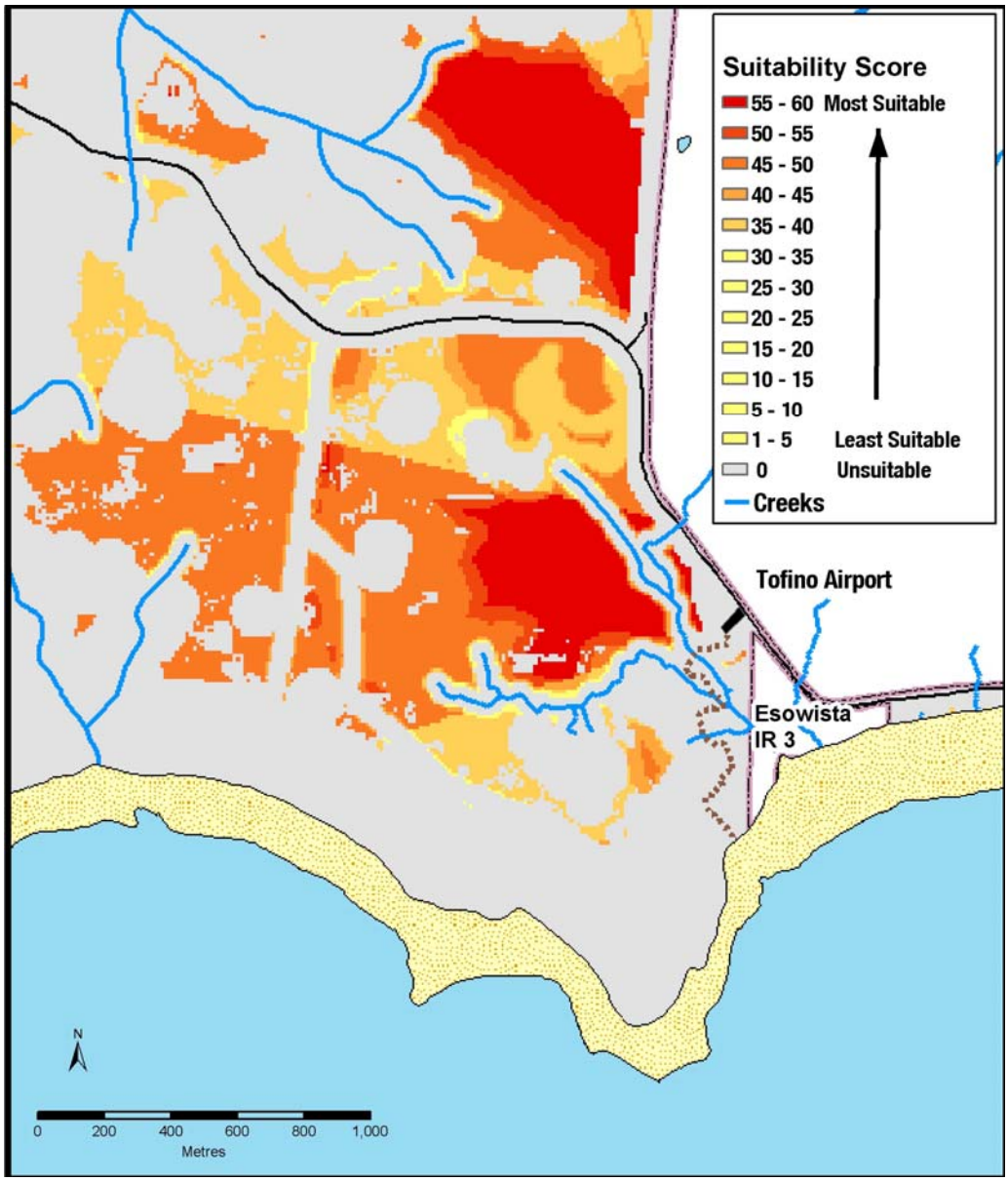


Figure A-1: *This map shows Suitability Scores for removal of lands from Pacific Rim National Park Reserve of Canada for the Addition To Esowista Reserve (IR 3). The map was produced by a Site Selection Analysis undertaken by Parks Canada. Areas in red represent areas that, if developed, would result in relatively less damage to ecological integrity of the remaining National Park Reserve. Areas in gray identify places rated as unsuitable by the analysis because additional mitigative measures would not sufficiently protect the ecosystem from damage.*

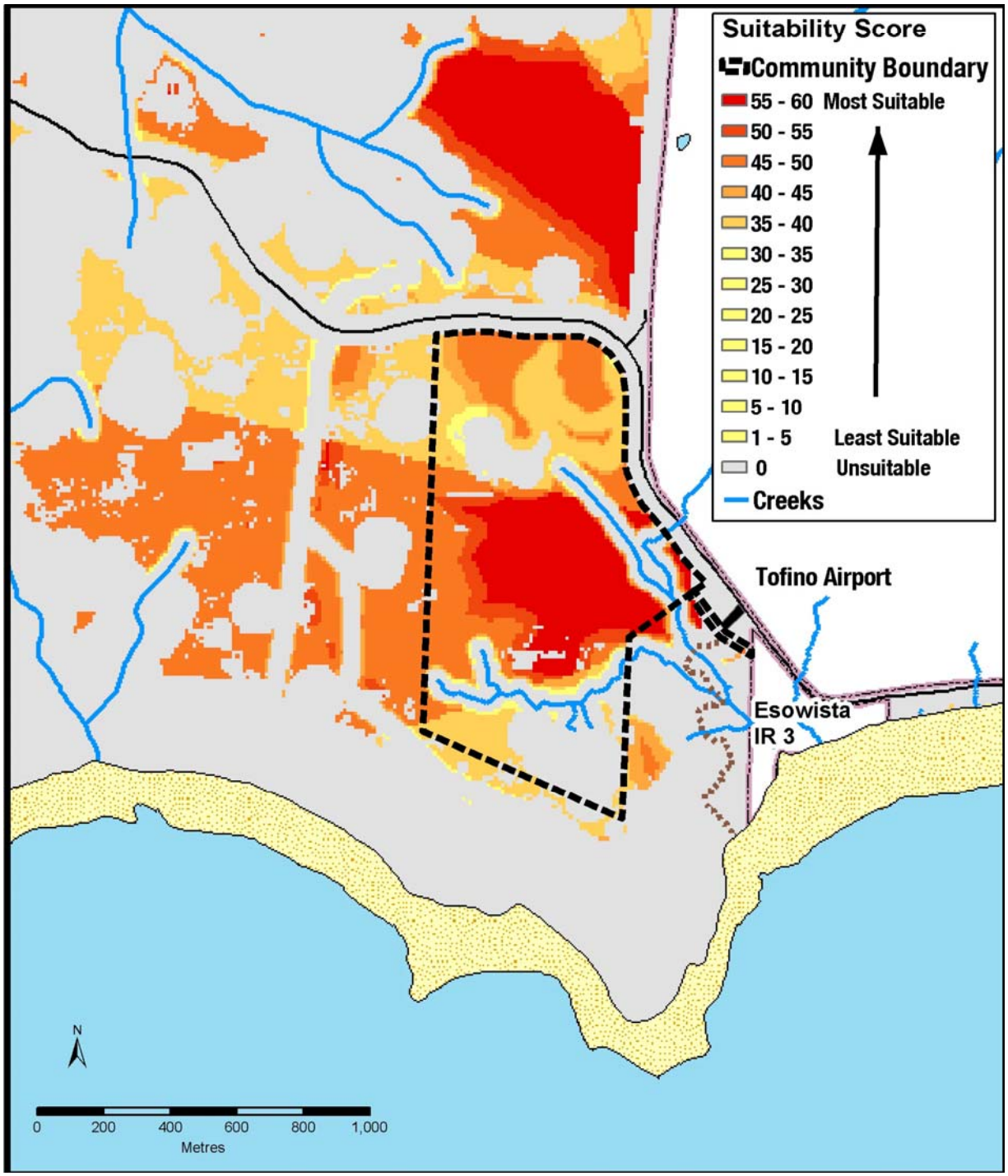


Figure A-2: *The Suitability Map from Figure 1 was used to draw a community boundary that would result in less impact on ecological integrity to the National Park Reserve. The boundary balances the ecological requirements of the Park with social design requirements of the community.*

2. Methods:

A steering committee developed the rules for site selection. This process was facilitated by the Park Data Management Officer, and the committee consisted of: the Park Environmental Assessment / Cultural Resources Officer; Wildlife – Human Conflict Specialist Park Warden; Park Terrestrial Ecologist; Chief of Resource Conservation for the Park; and the Park Superintendent.

Input maps were assembled (See Section 3) and the analysis was run. After examining output and discussing the rule system, adjustments were made and the model was re-run. Table A-1 shows a summary of the equation used in the final run of the analysis. The rule system and rationale for each rule are described in Section 3, along with maps related to each rule. Output of the final model is shown in Figure 17 (in body of the Strategic Environmental Assessment) and in Figure A-1.

1. Rules to Find Unsuitable Areas: (assigned a score of 0)

- In an airport approach-way and less than 330 m from end of a runway
- Less than 30 m from a creek
- Less than 50 m from the Schooner Trail
- Less than 50 m from Pacific Rim Highway (centre-line)
- Less than 30 m from a Class A Wildlife Corridor
- Within the Spruce Fringe Ecosystem
- Slope of greater than 20 %
- In a bog that is at least 4 Ha in size
- Within 300 m of the shore vegetation line (Bear Den Protection)
- Within 20 m of an Archaeological Site
- Areas that would result in the loss of Interior (75 m) Old Growth Forest

2. Rules to Determine the Relative Suitability of Remaining Areas: (additive scoring)

Creek Distance Bonus:

- 30 – 34 m from a creek + 2
- 34 – 38 m from a creek + 4
- 38 – 42 m from a creek + 6
- 42 – 46 m from a creek + 8
- 46 m + from a creek + 10

Class A, B, or C Wildlife Corridor Distance Bonus:

- 30 – 34 m from a Class A Wildlife Corridor + 2
- 34 – 38 m from a Class A Wildlife Corridor + 4
- 38 – 42 m from a Class A Wildlife Corridor + 6
- 42 – 46 m from a Class A Wildlife Corridor + 8
- 46 m + from a Class A Wildlife Corridor + 10

Airport Approach-way Bonus:

- In an approach-way vegetation management zone + 10

Distance from Old-growth CWH Forest Bonus:

- 10 – 20 m from Old-growth + 2
- 20 – 30 m from Old-growth + 3
- 30 – 40 m from Old-growth + 4
- 40 – 50 m from Old-growth + 5
- 50 m + from Old-growth + 10

Table A-1: *This table shows the rule system used by Analysis to produce the Suitability Map shown in Figure 1. Rules were developed by a steering committee and were based on professional judgement, field observations and data, peer reviewed literature, and standards developed by the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound.*

Site Selection Analysis Concepts:

One of the objectives of the Site Selection Analysis was to make the choice of site location transparent and well documented. An explanation of this type of GIS analysis follows. In order to understand the analysis, the reader should understand five basic concepts:

vi. Thematic Layers
vii. Conversion of Maps to Rasters (Grids)
viii. Elimination of Unsuitable Areas
ix. Scoring Suitable Locations
x. Combining (iii) and (iv) to Map the Suitability of Acceptable Locations.

i. Thematic Layers:

Maps in a GIS are stored as individual layers. Each layer has a theme (such as "streams"), and the layers stack up on one another like cards in a deck. One "card" or layer might be a map of Wildlife Corridors. Another layer might show Forest Type. To produce a "composite map", the GIS would to pull these two layers from the GIS and overlay them so they line up correctly. Figure A-3 illustrates the concept of thematic layers.

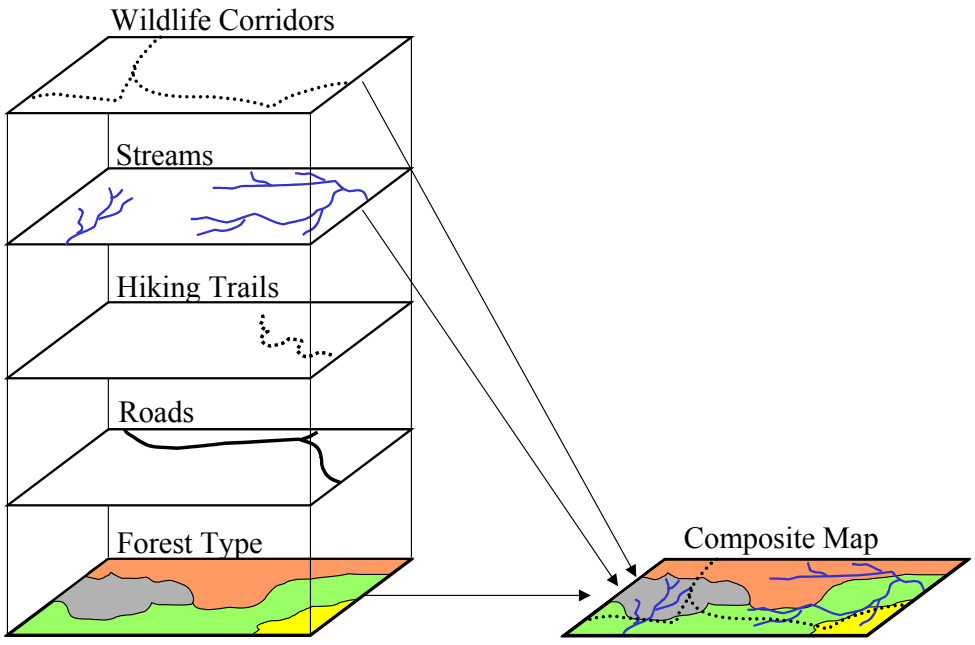


Figure A-3: A Geographic Information System (GIS) stores maps as separate "thematic layers". Individual layers can be selected and overlaid on one another to produce a "composite map".

ii. Conversion of Maps to Rasters:

In order to perform the site selection analysis, each layer was converted into a "raster". This process is analogous to draping a large net over the landscape. Each square would contain a number that describes what is found on the ground at that location. For example, a *Land Cover* layer might use the number 2 to represent Beach, 3 for Second-Growth Forest, and 5 for Bog. In other layers, numbers in could represent conditions such as the distance of the middle of each square to a wildlife corridor.

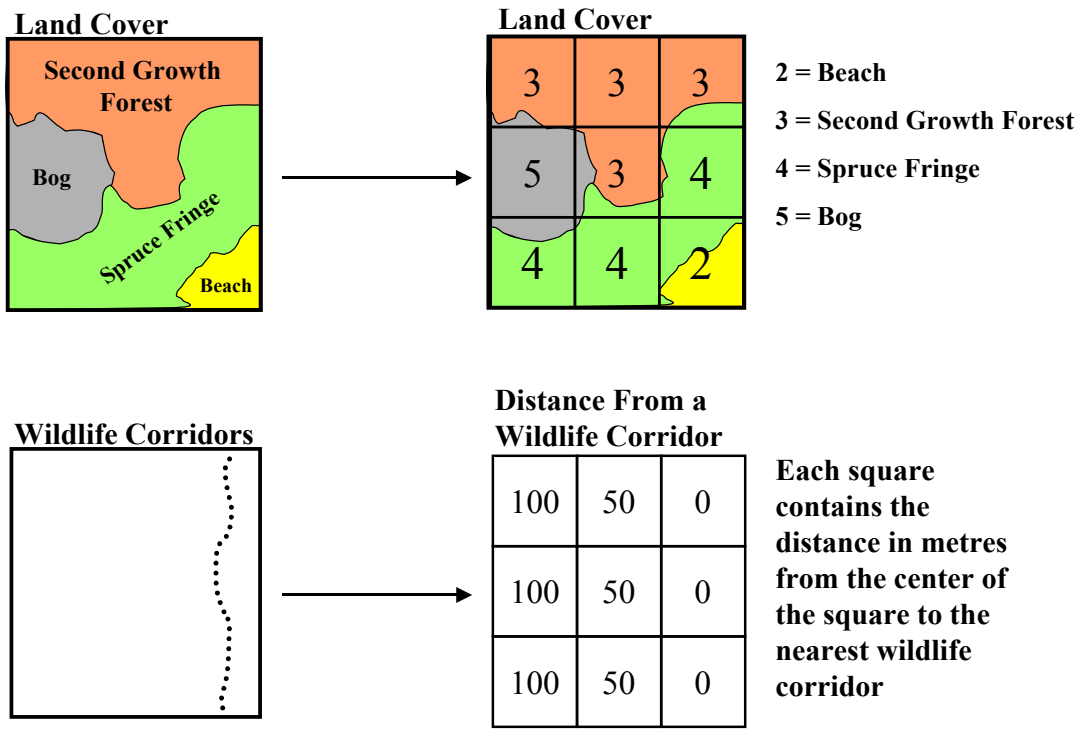


Figure A-4: *Maps are converted to rasters or grids. Each square in the raster represents a condition on the ground. This allows maps to be compared to each other by the GIS. In the upper example, the number 3 is used to represent areas that are predominantly second-growth forest while the number 4 represents Spruce Fringe Forest. In the lower example, each square contains the distance in metres from the centre of each square to the nearest wildlife corridor.*

iii. Elimination of Unsuitable Areas:

One aspect the Analysis was to identify areas where development would result in a significant loss of ecological integrity. In these sensitive areas, additional mitigative measures incorporated into planning, design and construction of a new residential area would not sufficiently protect the ecosystem from damage. The result would be a compromise of the ecological integrity of the local area and areas of the remaining Park Reserve. The steering committee identified a set of rules called ***elimination criteria***. Places where any of these rules were broken were eliminated from further consideration. An illustration of how places are eliminated can be seen in Figure A-5. A list of elimination criteria used by the model appears in Table A-1 in the section labeled *Rules to Find Unsuitable Areas*.

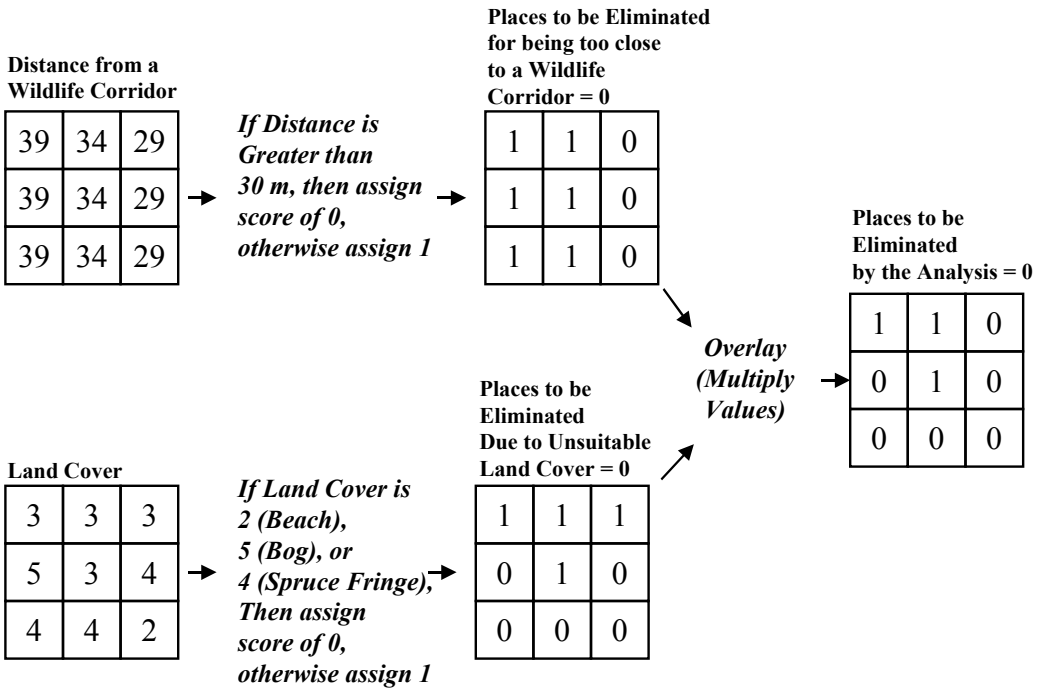


Figure A-5. Raster maps contain values representing conditions on the ground. In the top example, a rule is applied that instructs the GIS to eliminate any places that are closer than 30 metres to a wildlife corridor. In the second example, places that are Beach, Bog, or Spruce Fringe Ecosystem are eliminated. Once the two elimination maps have been produced, the unsuitable areas can be combined by multiplying the values in each map.

iv. Additive Scoring:

The second part of the Analysis was to rate the relative suitability of areas not eliminated by the model. Development in these areas will have less of an effect on ecological integrity provided that mitigative measures are implemented. Thus, the second set of criteria uses ***additive scoring*** to rank areas in terms of their ability to accommodate development without affecting ecological integrity. The scores for each criteria are summed together to determine a total for each location. The higher the score, the more suitable the land is for development.

The steering committee developed rules which assigned scores for different ground conditions. The rules used in the additive scoring part of the analysis are listed in Table A-1 under the title: ***Rules to Determine the Relative Suitability of Remaining Areas***. The concept of additive scoring is illustrated in Figure A-5.

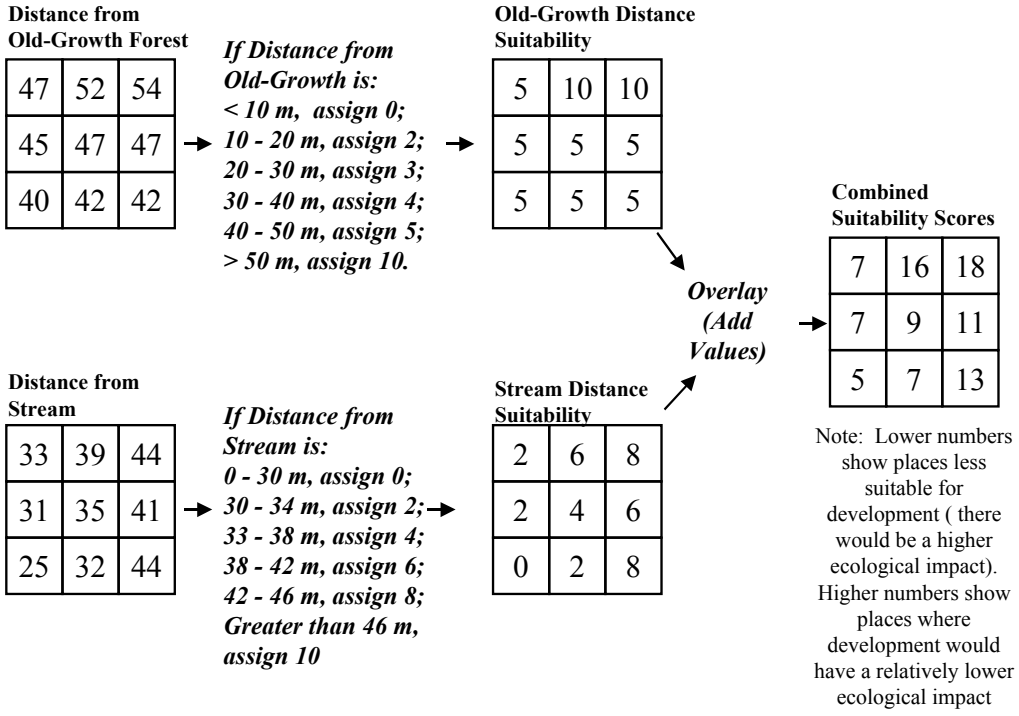


Figure A-5: *This figure illustrates the concept of additive scoring. Additive scoring was used to rate the suitability of areas based on a set of rules. A set of rules tells the GIS to examine each square in the map and assign it a new value. The center of the upper left square of the Distance from Old-Growth Forest map is 47 metres from old-growth forest. According to the rule system, the upper left square of the Old-Growth Distance Suitability Map is assigned a score of 5 out of 10. In the lower half of the illustration, a different set of rules is applied to the Distance from Stream map to create a Stream Distance Suitability Map. (Note that processes of score normalization and assigning weights have been omitted for illustrative purposes).*

v. Combining *Additive Scoring Results* with *Areas to be Eliminated Results*:

Some areas may score well on a suitability map that was created by additive scoring, but may have one ecological factor that would be damaged by development. The final step in the analysis process is to overlay the eliminated areas map with the suitability scores map. This process is illustrated in Figure A-4.

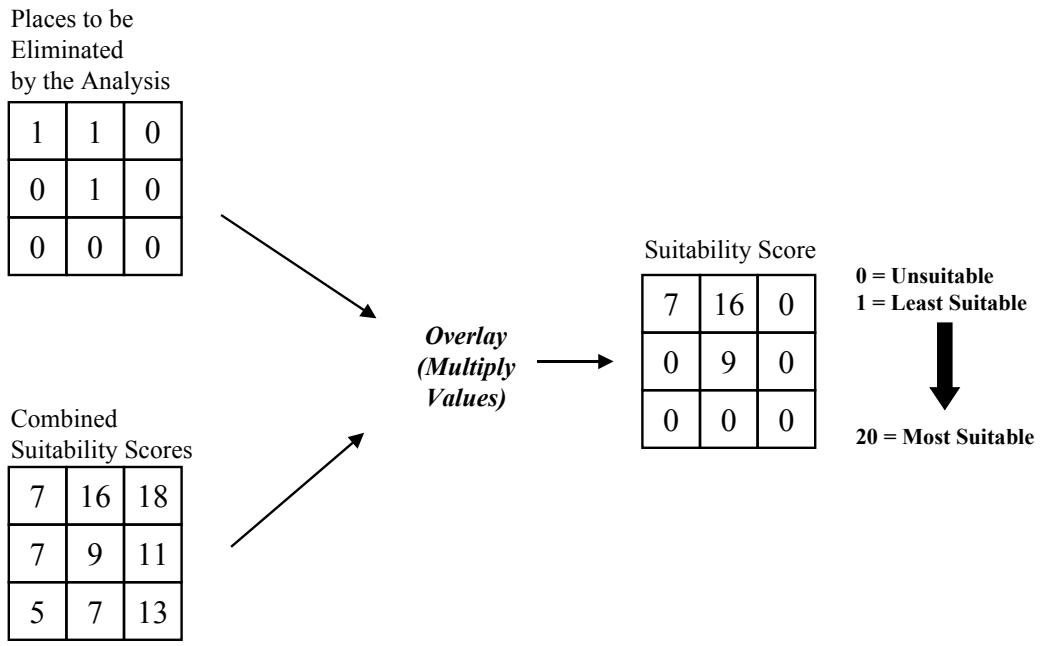
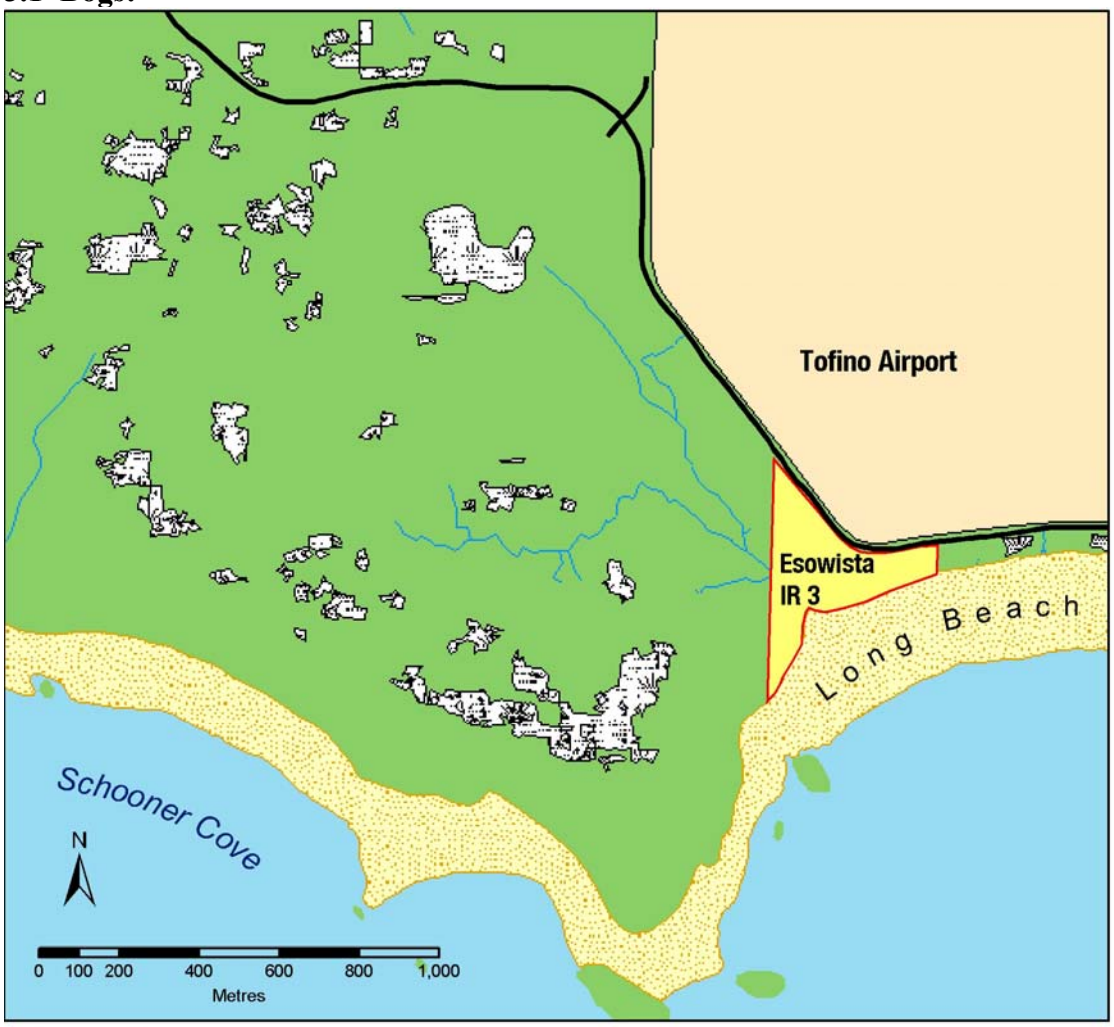


Figure A-4: This illustration shows how combined suitability scores are combined with areas that need to be eliminated from the model. Any places that are not eliminated retain their suitability scores.

3. Rules Used to Select the Most Suitable Site:

This section explains the rules used in the Site Location Analysis listed in Table A-1. Each rule is accompanied by a map showing pertinent GIS data.

3.1 Bogs:



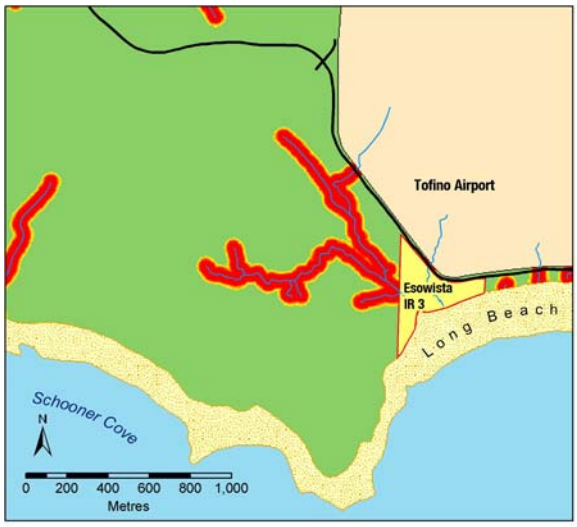
Rule: Exclude areas that are in bogs at least 4 hectares in size.

Rationale:

- Bog habitats are unique ecosystems and are the location of special plant communities.

- Bogs are important habitat for wildlife movement and foraging
- Bogs are important to hydrology, by releasing water slowly from the area.

3.2 Streams:



Rules:

1. Exclude Areas less than 30 metres from the edge of a known stream.
2. Areas 30 – 34 m from a stream, score + 2
3. Areas 34 – 38 m from a stream, score + 4
4. Areas 38 – 42 m from a stream, score + 6
5. Areas 42 – 46 m from a stream, score + 8
6. Areas Greater than 46 m from a stream, score + 10

Rationale:

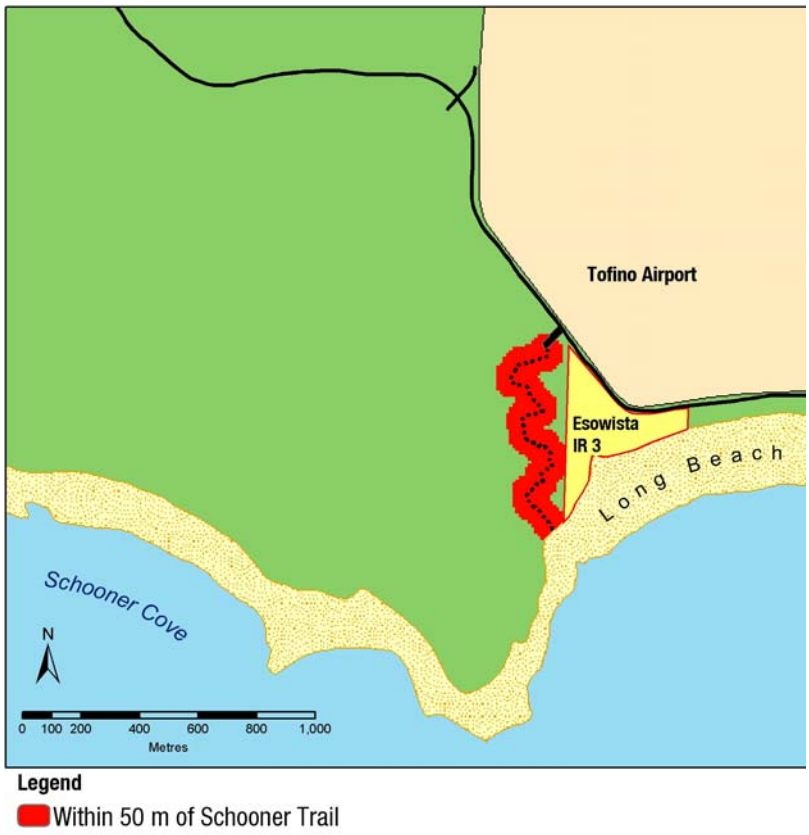
- Areas within 30 metres of the present channel should be preserved. This includes streams with alluvial channels less than 3m wide, non-floodplain, with gradients between 0% and 20%. (The Scientific Panel for Sustainable Forest Practices in Clayoquot Sound (1995). Recommendation R7.19 In Class A(2) (i))

- Buffers ensure the protection of fish habitat. Esowista Creek was surveyed for location (using Global Positioning Systems, compass, and chain) and were surveyed for fish presence. Resident trout were observed.

- Although no salmon were observed, it is believed that the large woody debris dam at the mouth of the creek (in the existing Esowista reserve) is preventing salmon from returning to the stream.

- Beyond the 30 m riparian buffer suitability for development increases along a gradient with distance from the stream. As distance between development and a creek increases, better protection is afforded.

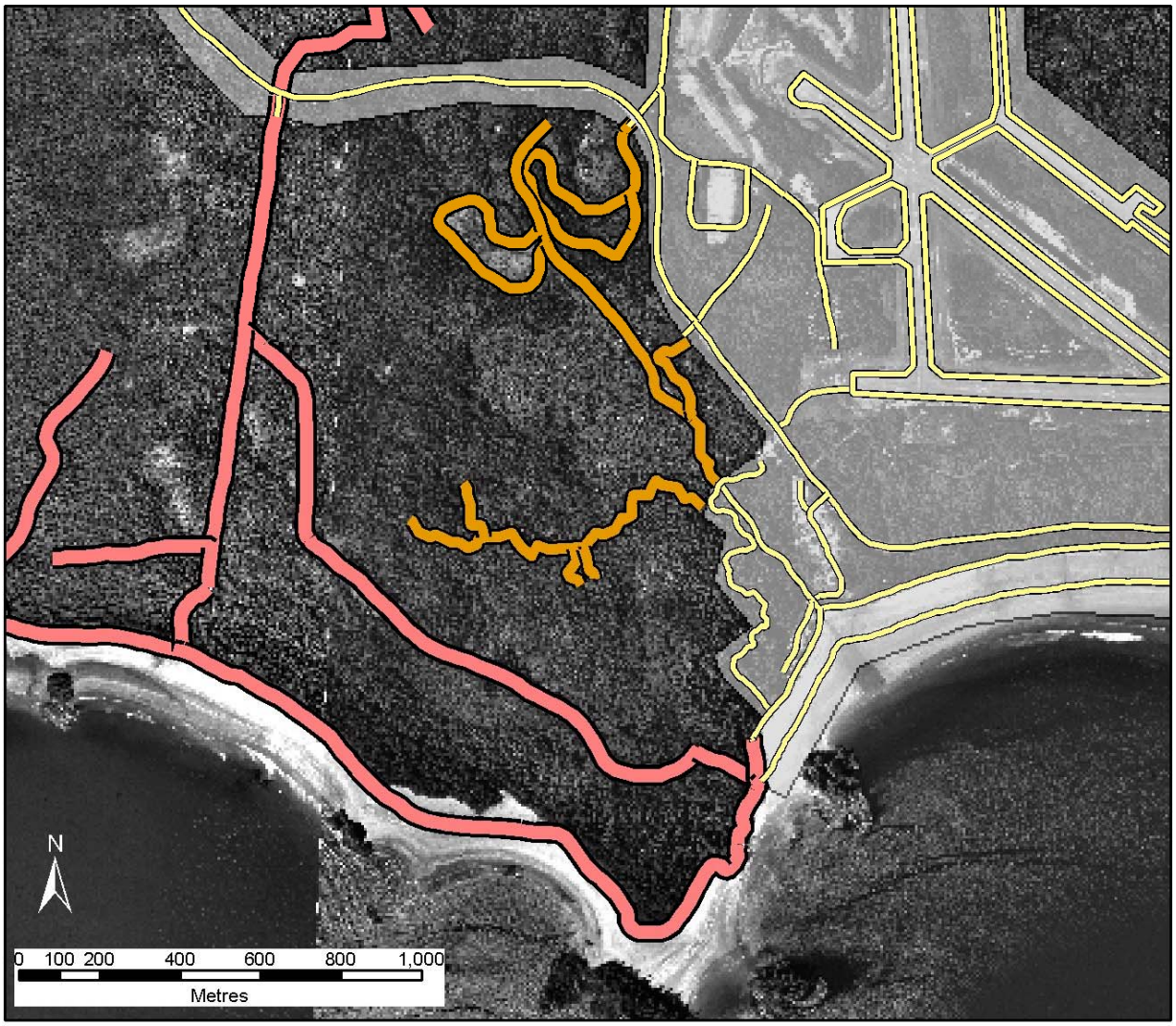
3.3 Schooner Cove Trail:



Rule: Exclude Areas within 50 m of the Schooner Trail

Rationale:
Trail counter systems indicate that the Schooner Trail is one of the most-used trails in the Long Beach Unit of Pacific Rim National Park Reserve. The visual and auditory qualities of nature, and the opportunity to view wildlife in natural surroundings contribute to that experience. 50 metres provides a buffer to intrusive sights and sounds. It also provides sufficient forest interior space to provide nesting, perching and refuge places for wildlife.

The Schooner Trail winds through both cedar-hemlock forest and coastal spruce fringe forest, enabling visitors to appreciate the natural transition between the two forest types. While sitka spruce (*Picea sitchensis)* is more tolerant of wind and salt spray of the ocean than are the western red cedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*), all three species are highly susceptible to wind throw when the canopy is adjacent to openings. Wind throw is the single most prominent mechanism of forest disturbance and regeneration in these west-coast forests. A broad buffer is essential to ensure a natural rate of disturbance. If disturbance is accelerated by development, the quality of visitor experience will degrade.



Legend

- Class A Corridors
- Class B Corridors
- Class C Corridors
- High Human Activity Areas

Rules:

1. Exclude areas within 30 m of a Class A Corridor.
2. Areas 30 – 34 m from a Class A, B, or C Wildlife Corridor, score + 2;
3. Areas 34 – 38 m from a Class A, B, or C Wildlife Corridor, score + 4;
4. Areas 38 – 42 m from a Class A, B, or C Wildlife Corridor, score + 6;
5. Areas 42 – 46 m from a Class A, B, or C Wildlife Corridor, score + 8;
6. Areas Greater than 46 m from a Class A, B, or C, Wildlife Corridor + 10.

Rationale:

- Observational data indicates that wildlife including wolves, bear, cougars and deer utilize identified tracts of land in this area, for movement, foraging and prey capture.

- Wolves appear to travel the beaches and to use abandoned roads as travel and hunting corridors. Bears forage in a variety of habitats including old growth stands, along stream courses, in shoreline and dune areas, and among beach logs.

- Three classes of wildlife corridor were identified by the Park Wildlife / Human Conflict Specialist.

    - Class A Corridors are travel aids such as streams, bogs, beaches, or abandoned roads that do not fall within, or lead directly to, areas of high human activity. These corridors allow animals to traverse the landscape without becoming further conditioned by human presence. It is thought that each time an animal is exposed to human activity, two things happen: First, the likelihood of a human-wildlife conflict increases. Second, the animal becomes more conditioned to humans. The conditioning alters animal behaviour patterns which increases likelihood of a conflict the next time it encounters humans. Class A Corridors may very briefly cross high-human activity areas.

    - Class B Corridors are travel aids that do not fall within areas of high human activity but lead directly into a high human activity area.

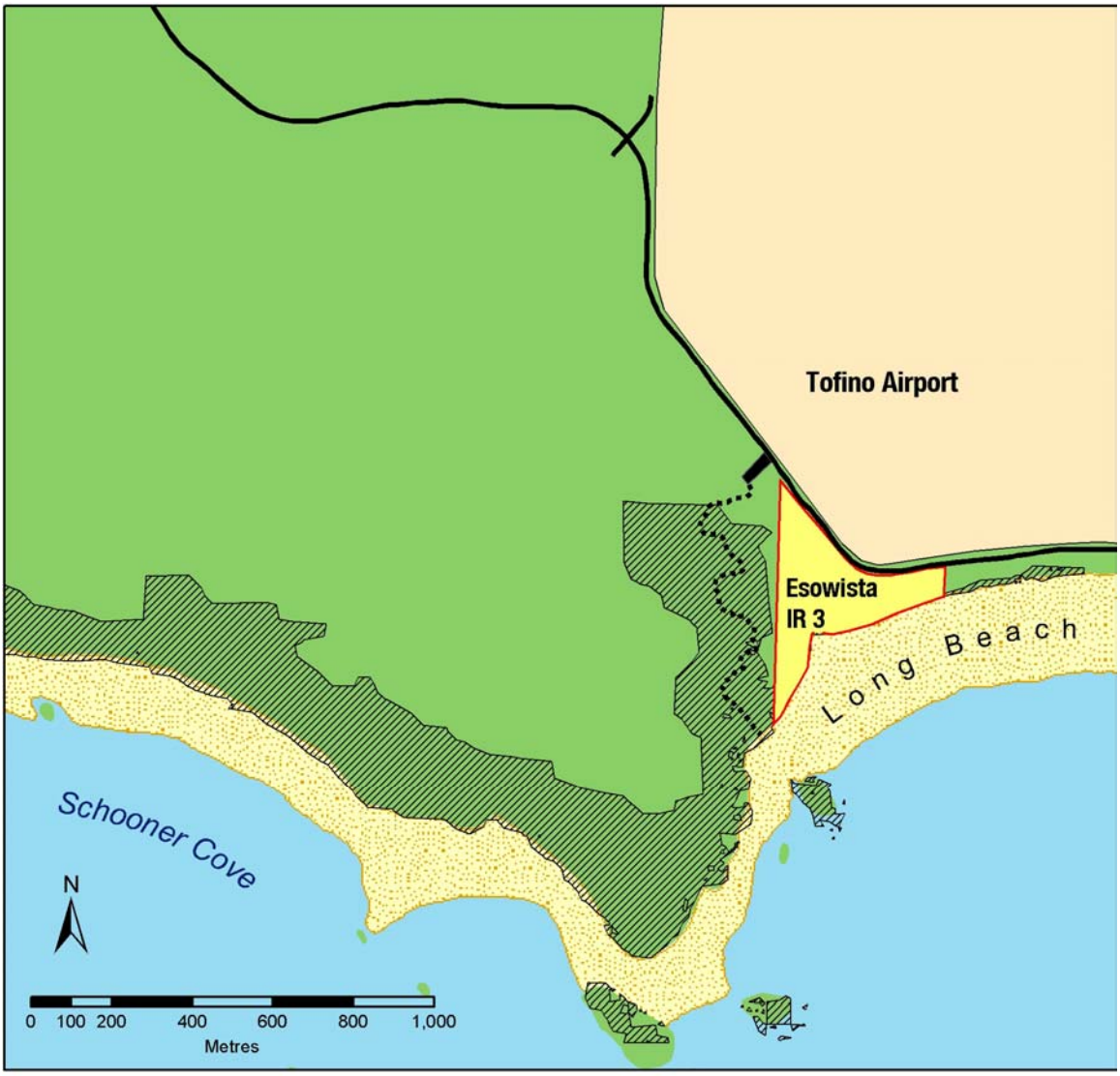
    - Class C Corridors are travel aids that occur within areas of high human activity.

- Human activity that produces wildlife attractants such as food, garbage, or pets has invariably given rise to human-wildlife conflicts with bears and wolves. This pattern has happened in developed areas of the park and in adjacent communities of Tofino, Ucluelet, Esowista Village, and on Tofino Airport lands. The closure of Schooner Campground in the early 90's greatly reduced the incidence of bear problems, however there are still bear-human conflicts each year.

- In order to both protect the wildlife habitat and reduce the risk of wildlife human conflict, Class A corridors should not be interrupted by development. Class B and C corridors should be buffered as a mitigating measure.

- Beyond the 30 m wildlife corridor buffer suitability for development increases along a gradient with distance from the stream. The further away development is from a wildlife corridor the better buffering protection that is afforded.

3.5 Spruce Fringe Forest:



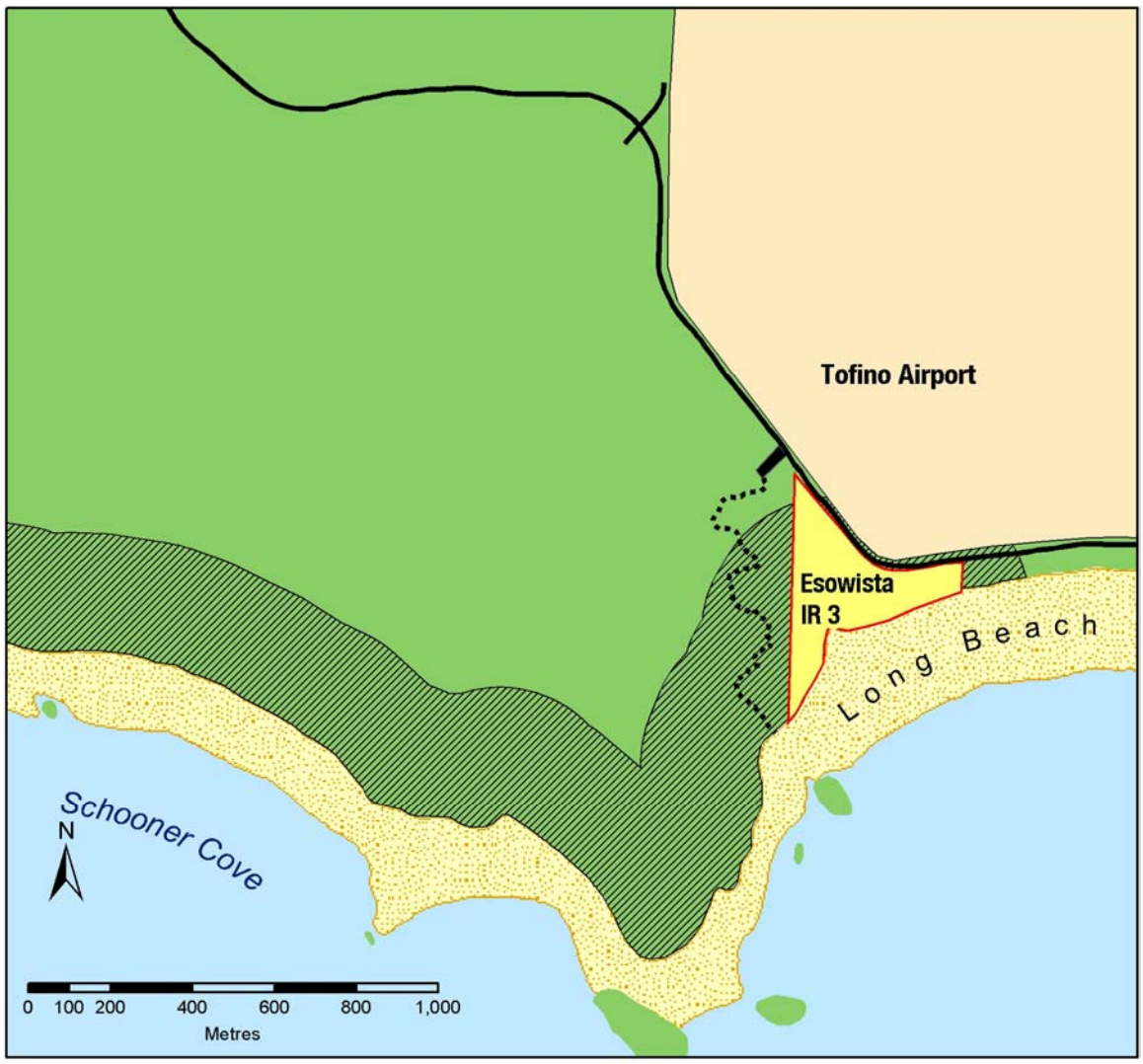
Rules: Exclude areas within the Spruce Fringe Ecosystem.

Rationale:
The old growth spruce fringe forest in the Schooner Cove area is one of the largest in the Long Beach Unit of the Park Reserve. It incorporates more interior forest area than any other spruce fringe in the Long Beach Unit. That depth of spruce fringe is a good indication of exposure to wind whipping and salt spray, of which the Sitka spruce (*Picea sitchensis*) is the most tolerant species. Any diminution of that protective barrier would expose other less tolerant species such as western red-cedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) to wind and salt spray. The primary mechanism of

regeneration in coastal forests is wind throw. The wind sculpted canopies of the spruce fringe forest form a wind-deflecting complex which, if disrupted, inevitably leads to destruction by blowdown. This would upset the natural rate of disturbance. (Refer to Goal 2 (2.1) of the *Ecological Integrity Statement for Pacific Rim National Park Reserve of Canada* (June, 2002): "- Maintain or restore natural disturbance regimes).

In the Long Beach Unit, the spruce fringe forest of Schooner Cove is the only example of spruce fringe forest that spans a whole cove without interruption. Combined with the comparatively large depth of interior to the spruce fringe in the Schooner Cove area, the cove-long nature of that span of forest provides a unique habitat, the full species richness of which has yet to be explored. It harbours some of the largest trees in the Park Reserve. The Schooner Cove area was the first known location in the world for the endangered (COSEWIC) Seaside Centipede Lichen (*Heterodermia sitchensis).* Parks Canada is the lead responsible agency for the recovery of this species. Several small populations of the Seaside Centipede lichen are distributed in the Schooner Cove spruce fringe forest. Also, the rare fungus *Steriopsis humphryii*, is known to occur locally only in the spruce fringe habitat. A biophysical inventory is required to determine presence of other rare, threatened or endangered species in the unique habitat of the Schooner Cove spruce fringe forest.

3.6 Bear Denning Habitat:



Legend

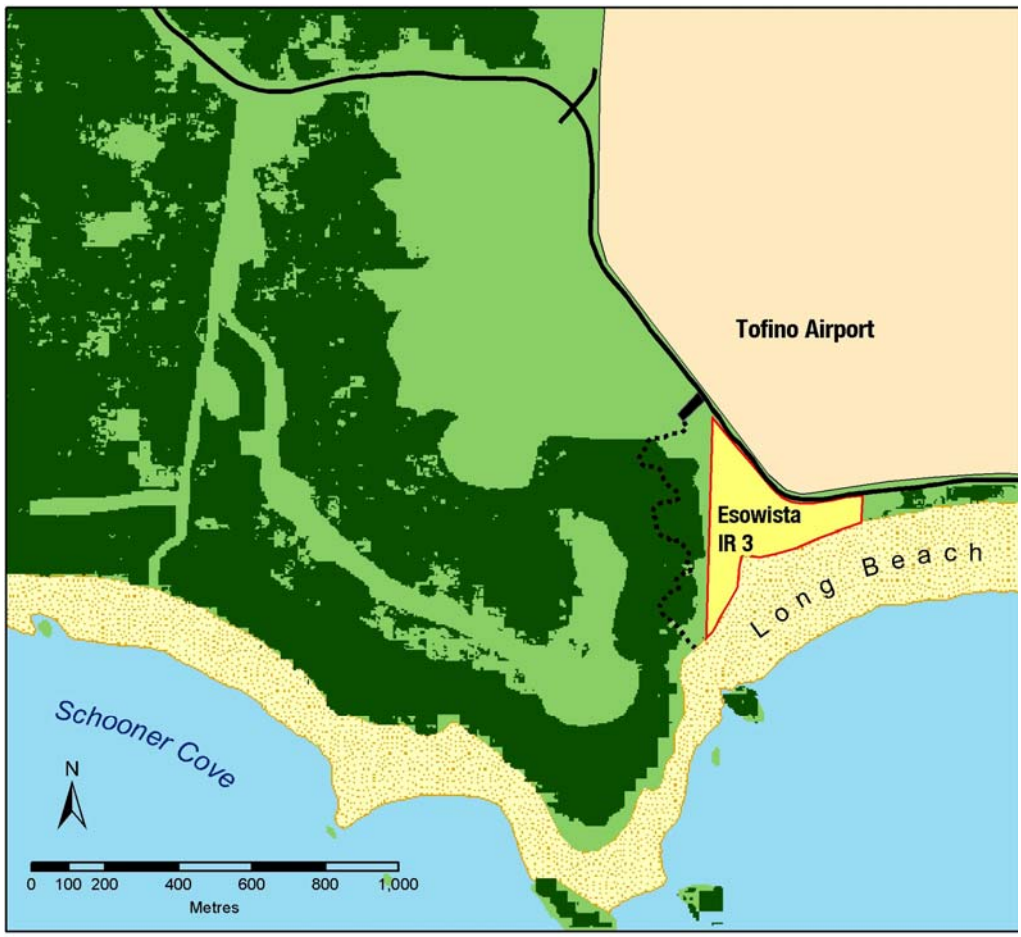
Bear Denning Habitat

Rule: Exclude development within 300 m of the shore vegetation line.

Rationale:

- Of the black bear dens found in the Long Beach Unit of the Park Reserve, all but one are located in very large old growth cedar trees on the headlands/slopes just behind the spruce fringe forest. All dens, except one, are located within 300 m of the shoreline.

3.7 Old Growth Forest:



Legend

Old-Growth Forest

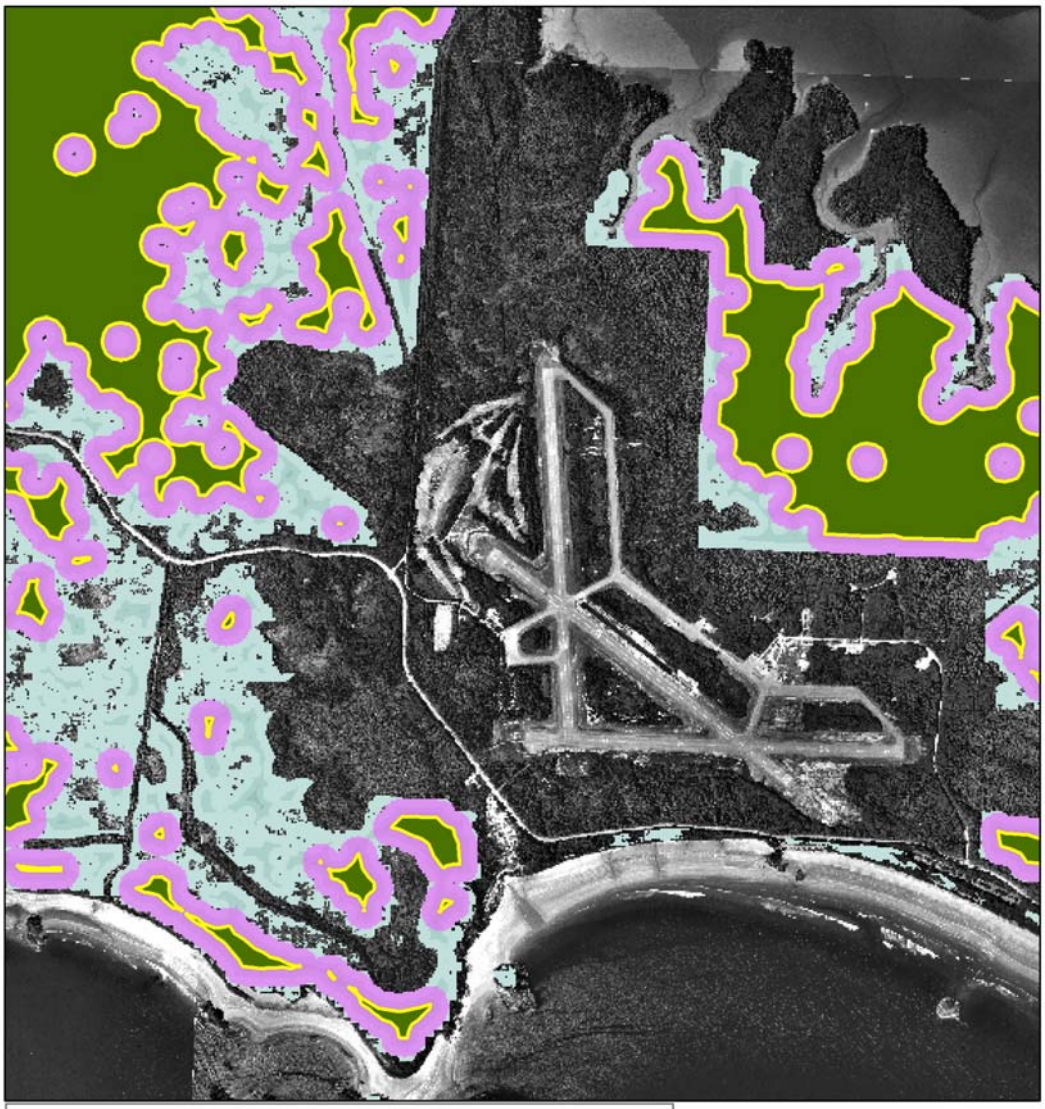
Rules:

1. Areas in or Less than 10 metres from Old-Growth Coastal Western Hemlock (CWH) Forest, score 0
2. Areas 10 – 20 m from Old-Growth CWH Forest, score +2;
3. Areas 20 – 30 m from Old-Growth CWH Forest, score +3;
4. Areas 30 – 40 m from Old-Growth CWH Forest, score + 4;
5. Areas 40 – 50 m from Old-Growth CWH Forest, score + 5;
6. Areas Greater than 50 m from Old-Growth CWH Forest, score + 10

Rationale:

- Beyond ten metres from a patch of old growth forest the suitability for development begins to increase. The further away development is from the Old-Growth areas, the better the site suitability.

3.8 Interior Old Growth Forest



Rule: Exclude areas that would result in a loss of Interior (75 m Deep) Old Growth Coastal Western Hemlock Forest. (Shown above as both "Old Growth Forest At Least 75m Deep" and "Old Growth Core Protection Buffer".)

Rationale:

- Old-growth forests have characteristics related to vertical complexity, size and randomness of canopy openings, and nurse log ecology that are required by some plants and animals. At the edge of a patch of old-growth forest, humidity, exposure to wind, and exposure to light, and access by predators compromise these conditions. (Clayoquot Sound Technical Planning Committee, 2001)

  > "The Scientific Panel recognizes the importance of maintaining some sections of older forests, and of ensuring that these sections of forest are large enough to maintain conditions similar to those in the interior of historic forests" (Clayoquot Sound Technical Planning Committee, 2001).

- Interior forest conditions are judged to be impaired by edge effect at distances ranging between 25 metres and 150 metres, depending on the adjacent land-cover. (Clayoquot Sound Technical Planning Committee, 2001) For this analysis, 75 metres was chosen as the distance to define old-growth interior requiring protection.

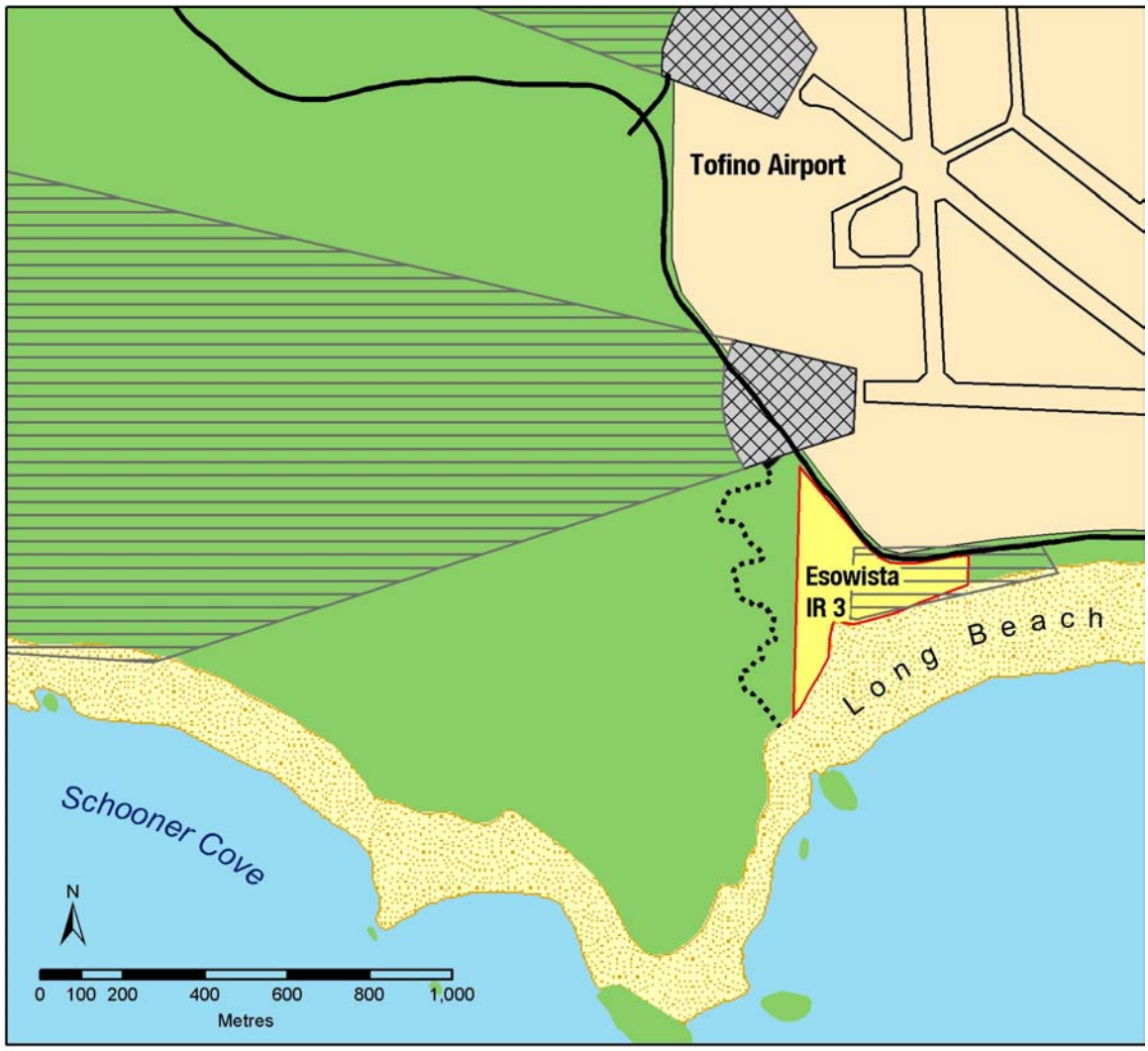
- To identify areas that would compromise interior old-growth forest characteristics, the following steps were taken:

  1. Old-growth forest was identified using satellite imagery and air photos that identified previous disturbance.

  2. Old-growth forest patches were buffered in by 75 metres to identify "Old-Growth At Least 75 Metres Deep".

  3. "Old-Growth at least 75 Metres Deep" was then buffered out by 75 metres to define areas that needed to be conserved to protect interior old-growth. These areas were entitled "Old-Growth Core Protection Buffer".

3.9 Airport Runway Approachways:



Rules:

1. Exclude areas in an approachway and less than 330 metres from a runway end.
2. Areas in an approachway and greater than 330 metres from a runway end score +10

Rationale:

- Aeroplanes must have runways and transitional surfaces (approachways) free of hazardous obstacles.

  Refer to documents:
  1) Land use in the Vicinity of Airports, *7th Edition*, March 1989 (TP1247E)
  2) Aerodrome Standards and Recommended Practices, *4th Edition*, March 1993(TP312E)

- The Tofino Airport requires that the runway approachways be cleared to an angle of 3.3 degrees (at a 10 degree lateral divergence from the end of the runway.)

- The Site Selection Analysis eliminated areas within 330 metres of the end of a runway. This would allow a house antenna that is 330 m away to extend 19 metres above the ground. A structure 500 metres from the runway could extend 46 metres. At 1000 metres from the runway, maximum allowable height would be 57 metres.

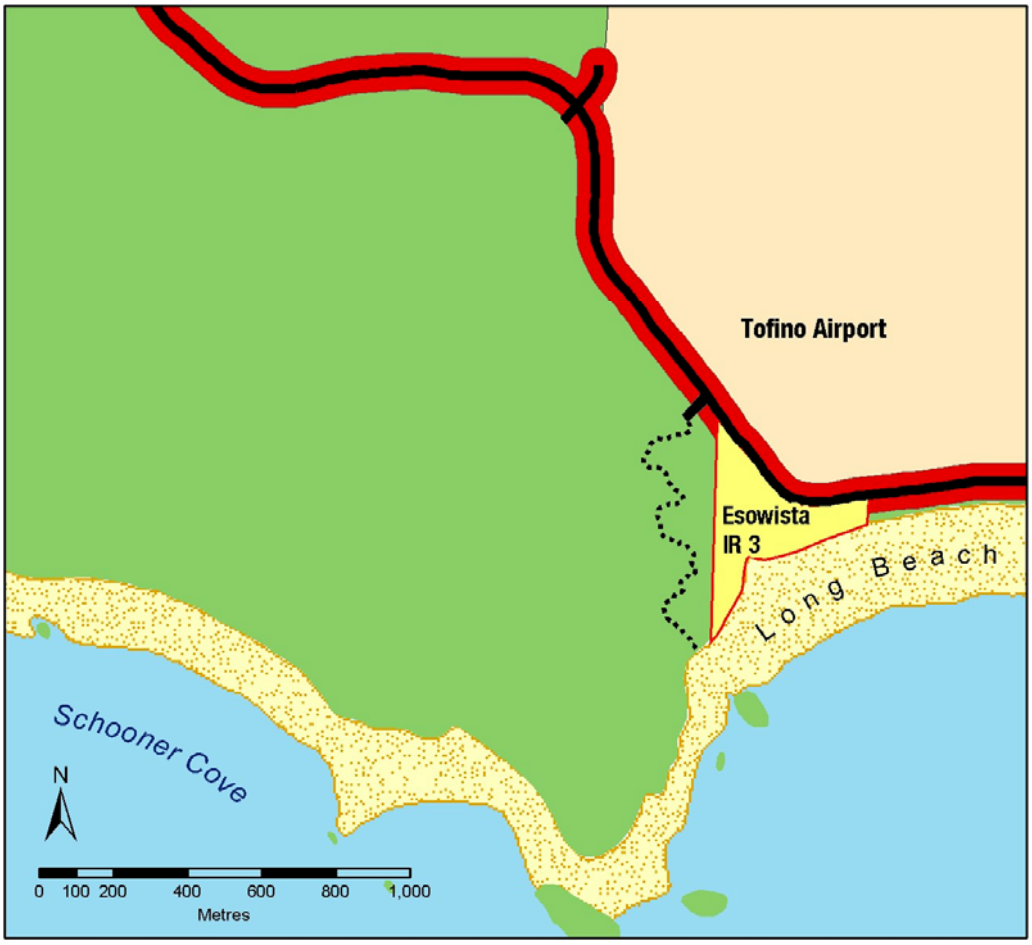
- There are no other legislated building requirements/constraints in airport approachways, other than height restrictions.

- Because vegetation had been trimmed historically for approachway clearing, portions of the currently defined approachway are not considered old-growth forest.

- Vegetation in airport approachways must be trimmed regularly. In the past, this has been done through clear-cutting within the National Park Reserve. Today, approachways are cleared by helicopter based tree topping. Combining development with approachways reduces the ecological footprint from that produced by separate clearing for an approachway and a community.

- The rules used by the Analysis exceed Transport Canada safety requirements for landing and take-off zones at airports.

3.10 Highway Visibility and Noise Protection:

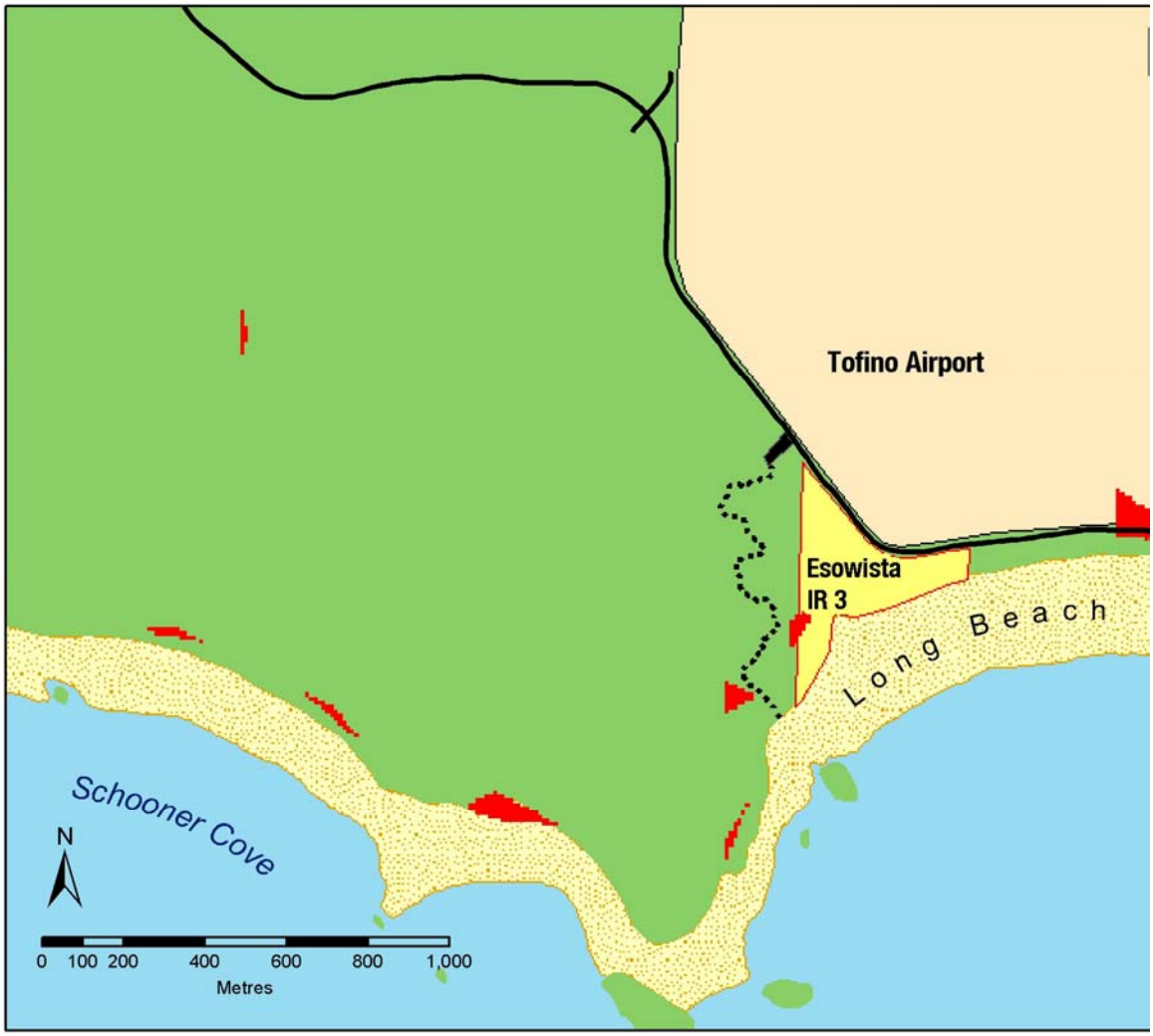


Rules: Exclude areas within 50 metres from the centreline of Highways.

Rationale:

- Provide travel corridors and refuge for small wildlife
- Reduce/buffer noise from roadway
- Reduce visual impact from road on residential area and *vice versa*.
- This 50 metre buffer will be combined with another 50 metre buffer to be administered by the Tla-o-qui-aht First Nation resulting in a 100 metre vegetation buffer between the highway centreline and areas cleared for development.

3.11 Slope:



Rules: Exclude areas where slope is greater than 20 %

Rationale:

- Building on the upper slope or on the hillsides could trigger slope failure.
- Ecological damage may result, including loss of large trees and wildlife habitat.
- Risks to visitors and residents from unstable slopes and falling debris.
- Slopes were identified using 1 : 20 000 Elevation from provincial base maps

3.12 Archaeological and Cultural Resources:

The map for this layer is not shown. This is to protect cultural integrity of these sensitive sites.

Rule: Exclude areas within 20 metres of an archaeological or cultural heritage site.

Rationale:

- Protect cultural and archaeological resources in the area (e.g. burial sites, midden site, homestead).

References:

Clayoquot Sound Technical Planning Committee. 2002. *Vargas Island Watershed Reserve Plan.* Crown Publications, Victoria BC,.

Pacific Rim National Parks Reserve. 2000. *Ecological Integrity Statement.* Parks Canada.

Scientific Panel for Sustainable Forest Practices in Clayoquot Sound. 1994. *Report 5: Sustainable Ecosystem Management in Clayoquot Sound: Planning and Practices*. Crown Publications, Victoria, B.C., 296 pp.