Systematic Reserve Selection for Conservation in Whistler, Canada

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Assessing Approaches in a North American Mountain Resort Community—A Case Study

Mountain resort communities in North America depend on tourism and recreation for their economic viability. Heavy recreation and other anthropogenic activities such as land conversion for development directly threaten mountain ecosystems. To maintain beneficial ecosystem services and preserve the characteristics that draw people to the area, there is much interest in setting aside conservation reserves. Historically, reserve networks have been selected in an opportunistic manner guided by local expert knowledge, but this method frequently results in networks that fail to be fully representative of biodiversity. More recently, systematic reserve selection tools have been developed for conservation planning at national or regional scales. This science-based approach has great appeal to local planners, as it has the potential to be very effective and efficient. Systematic tools have not been used for reserve selection at small scales and their merit in community planning is unknown. Here we present the results of a case study in which we used systematic software to select a conservation reserve network in the Resort Municipality of Whistler, Canada. We describe the Whistler area ecosystems and potential threats, and examine the suitability of systematic reserve selection tools for mountain resort planning. After considering factors such as the discrepancy between scales of planning and geographic data, data quality, and expected delays in designation of reserves, we suggest that systematic reserve selection tools should be used with caution, and only in conjunction with local expert knowledge.

Keywords: *Conservation planning; resorts; recreation; tourism; systematic reserve selection; Canada.*

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Introduction

Mountain resorts and communities in North America are facing unprecedented rates of growth and development. As personal disposable income has increased and communication technologies have improved, more people want to reside in and visit mountain areas (Price et al 1997). The scenery, wildlife, open spaces, and clean air and water that draw people to mountain communities are being threatened by the resulting development. Mountain areas—often mistakenly thought of as having low diversity and productivity due to their extreme environments—are also important centers of species endemism, refuges for formerly wide-ranging species, and may play an important role in biodiversity conservation (Jenik 1997). Mountain resort communities worldwide are faced with the task of balancing development and the demands of tourism and recreation with a need to conserve the natural environmental features that attract visitors and residents.

The conservation planning process must be timely and transparent, and conservation actions must be both effective and efficient to achieve this delicate balance (Cowling et al 2003). Time is an issue because once land is developed its conservation value is usually greatly reduced. To ensure protection status is maintained into the future, the process that leads to the selection of a particular site for conservation needs to be transparent and the selection justifiable. Finally, an efficient selection of conservation areas will maximize conservation value while minimizing costs associated with lost development or land use.

Communities may choose two general paths to develop land conservation plans. 1) The more traditional method is to rely on local expert knowledge and select areas for conservation in an opportunistic manner, based on what is realistic considering land ownership and prices, and what likely has high conservation value. This method had some success in identifying conservation areas in the Cape Floristic Region of South Africa, but was heavily biased by uneven knowledge of places and taxa, and by the individual management and implementation experience of experts (Cowling et al 2003). 2) Over the last 25 years, systematic methods for conservation planning have been developed that use geographic information systems (GIS) and computer software selection packages. Systematic techniques increase the efficiency, effectiveness, and defensibility of reserve networks by reducing the redundancy of features represented (Margules and Pressey 2000). However, systematic selections fail to consider the probability of biodiversity persistence, as they generally use only presence/absence data and do not take into account practical implementation constraints (Cowling et al 2003).

Computer-driven methods have been used most often at large, regional scales such as the Cape Floristic Region mentioned above, but rarely at the scale of mountain resort communities. Given that opportunistic, expert-based conservation efforts can be biased and lead to under-representation of some conservation elements, we are interested in the application of GIS models and selection software to conservation at the small scales of mountain resort communities. Hence we present here a case study of the utility of GIS and selection software at the local level in the Resort Municipality of Whistler

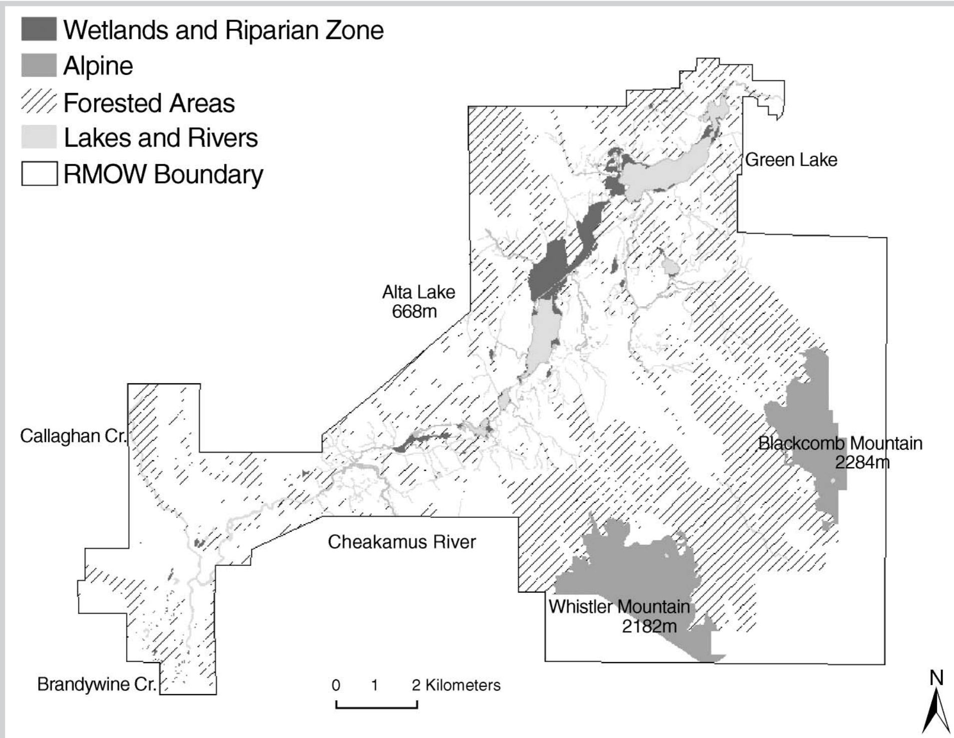


FIGURE 1 The 12,630-ha Resort Municipality of Whistler (50.11°N, 122.96°W) in coastal British Columbia encompasses an extensive wetland and riparian zone, mountain forests, and alpine ecosystems. (Map by H. Lindh)

(RMOW), BC, in western Canada. We first give a description of the Whistler resort area, its ecology, geography, land use, and potential threats to its systems. This is followed by an outline of the methods used to select conservation areas, and presentation and discussion of what the results might mean to Whistler and to conservation planning in other mountain resort communities.

Setting, ecosystems, and threats

The Whistler valley is surrounded by the Coast Mountains in British Columbia, Canada. The municipality (12,630 ha) lies predominately in the coastal western hemlock zone with mountain tops reaching into mountain hemlock parkland and alpine tundra zones (provincial biogeoclimatic classification system, MELP 2001). A number of distinct ecosystem types in Whistler contribute to local and regional biological diversity (Figure 1, RMOW 1995). More than half of the wildlife populations depends for some aspect of their survival on a corridor of wetlands and riparian areas (~1% of RMOW) that bisects the valley (RMOW 2002).

High elevation coastal forests (~45% of RMOW) and alpine habitat (~9%) line the valley, and residential and commercial areas (~15%) subdivide remaining natural patches. The biological diversity of mountain forests has not been surveyed in Whistler, but studies of similar forest types suggest that Whistler forests have the potential to support a wide diversity of invertebrates, plants, and mammals (Pojar et al 1991; GeoAlpine Environmental Consulting et al 1995; MELP 2001). Alpine ecosystems such as those on Whistler and Blackcomb Mountains (2182 m and 2284 m, respectively) are characterized by extremes of temperature, wind, snow pack, ultraviolet radiation, and topography. Despite the harsh environmental conditions, similar ecosystems in the northwest United States provide habitat to about one third of all vertebrates found in the region (Martin 2001).

Anthropogenic impacts on the Whistler environment in the past were primarily resource-based activities such as logging and mining (GeoAlpine Environmental Consulting et al 1995). More recently, local ecosystems and biodiversity are being impacted by amenity-based economies which depend on tourism and recreation (Figure 2). Tourism facilities are concentrated in a small area, but offsite impacts from recreational activities (downhill and Nordic skiing, snowmobiling, helicopter skiing and sightseeing, mountain biking, hiking, golf, swimming, waterskiing, all terrain vehicle [ATV] tours) introduce a large number of people, their pets, and equipment into sensitive mountain environments. Snow compacted by skiers melts later in spring, shortening the total growing season, disrupting plant phenology, and in turn, adversely affecting wildlife that depend on late season alpine forage (Price 1983). Skiers may also disturb alpine residents and breeders when they go off-piste in search of the powder that alpine birds use for snow roosts (Martin 2001). Lift-accessed mountain

FIGURE 2 Ski runs on Blackcomb and Whistler Mountains, golf courses, hydroelectric power lines, roads, and trails fragment habitat in Whistler Valley, Canada. (Photo by Greg Griffiths, Mountain Moments Photography, Whistler)

biking and hiking threaten sensitive alpine heath meadows, which are prone to erosion with repeated trampling. The growing number of people visiting alpine areas at all times of year and the amplified intensity of use increase the frequency of humans encountering and disturbing wildlife. Wildlife response to human disturbance may result in immediate and long-term behavioral and psychological changes. Hikers and cross-country skiers, for example, have displaced ungulates from nutritionally important forage areas in alpine tourist areas of Austria (Hamr 1988).

Unlike mountain resort communities in the developing world, North American resort communities often have fairly sophisticated planning and environmental departments. In 2001, the RMOW adopted the Whistler Environmental Strategy (WES) with the intent of moving towards environmental sustainability through enhanced stewardship. The WES placed high value on biological and geological diversity, recognized the dynamic nature of ecosystems, and gave high conservation priority to rare and sensitive ecosystems such as streams, lakes, wetland and riparian areas, alluvial and old-growth forests, and the alpine zone.

The RMOW plans to protect ecological integrity by establishing a system of conservation reserves, which it termed a protected area network (PAN), with three levels of protection (RMOW 2002). PAN 1 areas will be unique or sensitive ecosystems in which human development is excluded entirely, and conservation of streams, wetlands, riparian areas, old-growth forests, and wildlife corridors are emphasized. PAN 2 areas also will be protected, but will allow some lower-impact human use such as hiking and biking. PAN 3 areas will be semi-natural lands such as second growth forest and golf courses that allow recreation and some types of development following an Environmental Impact Assessment. About 15% of the RMOW is already developed and another 3% is open water (RMOW 1995). Seventeen percent of the municipality is within Garibaldi Provincial Park and is already afforded a PAN 1 level of protection. The remaining 65% of land in the municipality is available, though not necessarily appropriate, for PAN designation. The Whistler municipal council is in favor of using systematic tools (computer-driven heuristic algorithms) to design and select its PAN. We believe there is no precedent for the use of these tools at the local scale and we present a test of the utility of systematic tools in the RMOW.

Test of systematic tools to design and select a PAN in the RMOW

We obtained digital geographic data through the RMOW planning department and used ArcGIS 8.0, a

Parameter combination #	Size of planning unit	Development status	Unit adjacency
1a	1 ha	Locked out	No
1b	1 ha	Locked out	Yes
1c	1 ha	Allowed	No
5a	5 ha	Locked out	No
5b	5 ha	Locked out	Yes
5c	5 ha	Allowed	No
10a	10 ha	Locked out	No
10b	10 ha	Locked out	Yes
10c	10 ha	Allowed	No
25a	25 ha	Locked out	No
25b	25 ha	Locked out	Yes
25c	25 ha	Allowed	No

TABLE 1 Input variables for selecting reserve sites in the Whistler municipality. The number in each parameter combination refers to planning unit size, which varied from 1–25 ha. The letter indicates the type of constraint applied to the run. Planning units containing developed areas were either excluded from the potential solution (a, b) or included (c). The adjacency constraint (b) favored selection of adjacent over dispersed planning units. One hectare planning units were required to be adjacent to 4 others whereas larger planning units needed to be adjacent to just one other unit.

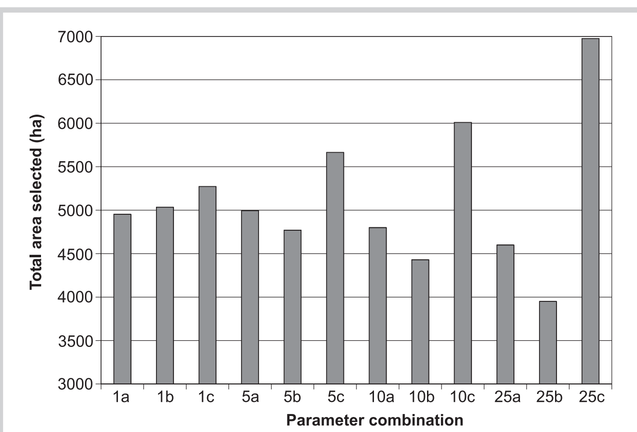


FIGURE 3 Total area selected under variable combinations of input parameters for reserve selection scenarios in the Resort Municipality of Whistler. Parameter combinations are listed in Table 1.

commercially available GIS, for analysis. Data for this exercise were limited to forest cover (FC) mapping based on 1:20,000 TRIM data and aerial photography from 1993 that gave projected stand-based information such as forest age class, tree species composition, and sites "not suitable" for timber harvesting. Environmentally sensitive areas (ESAs) were derived from the same forest cover polygons and identified wetlands, alluvial forests, fish bearing streams, and developed areas (accuracy estimated to be 20 m for both data layers).

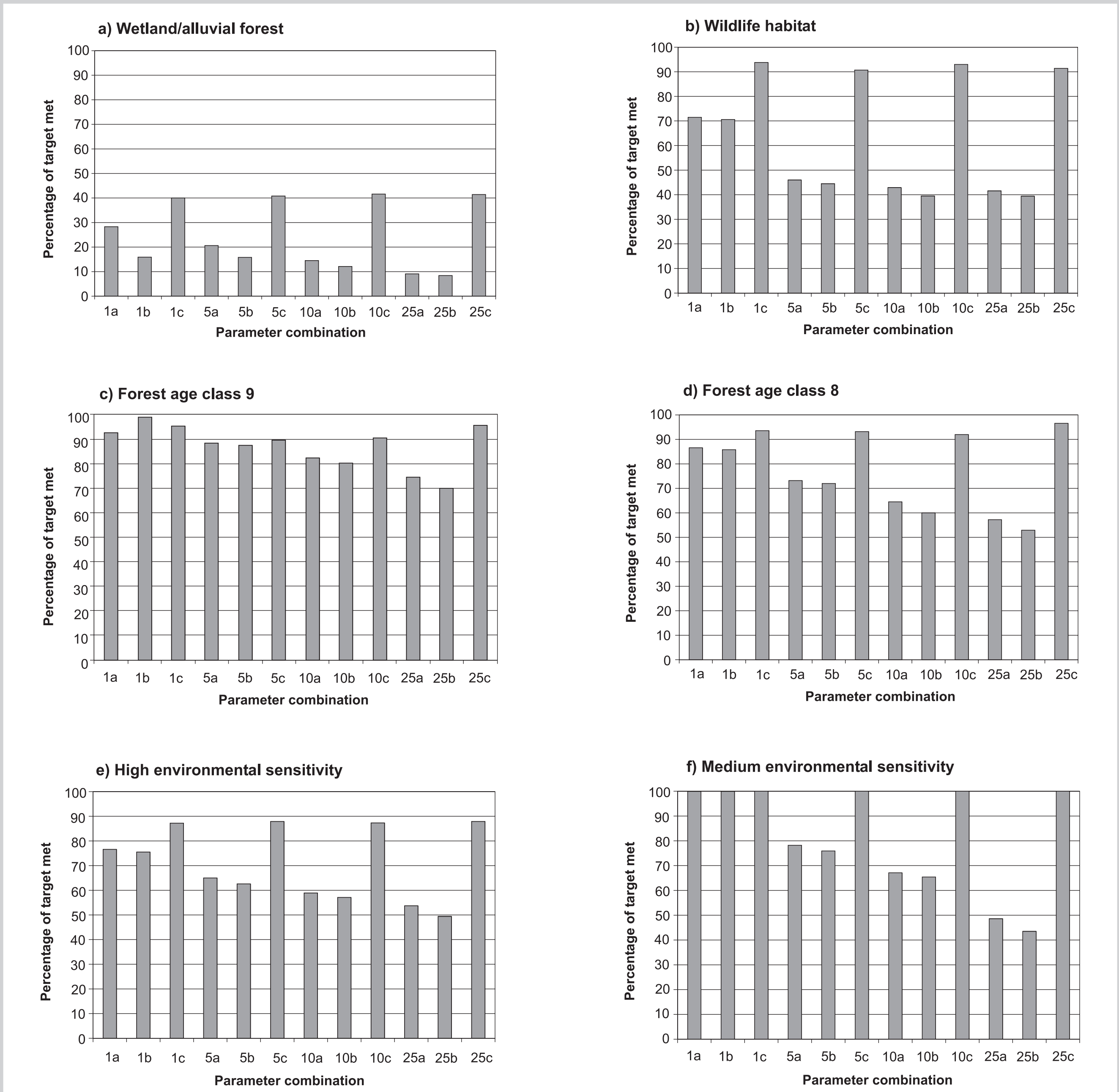
From these data we identified 7 "conservation elements," or categories for which we could set goals. These were areas of 1) wetlands and 2) alluvial forest, forested areas categorized as 3) age class 8 or 4) age class 9 (over 140 and 250 years old respectively), areas with 5) high or 6) medium environmental sensitivity according to forest cover mapping, and 7) habitat essential to fish and breeding birds. We formulated representation goals for these elements based on our interpretation of the WES (RMOW 2002). Our targets were to select 100% of existing wetlands/alluvial forest, 100% of essential wildlife habitat, 80% of age class 9 and 60% of age class 8 forests, 80% of areas with high environmental sensitivity and 60% of areas with medium environmental sensitivity.

We used the program SITES (www.biogeog.ucsb.edu/projects/tnc/toolbox.html) to explore alternative sets of conservation reserves for Whistler in order to determine the utility of applying such reserve selection techniques at small scales. SITES is a customized Arc View 3.3 project (Environmental Systems Research Institute, earlier version of, and compatible with ArcGIS) that uses heuristic algorithms to identify alternative sets of conservation reserves (Andelman et al 1999). SITES performs best when the study site is divided into a set of similar sized planning units that completely fill the region, so we constructed regular square polygon grids with which to overlay existing geographic data. The 2 layers were merged, with the result that an individual square planning unit could potentially contain both valuable conservation elements and already developed lands.

Results and discussion

In order to determine whether input data quality and parameter choice influenced the outcome of our iterations, we used a simulated annealing algorithm where we varied a) planning unit size from 1 ha to 25 ha, b) selection unit adjacency, and c) exclusion/inclusion of existing developed areas (non-PAN habitat, Table 1). Planning unit size (a) had little effect on how much total area was required for an optimal solution, as there was remarkably little difference in the area selected between the 1, 5, 10, and 25 ha planning units. Exceptions were the solutions for 10 and 25 ha units for which developed areas were included (Figure 3). However, planning unit size did affect the level of representation of each conservation element in a reserve solution (Figure 4). As planning unit size increased from 1 ha to 25 ha, the ability of the solutions to meet representation

FIGURE 4 Effectiveness of each parameter combination in meeting goals for conservation elements. Omitting the developed area constraint in PC 1c, 5c, 10c, and 25c consistently allowed higher levels of representation of most elements. There was also a general trend towards poorer representation as planning unit size increased among the remaining parameter combinations.



goals decreased. The 1 ha planning units (PC1a) produced a solution that included over 90% of the targets set for forest age class 9 and areas of medium environmental sensitivity, over 70% of targets set for forest age class 8, areas of high environmental sensitivity, and wildlife habitat, but only 28.3% of the target for wetlands and alluvial forest (Figure 4). However, the result that the small-sized planning units work best is problematic because the 1 ha and 5 ha solutions occur at a finer scale than the spatial resolution of the available data used to generate the selection units. Thus communities might be constrained to relatively large planning units unless they have access to fine-scale data.

Unit adjacency may be a critical constraint for selection because single isolated units are unlikely to provide enough habitat area to maintain wildlife populations. Therefore selected units that are adjacent to one another likely are more valuable than units that are diffused. In our iterations, total area selected with the adjacency constraint (b) was less than or similar

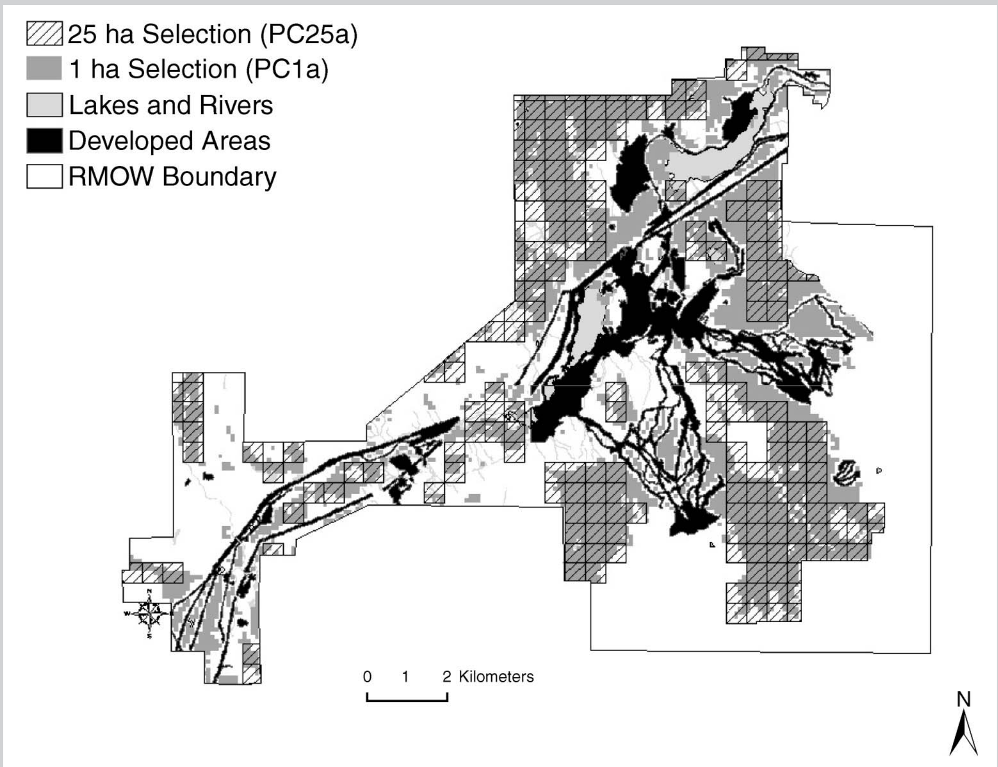


FIGURE 5 When developed areas were locked out of potential solutions, the 1 ha planning units generated a selection with sites located closer to development than did the larger planning units. (Map by H. Lindh)

to solutions without the constraint (a, c), but the level of element representation was also lower (Figures 3 and 4). Representation of wetlands and alluvial areas was most dramatically reduced by the adjacency constraint (from 28.3% to 15.9% and from 20.6% to 15.8% for the 1 and 5 ha planning units). This may have been due to the linear nature of these ecosystems, which makes adjacency difficult to achieve. Forcing adjacency, though intuitively beneficial to conservation goals, may reduce overall representation of conservation elements when the total area from which to select is small.

Inclusion of existing developed areas (c) in selections met representation goals more successfully than exclusion of those areas (a, b). However, elements present in planning units that also contained developed areas likely were of lower conservation value than elements located further from developed areas. Some solutions included up to 677.3 ha of developed area, thus suggesting that meeting conservation targets in this case was not equivalent to meeting conservation goals. It also emphasized the care that must be taken when choosing conservation elements and setting targets to ensure they are accurate indicators of general planning goals. Small planning units were less likely to contain both desirable conservation elements and developed areas, so those solutions may have more accurately reflected conservation goals than did those of large planning units without the constraint. However, the small size of the 1 ha planning units *with the constraint* (PC1a, b) did not prevent selection of land in close proximity to developed areas (Figure 5). The conservation value of small units would just as likely be compromised by the close proximity of developed areas as planning units that include developed areas. To reduce the amount of compromised conservation area, planning units could be defined by cadastral boundaries rather than regular polygon grids. This would prevent them from simultaneously containing developed areas and conservation elements; however, there are consequences associated with using irregularly-sized planning units. Cadastral data are available at the RMOW, but considerable time would be required to convert them from paper to a digital GIS.

Conclusions and recommendations

Reserve selection algorithms may not be appropriate tools for conservation planning at small scales because 1) alternative solutions are relatively few, unlike those for regional scale planning which have many possible solutions and high complexity; 2) the approach requires considerable time to implement if data need to be digitized; 3) data are frequently out of date; 4) the scale of planning is fine relative to the scale of data normally available; and 5) the scale of planning amplifies general limitations. Thus, there are several reasons why mountain resort communities like Whistler may want to reconsider using systematic reserve selection tools for conservation planning. We elaborate on these points below.

A large proportion of RMOW lands may eventually be selected for a PAN, thus the value of the optimizing algorithms is reduced relative to larger planning areas from which the proportion to be selected is small. Still, using selection algorithms may help clarify planning objectives and priorities. The amount of time required to implement the systematic, computer-based approach at the municipal level is a disadvantage. Using readily available data, it required 2 months for us to conduct this exercise, but we did not adopt a consultation process or convert paper cadastral information for digital use. Additionally, geographic and forest cover data for this exercise lacked detailed and current information. Elements such as forest stand age, tree species composition, and non-harvestable sites are rarely used by biologists or planners in reserve selection procedures. More commonly used data such as species–habitat associations, territory and home range sizes, and presence/absence of rare or threatened species were not available in the RMOW. Coarse resolution of data was also problematic as an error of 20 m in a 1 ha (100m × 100m) or 5 ha (232m × 232m) planning unit reduces confidence in results considerably.

Some limitations of systematic reserve selection appear when applied at small scales. In a 177,000 ha area of the South Okanagan, British Columbia, variation in planning unit size and shape, conservation elements, and targets all strongly affected selection results (Warman 2001). Unit adjacency is a critical constraint on selections in large regions because single isolated units are unlikely to provide enough habitat area to maintain species populations. However, the adjacency constraint reduced representation levels in our selections in the RMOW, where total area was small and proportion of planning units available for selection was high.

With expected Olympic-related development activities over the next several years in Whistler and the demand for recreation continuing to escalate in all parts of the world, mountain resort communities cannot afford to delay conservation planning. More importantly, it is unclear whether the systematic approach will result in a network of reserves that protect ecosystems substantially better than one produced by opportunistic means, even when more detailed and current ecological data are available (Warman 2001). We suggest the resort communities have 2 alternatives. They can use the systematic approach informally to select an initial set of protected areas. These areas would be protected until knowledge of the sites becomes more accurate and the public can voice its concerns and desires. Locations of protected areas could shift over time (assuming alternate areas appropriate for protection exist) while the quantity protected would remain consistent. Where land use conflicts arise, developers could initiate surveys to determine ecological “value” and to identify equivalent unprotected replacement sites for the PAN. Conversely, communities can take an opportunistic approach to select protected areas based on design theory, available land, current ecological knowledge, and expert consensus. In Whistler, planners can follow the broad guidelines already outlined in the WES to make specific decisions (RMOW 2002). According to the WES, all riparian areas, wetlands, waterways, alluvial and old growth forests should have PAN 1 level protection, relatively undisturbed wooded areas in the valley should be PAN 2, and remaining municipal property should be PAN 3. Although it is unlikely that all of these areas can be protected (some will be developed), local experts in Whistler can use existing knowledge to prioritize areas for conservation. These designations will accomplish the goal of maintaining existing ecosystem function and integrity and have the strong advantage of timeliness. We encourage other mountain resort communities to use systematic planning tools with caution, as a preliminary objective planning exercise, and always in conjunction with local expert knowledge.

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