CONSERVATION PLANNING AND TARGETS FOR THE COASTAL DOUGLAS FIR ECOSYSTEM. A SCIENCE REVIEW AND PRELIMINARY APPROACH.

FEB, 2007
FINAL DOCUMENT

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OBJECTIVES

The status of biodiversity in the Coastal Douglas Fir (CDF) biogeoclimatic zone, located on the east side of the Vancouver Island, has received considerable recent attention. Historic and current development pressures have, and are having significant negative impacts on biodiversity values and it is widely recognised that considerable efforts will be required to restore and maintain biodiversity values within the zone.

This report was commissioned as part of a number of different projects relating to the broader goal of developing a conservation strategy for the CDF, and has a number of specific goals including to provide:

- A review of approaches to setting conservation targets,
- A target, or target range that relates to the risks associated with different levels of conservation,
- A summary of uncertainties,
- Examples of planning used in ecosystems similar to the CDF.

In order to meet these goals and provide a preliminary approach to conservation planning in the CDF, the paper is laid out in the following way:

<u>Section 1:</u>

- A review of the science of conservation planning, with
  - A summary of the concepts of conservation planning,
  - A review of approaches to target setting
  - A case study from a similar ecosystem

<u>Section 2:</u>

- An overview of the approach to setting conservation targets, with examples.

<u>Section 3:</u>

- An application of the science to the CDF ecosystem, with
  - A preliminary proposed series of steps for conservation planning,
  - Proposed targets for the CDF,
  - Identification of next steps and uncertainties.

1.0 A REVIEW OF THE SCIENCE OF CONSERVATION PLANNING

This section reviews science literature and presents an overview of some of the key ideas that have been part of the conservation planning debate over the last few decades. Core approaches to conservation planning are identified. Many of these ideas are 'variations on a theme' but have been used in subtly different ways to result in different conservation outcomes.

1.1 SETTING GOALS

Determining the goal of a conservation strategy is a key first step, and should inform all subsequent decisions. Typically, conservation planning has a broad goal such as 'maintain or restore ecological integrity', since to maintain functioning ecosystems and their associated species is the goal of an effective process.

Within the broad goal, specific objectives (or sub-goals) need to be outlined, and should include approaches to maintaining the key elements of biodiversity (ecosystems, species and processes) as outlined below. In the past, conservation planning focused on rare elements of biodiversity, but it is now recognised that ensuring adequate management of common elements is as, if not more, important. This is a relatively recent change in the approach to conservation planning, but is a key one, since it has been recognised that former common species can quickly become rare species if they are not adequately managed for (e.g. Scott et al. 1996); examples include the passenger pigeon, gray and red wolf and grizzly bear in large parts of Canada and the United States.

Identifying quantitative objectives has been identified as an important factor in goal-setting, since even though all goals will be somewhat subjective, having quantitative goals reduce confusion and provides direction around assumptions that may require further testing.

1.2 RESERVES FOR DIFFERENT GOALS

Identifiying 'reserves' is a central approach advocated for maintaining biological values in a region. Reserves are generally considered to be necessary for effective conservation, but typically are not considered sufficient. Complementary approaches such as conservation-friendly management and development are often required outside reserves, in the 'matrix'. However, reserves remain the core of most conservation strategies and the following section addresses different approaches used to identify and select potential reserves from a series of options.

The first step is to understand and articulate the goals that a particular set of reserves is intended to achieve. There are three main objectives for reserves: a) to capture representative ecosystems, b) to capture rare or unique elements of biodiversity and c) to maintain adequate habitat for individual species.

1.2.1 REPRESENTATION:

One of the first ideas to affect reserve design was the idea that reserves should be representative of all the ecosystems present in an area. This is now fully accepted within conservation science. 'Representation' of ecosystems is important for a range of reasons including that:

- different ecosystems and their associated species and processes have inherent value,
- maintaining the range of ecosystems is crucial because they support different communities and species and so this approach maintains the breadth of 'biodiversity' and associated processes,
- this is the most efficient approach to developing a true coarse filter (i.e. that insufficient is known about individual species (particularly non-vertebrates) to manage for them on a species-by-species basis.

Different approaches to defining the appropriate 'ecosystem' to be represented have been developed, including using 'land forms', enduring features (e.g. the WWF Gap Analysis approach), broad habitat types, or mapped ecosystems using the finest scale of information available. For example, the Coast Information Team (2004) proposed using site series for the Central and North Coasts of BC. The idea of maintaining representative ecosystems is analogous to the coarse filter approach as first outlined by Noss (1987).

How much representation is required remains a key question (see below.).

1.2.2 SPECIAL ELEMENTS:

A second key function for reserves is to maintain special elements – typically described as the biodiversity elements likely not maintained using the coarse filter approach/ representation.

Identification of special elements has been a key part of a number of large scale reserve designs, and examples (e.g. Miller et al. 2003) include:

- known locations of rare, threatened or endemic species
- biodiversity hotspots
- rare and / important natural communities such as wetland / riparian ecosystems
- critical habitat features, e.g. breeding areas for focal species
- landscape corridors that connect known areas of use
- unique geologic features
- remaining roadless areas (depending on the landscape context).

Identification of special elements is typically considered analogous to the fine filter approach outlined by Noss (1987).

1.2.3 MAINTAINING VIABLE POPULATIONS OF SPECIES:

A third function of reserves is to provide core habitat to maintain viable population of species, particularly wide-ranging species. Species which use large areas and require specific combinations of habitats across the landscape which are unlikely to be maintained by the coarse filter alone are often presumed to be umbrella species, whose protection is predicted to result in protection for a wide range of other species.

For example, the umbrella species concept was used to identify priority conservation areas in a Minnesota landscape and the results tested to determine whether there was additional and effective conservation of other elements (Poiani et al., 2001). In this case, the greater prairie chicken was identified as a potential umbrella species requiring specific habitat in a particular layout around booming grounds. Large patches around booming grounds were selected, and compared to simply choosing the largest available patches and randomly selected patches. In this case, patches selected on the basis of the umbrella species encompassed slightly more biologically-important land (59%) versus simply choosing any large patches (56%) and more than random patches (47%). Umbrella species, in this case, increased the efficiency of planning. However, other studies have questionned the ubiquitousness of this result (see the multi-species predator example in Section 2.2).

Considering how much habitat will be required to maintain viable and resilient populations of a single, or group, of large-ranging species has also been effectively used to provide input into 'how much habitat' is enough (e.g. Carroll et al. 2003 – Section 2.2).

1.3 FACTORS TO CONSIDER WHEN IDENTIFYING RESERVES

In a case study in New South Wales (Pressey and Tully 1994), it was demonstrated that reserves allocated based on expediency or opportunism tended to be concentrated in areas with the least potential for commercial purposes. As a result, of this *ad hoc* reserve design, the ecosystems most in need of strict reservation were not effectively protected. In addition the authors predicted that continued *ad hoc* reservation would result in lower probability of conservation success overall since over-represented areas were likely to be added, increasing area but not conservation gains.

In response to this observed trend a whole series of conservation planning approaches were developed. Note that many of these approaches overlap in some ways, but can be subtly different and used in different ways to set targets. The following sections address ideas encompassed within the different approaches to design.

1.3.1 COMPLEMENTARITY

Real-world biodiversity conservation requires efficiency because resources are always limited (Faith and Walker 2002). Considering which area is the best to add to a growing protected areas network can be aided by the idea of marginal gain, or complementarity (Pressey 1994). In its most basic form, this approach focuses on identifying reserves based on their species richness (i.e. number of species present). The first reserve is chosen based on having habitat for the largest number of species. Additional reserves are then assessed and added to the list based on having the most additional new species with the minimum of area added (marginal gain). This approach was originally touted as the most efficient approach to attaining species representation in the minimum area.

Early applications of complementarity were criticised for failing to consider viability of species (e.g. Salomon et al. 2006), and more recent examples have included considerations about viability. However, at in its most basic form the concepts can be usefully applied as part of the reserve selection process combined with other approaches.

Modeling algorithms in GIS have been developed in order to efficiently assess which suite of patches protects the most number of elements in the smallest area. Creating data sets that can be used in the GIS realm is a first step in this process and can in itself be a costly and cumbersome process. Alternatively, the concept can be applied using a 'back of the envelope' type of approach - for example, the idea of complementarity was used in the Arrow Forest District when assessing which old-growth management areas to be proposed while implementing land use planning (Holt 2000).

1.3.2 SPECIES VIABILITY

As outlined above, the inherent trade-offs associated with trying to maximise the number of species or ecosystem components captured within a series of reserves (i.e. the complementarity method) tend to trade-off (or at least ignore) the requirement to maintain viable, robust populations of species. Refinements to the original methodology have been suggested which use spatially explicit metapopulation methods to estimate extinction risk for groups of species. In comparison with more traditional methods this approach has been predicted to result in lower species loss of over time because it is based on population processes, rather than assigning arbitrary weightings to reserve size and configuration. This type of approach however requires detailed baseline data for the areas and explicit population modeling for the species in question.

Alternatively, others have used 'probability of persistence' to identify important conservation areas. In a case study that focuses on trees in Europe (Williams and Araujo 2000) the authors propose that considering probability of persistence for a particular value provides a consistent basis for integrating the patterns and processes that influence conservation success. Using data from European trees, they assessed the area requirements for maintaining species, and using this methodology required less half the area estimated by simply representing all species with a probability of 0.95. They suggest that using the approach preferentially benefits the least-widespread species and results in greater connectivity among areas. However there remain practical difficulties, since identifying 'probability of persistence' for individual species is in itself quite difficult[1]. However, even if detailed modeling is not undertaken the conceptual approach can provide significant benefits if it is used to ensure that areas with the worst persistence prognoses are avoided as reserves.

1.3.3 SIZE OF PATCHES

The importance of the size of conservation patches is underscored by the equilibrium theory of island biogeography (MacArthur and Wilson 1967), which was proposed to explain the observed

[1] details are provided in the paper, but are complex and not repeated here.

phenomenon that as the area of an island increases, the number of species on it generally also increases. Larger islands have higher immigration probabilities and lower extinction rates, and so tend to maintain greater species richness and larger population sizes. A link between islands and 'conservation reserves' was suggested, and this theory was explored for a long time to determine whether it could be used to make guidelines for identifying reserves of different sizes.

The resulting debate focused on the question of whether 'single large or several small' reserves (the SLOSS debate) are most effective. And the outcome from those decades of debate is that generally, all things being equal, larger reserves are more likely to maintain the biological values within them. However it is also accepted that information on the life-histories of the species of interest is required before specific predictions can be made about how reserve size should influence decision-making (e.g. Zimmerman and Bierregaard 1986). Small patches that capture rare elements are also recognised as an important aspect of a conservation strategy.

At the minimum end of the size spectrum, the question to determine whether an area is large enough to be chosen as a reserve should be to explore whether the area is 'functional' or not for the values of interest. It is difficult to make *a priori* generalisations about this and case-by-case decisions should be made depending on the species and elements present.

An example of a case study that sets size thresholds for plants is given in Box 1.

Box 1. Burgman et al. (2001) explored the area required to maintain rare plant communities. Rare plants are not expected to be maintained by coarse filter conservation strategies and are subject to disturbances which can cause decline or loss of a local population.

Potential deterministic and stochastic events were identified which were likely to increase the change of extinction for a particular population (e.g. habitat loss or effects of predation or competition). These processes were then linked to a simple population model and used to estimate minimum size area required to maintain the population above a set minimal level.

A threshold of 50 adult plants was identified as the minimum population size for viability because irrespective of life history this has been predicted as a likely lower limit. After applying their models to three rare species (two shrubs and a vine) with quite different life-history strategies they obtained target areas for conservation of 1102, 733 and 1084ha for each species, which they suggest could be used (in lieu of no direct information) for other rare plant species. They also hypothesise on life-history traits which may alter this required area (Table 1).

In Summary: After applying the models to the three rare species the authors note that simply the process of identifying key elements of threat for individual species may be helpful in guiding conservation priorities. Considering the threats associated with particular potential reserve is an important consideration.

Table 1. Ecological factors predicted to affect initial the population size required to remain viable, assuming all other things being equal (from Burgman et al. 2001).

Resilience (positive)	Vulnerability (negative)
Many large populations	Few small isolated populations
Widespread distribution	Restricted distribution
Habitat generalist	Habitat specialist
Vigorous post-disturbance regeneration	Weak post-disturbance regeneration
Rapid, vigorous growth	Slow, weak growth
Quickly achieves site dominance	Poor competitor

Resilience (positive)	Vulnerability (negative)
Short time to set first seed or propagules	Long time to set first seed of propagules
Long reproductive lifespan	Short reproductive life span
Readily pollinated	Not readily pollinated
High seed production and viability	Low seed production and viability
Good dispersal	Poor dispersal
Not restricted to a temporal niche	Restricted to a temporal niche
Generally survives fire or other disturbance	Generally killed by disturbance
Adapted to existing disturbances	Not adapted to existing disturbances
Able to coppice / resprout	Not able to coppice / resprout
Not dependent on vulnerable mutualist	Dependent on vulnerable mutualist.

Modeling of any kind aimed at identifying the habitat required for single species always has limitations. In the plant example provided by Burgman (Box 1) it is assumed that potential habitat can be mapped reliably, and that there is reasonable information about species' density, life history and response to disturbance. The methods don't include effects of spatial arrangement or adjacency of patches, or inter-specific competition between other species. However, because assumptions are made explicitly, they can be modeled within a likely range and tested with future information. This approach is useful because it tries to find a midline between making the best decision today given what is known and within opportunity constraints.

1.3.4 VULNERABILITY AND IRREPLACEABILITY

Another pragmatic approach to reserve design has been suggested which focuses on identifying which elements of the ecosystem are most vulnerable or irreplaceable, and to focus reserve designation around these. This approach is intended to reduce the immediate impacts of losses in landscapes under high pressure (Pressey and Taffs 2001). Vulnerable areas are those at high risk of immediate loss through some type of disturbance, whereas Irreplaceable (unique) areas are those that have a high probability of being needed to create a robust reserve design, i.e. there are no or only a few other similar options that contain particular values. Areas that should receive attention in the immediate term are those which are both vulnerable and irreplaceable.

There remain difficulties of actually quantifying irreplaceability and vulnerability in real world situations. For example, algorithms have been generated that statistically identify irreplaceability (Ferrier et al. 2000) but difficulties remain because potential protection areas are usually a complex of different ecosystems and quantitatively determining the probability that a particular area will be needed to meet an overall target is difficult. However, in its more simple application, the uniqueness of a particular area can often be identified and can be used to aid decisions about suitable reserve areas.

1.3.5 MATRIX OR LANDSCAPE HOSTILITY

The importance of the condition of the 'matrix' on reserve design is well known in theory, but generally unquantified. The extent to which the matrix will increase or decrease the probability of persistence for individual species is clearly important, but has usually not been directly incorporated into regional conservation planning.

A very hostile matrix likely means that higher levels of reserve are needed to maintain ecological values through time, whereas a benign matrix likely results in a decreased need for reserves for individual species. The difficulty lies in defining how concepts of 'hostility' for individual species relate to ecosystems and processes.

This idea has perhaps been best applied using the concept of mimicking natural disturbance as a test for general 'hostility', and to maximise the matrix benefits gained in order to augment reserves.

1.3.6 SPATIAL LAYOUT

Fragmentation of habitat (i.e. the additional effects caused by patches being widely distributed as opposed to simply habitat loss) and the use of corridors to mitigate fragmentation impacts, have been the subject of much debate in the conservation literature. Key lessons emerging from this debate include the idea that the larger the amount of protection, the less important is spatial layout. For example, if an ecosystem is generally in good condition, and a relatively high protection target is chosen for ecosystem representation then determining where the protection occurs is relatively unimportant. However, where there is a low level of protection, spatial layout can significantly alter the effectiveness of the reserves.

Where information on movement requirements of specific species are unknown, the importance of spatial layout can also be thought of in terms of the 'permeability' of the landscape. Distributing patches across the entire landscape and ensuring that adequate reserves exist as hubs within otherwise hostile areas is likely to be a key factor of conservation planning in an area with a history of existing development. Additionally, where corridors are spatially identified it is useful to determine what species are being targeted, so specific required elements can be identified.

1.4 IN SUMMARY

Incorporate the three R"s into design – representation, redundancy and resiliency (Tear et al. 2005). Representation means capture something of everything (Section 1.2.1), redundancy means capturing enough to result in an acceptable level of risk (Section 2.0), and resilience is the ability of the element to persist through several severe hardships (Section 1.3).

Representation and redundancy have been part of different reserve design schemes for more than a decade, but exactly what is required to maintain resilience continues to require scientific attention (e.g. Gaston et al. 2002). Some concepts presented here include concepts of viable populations, probability of persistence and minimum viable area.

An important aspect to consider is that many of the formal methodologies to identify conservation reserve patches do not include assumptions about to what degree maintenance of biodiversity is happening OUTSIDE these reserve networks, and they therefore may result in an unnecessary and skewed result to maintain some values that may be reasonably maintained across the matrix. Assessing which elements find the matrix most hostile may be an important approach to identifying elements that require additional protection over the suite of reserves.

From the review of approaches taken to conservation planning, a number of messages or key concepts stand out. Within the broad approach of the 'three R's, consider the following:

- Threats: Consider vulnerability of the habitat – vulnerable areas are those at high risk of immediate loss through some type of development.
- Uniqueness: consider irreplaceable areas – which are those that have are in some way unique and therefore have a high probability of being required to complete the conservation design.
- Patch size: larger patches maintain more species, all other things being equal. Small patches with rare elements remain important however.

- Persistence: Avoid areas where the prognosis of persistence is low. This could include areas that are small, contain many invasive species, are embedded in highly hostile matrices, have high probability of future disturbance, are isolated etc.
- Life-history: Consider the life-history traits of the species of interest, and modify reserves accordingly.
- Population parameters: - consider population and metapopulation dynamics for key vulnerable species.
- Efficiency: - use a complementarity approach where feasible. Ensure new reserves add new elements where possible.
- Pragmatism: Consider areas where risks are highest and options are most limiting (i.e. a combination of threat and uniqueness)
- Connectivity: Consider connectivity across the landscape, both theoretically (as permeability for general species) and specifically for species known or predicted to be movement limited.

1.5 CASE STUDY – FLORIDA GREEN WAYS

Case Study description based on Hoctor et al. 2000.

The state of Florida has exceptionally high and diverse biodiversity values. It also has high density of people in many areas, very high real estate prices and high development pressures.

In the 1980s a Florida Reserve Design process was proposed (Noss 1987), and expert workshops were held to identify conservation priority areas (Hoctor et al. 2000). In 1991 the Florida Greenways program was started by a group of ENGOs, and in 1994 'greenways' legislation was adopted which promoted development of a series of reserves that would meet recreational and environmental objectives. This discussion focuses only on the ecological side of the work.

Identifying a reserve network was considered an essential primary element to conserve biodiversity because of the extreme land base pressure. In this light, an analysis was undertaken to design an ecologically functional, state-wide, greenways system (Florida Greenways Commission 1994) that:

- Conserves critical elements of Florida's native ecosystems and landscapes,
- Restores and maintains essential connectivity among diverse native ecological systems and processes,
- Facilitates the ability of these ecosystems and landscapes to function as dynamic systems, and
- Maintains the evolutionary potential of the biota of these ecosystems and landscapes to adapt to future environmental changes.

<u>Step 1:</u> Ecologically significant areas were identified by combining a wide range of data layers of ecological values, including maps of natural communities, existing protected areas, roadless areas, aquatic ecosystems and single species data. Criteria for inclusion as a priority ecological area are shown in Table 2.

Table 2. Criteria for selecting priority ecological areas for the Florida Ecological Network.

#	Layer	Criterion
1	Strategic conservation areas (identified separately by Cox et al. 1994)	Habitat predicted as required to maintain viable populations of 30 focal species, including rare natural community types, important wetlands.

#	Layer	Criterion
2	Areas of conservation interest	Areas identified using air photos that are high quality natural areas, including known or predicted habitat for rare species.
3	Biodiversity Hotspots	Areas containing potential habitat for seven or more focal species
4	Wetland hotspots	Potential habitat for seven or more wetland-dependent species
5	Rare and priority natural community types	Based on the Nature Conservancy global ranks (G1 etc.).
6	Existing public conservation lands	All
7	Proposed public conservation lands	All
8	Roadless areas	>2000ha
9	Roadless areas without major roads	>40,000ha containing no significant roads
10	State aquatic reserves	All
11	Overlap areas	Areas that did not quite meet the criteria above, but had significant overlap of values at a slightly lower threshold.

Most of these criteria were met by performing GIS queries on existing data sets. However, two of the most important layers required significant work upfront (layers 1 and 2), and were key information layers that aided in setting the conservation priority areas.

The layers from Table 2 were then overlaid to identify areas with primary ecological significance (All Layers + Layer 11).

Step 2: involved the identified of 'core' habitat areas. The output from Step 1 was screened to identify areas with the highest 'ecological integrity potential', and involved removing areas which met the following criteria:

- intensive land use (commercial, residential, industrial, agriculture, croplands)
- extremely high road density areas (they used >3km/km2 as a threshold for protecting sensitive species – from Noss 1992)
- greatest potential for negative edge effects (i.e. areas within 180m of urban land uses).

Remaining priority ecological areas were then identified that were

- large patches (>2000ha) contiguous size. In the Florida landscape this was considered sufficiently large to include many species and processes of importance, plus small enough to capture areas of ecological significance.

To these resulting 'hubs' or 'core' areas, gaps were filled using lower priority native habitat and potentially compatible land uses such as pine plantations and rangelands.

Step 3: involved identifying linkages between the core areas. The authors note that this was the most complex part of the GIS exercise. They classified the Florida landscape into three very broad habitat types : i) upland dominated, ii) riverine and large wetland basins and iii) coastal. These classes were then used to identify broad landscape linkage types. Within this they identified subsets of 'desired' linkages including: coastal to coastal, riverine to riverine, upland to upland, riverine to coastal, and cross-basin.

Using GIS, they created a layer to identify the 'suitability' of individual cells to act as a linkage using a scale from 'highly suitable' to 'unsuitable'. An algorithm was then used to identify potential linkages (called 'least-cost path') which summed up potential corridors in terms of their composite potential and identified the optimal set of solutions to link all the hubs within a series of corridors.

The result: The final network consisted of a set of hubs and associated corridors and in total identified approximately 9.3 million ha (57.5%) of the State of Florida. Of this, approximately 50% (4.8 million ha) were in existing public conservation lands, private reserves (e.g. owned by the Nature Conservancy), or open water. The remaining 50% was private lands in different land uses.

In summary: the ecological network was identified using a series of steps that included creating data layers that summed individual biological data into strategic planning layers. These were then combined on the landscape to identify priority core areas and critical landscape linkages. Although it is not stated, I assume they used connectivity as an important 'driver' of the process because of the high hostility of large parts of the landscape, resulting in the need to purposely 'plan' to connect remaining high value areas.

The network as a starting point: although the network included habitat for a large number of sensitive species the authors assume that additional modeling should be undertaken to assess whether this constitutes adequate habitat with a high likelihood of population viability for some of these species. In addition, although population models were used to identify preliminary habitat (e.g. Cox et al. 1994), it is also noted that additional species-specific models will be required to check whether the habitat is adequate to maintain the most sensitive species such as Florida panther and Florida black bear. Interestingly, the authors didn't start from the place of identifying representation gaps and needs (this is particularly interesting because a key author of the plan, Reed Noss, is a strong advocate of this starting place). However, Hoctor et al. 2000 discuss that a *post hoc* representation analysis was undertaken, which showed a good representation of most native ecosystems and identified a number of key areas of under-representation which will require additional work to fill.

A key 'threshold' question in the model was the minimum size of patches that could be classified as core areas. A minimum of 2000ha was used though this large threshold was questioned because small and often isolated areas (e.g. patches of 400ha) often contain high value attributes and have high conservation significance. The authors note that many critical elements were not included in the basic reserve design and that a *post hoc* representation analysis to fill gaps is a critical part of adding smaller patches to the overall design. Although they do not state the reasons for keeping the threshold larger, I assume it is because the broad scale planning requires relatively large patches to be considered in the broad planning, and that finer scale planning can be used to fill gaps as a second step.

Another future step in the model is to identify 'buffer' areas of semi-natural habitat around high value habitat that exists today. Proposing management to maintain or increase biodiversity in these areas will likely be important in future, as development pressures increase.

Commitment: Florida has committed at least $300million for purchase of conservation lands. Within the lands identified by the original planning, a process is now underway to prioritise those areas under most immediate threat because even at current levels of funding it will take at least three or four decades to protect the level of habitat proposed. This prioritisation process is a very critical step to reduce the chances of losing opportunities for conservation before efforts really start.

2.0 SETTING TARGETS

Approaches to conservation planning are relatively well defined. However, there is no definitive approach that has been identified for setting conservation targets. There are three broad classes of approach

- targets relating to representation levels
- targets related to single or multiple species population viability
- targets determined based on a combination of these two approaches.

In this section, each of these three is examined and approaches to risk discussed.

2.1 REPRESENTATION TARGETS

A number of approaches have been used to set targets for ecosystem representation, or 'broad protection' in different ecosystems.

An original review of science literature was produced for the Coast Information Team (CIT 2004 Science Compendium), and more recently updated and clarified (Price et al. 2007) which examines landscape thresholds for individual species. Although 'representation' is not intended solely to maintain individual populations, focusing on the habitat required to maintain populations provides an approach to setting quantitative targets within a representation framework.

Species populations are known to decline as habitat declines (UNED Millennium Assessment 2000), but determining ecologically significant levels of habitat within this decline is difficult if the decline is linear (Ludwig et al. 1993). Identifying 'thresholds', i.e. places where the rate of decline increases suggests ecologically significant events are occurring. Box 2 summarises the results of a recent threshold review (Price et al. 2007).

Box 2. Thresholds and representation (Price et al. 2007)

A review of the literature shows that the first 'thresholds' are observed at above 70% of total habitat for a group of most sensitive species. Below 60% of total habitat, the number of species or communities crossing thresholds increased linearly for both abundance and extinction thresholds. More than one-third of species or communities crossed thresholds above 50% of total habitat; nearly two-thirds reached thresholds before their habitat dropped to 30% (Figure 1).

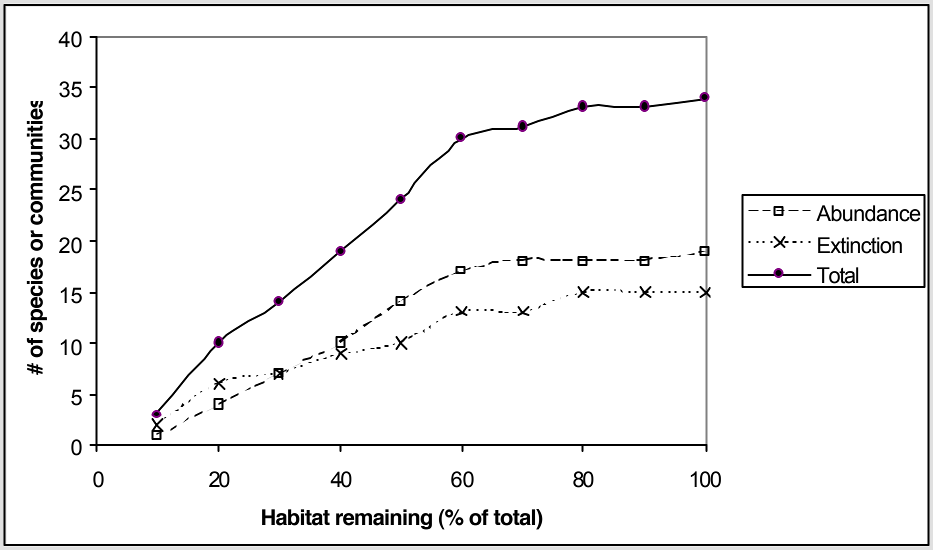

Figure 1. Review of thresholds – taken from Price et al. 2007.

Community thresholds: community thresholds identify the place where the community as a whole demonstrates a change in rate of species loss, and are particularly important to consider because they examine potential community disassembly as the rate of extinction increases. **The three studies that detected community thresholds found a wide range of thresholds (10%, 35% and 53% of total habitat).**

The conclusion made from this review is that setting a representation target of more than 60% of total habitat would equate to low risk – i.e. a high chance that ecological integrity would be maintained, and that in composite most species would not cross thresholds at this level of habitat.

Because 2/3rds of species crossed thresholds around 30% of total habitat, this level was suggested to equate to 'high risk' – i.e. a high chance that ecological integrity would NOT be maintained at this level of total habitat.

Based on the original science review (CIT 2004), and substantiated by the more recent review (Price et al. 2007), the CIT recommended representation targets for the North and Central Coast of BC. It was recommended that rather than targets linked to absolute habitat amount, it was appropriate to refine targets based on the natural disturbance regime defining a particular ecosystem. As a result, a 'low risk' target was identified as being '70% of the natural levels of old-growth in each ecosystem', and a high risk target was identified as being '30% of the natural levels of old-growth in each ecosystem'. In the range of ecosystems from fir-leading sites in the south, to bog forests in the Hecate Lowland this results in absolute targets of between 35% - 69% old growth protection for low risk.

The CIT also recommended that maintain ecological integrity was possible by implementing a low risk target at the regional level, while allowing high risk to occur within watersheds within this area. This approach allows 'zoning' of development and protection, making development more practical and conservation areas potentially more effective.

Another example of a broad scale representation target was laid out by the Clayoquot Sound Science Panel (CSSP 1995) which outlined an approach for creating a reserve approach for Clayoquot Sound. A number of key elements were identified that should be reserved to maintain functioning ecosystems, including coarse filter elements such as a riparian reserve network and maintaining old growth forests. They suggested a target for old-growth forest protection of 40% (of the landbase / by ecosystem), but did not provide any data or specific rationale for this level of protection.

Many other design approaches have generated broad goals about 'maintaining representative ecosystems' without identifying how much habitat should be identified. As outlined by Margules and Pressey (2000) failing to identify quantitative targets is problematic because it leaves planning in a state of confusion, with no clear sense of objective or achievement. Applying some broad ideas of representation targets based on habitat needs of individual species is feasible, and the approach of basing targets on natural disturbance information from that ecosystem allows generic targets to be applied in an ecologically relevant way to different systems.

2.2 SINGLE SPECIES APPROACH

The 'umbrella species' concept has been widely touted as alternative or complementary to the 'representation' approach to regional conservation planning. The idea is simply that a wide-ranging species (such as grizzly bear) uses a large area and diversity of habitats, and therefore managing for that species should do a reasonable job of managing for other species. A recent test of this theory was undertaken for the large area encompassing the Rocky Mountains in northern USA and southern Canada (Carroll et al. 2001). Habitat models developed for four focal species – grizzly bear, fisher, lynx and wolverine – were used to test how habitat identified for individual species provided an 'umbrella' for the other species. Predicted high-quality habitat for grizzly bear had high overlap with that for wolverine, moderate overlap with that for fisher and low overlap with lynx. The authors suggest that any one of the individual species would provide a poor surrogate for a coarse filter strategy, but summing up the habitats and areas required for the four species together results in a useful approach to real conservation planning and target-setting.

Viability analysis for single species can also be used to confirm or complement targets based on a coarse filter approach by identifying the amount of habitat area required to maintain that species, and for identifying important areas of landscape connectivity where a focal species that is sensitive to landscape pattern exists. For example, in the Canadian Rocky Mountains Ecoregional Assessment (NCC 2002), population viability models were produced for grizzly bear and wolf. It was determined that the objective was to maintain or have slightly increasing populations for these species, and that this would require 40% of the existing habitat values for these species. Building on the existing park system, and adding in additional habitat to meet the target, maintaining 40% of the habitat values required for the two species required 52% of the region (NCC 2002).

A different type of example is discussed in Box 1, where the life history traits of rare plant species are used to identify how much area is predicted to be required to maintain a viable population of a species (Burgman et al. 2001). In that work they found that, in general, an area of approximately 1000ha (700 – 1100ha) was the minimum size likely required to maintain a particular population of rare plants (with three different life history strategies). These authors also provide examples of how different decisions may link to 'risk' and what might be deemed 'acceptable risk'. Using population modeling they provide the example that the model can be set to 'allow' different levels of chance that a population may become extirpated – for example, supposing sufficient area is protected to result in a <0.1% chance of a species becoming 'extirpated' in 50 years. If this is then 'rolled-up' to the 25,000 vascular plant species in Australia they assume this means we are ready to accept the potential extirpation of 25 species within this timeframe. If this level of risk is unacceptable then the model parameters, and thus area required for an individual species can be altered to reflect this.

2.3 MULTIPLE OBJECTIVES APPROACH

Many small-scale projects focus on meeting single objectives for single species, however, 'real-world' conservation plans tend to use a whole suite of approaches to developing a reserve network (see Case Study Section 1.5, plus examples below). These multiple objective / multiple approaches are most relevant to a realistic effort to maintain or restore biodiversity values in a large area, and the targets that are identified, or that 'fall out' from applying a series of planning steps to a large region can provide the most comprehensive idea of the kind of ballpark required for an ecologically relevant target.

For example, in the case study in Florida, a series of steps were undertaken to identify key elements of the landscape that should be included in a reserve design, without setting *a priori* targets of how much was required. After that broad planning was finalised, 57.5% of the Florida landscape was identified, 50% of which was already located within an existing reserve. It was additionally noted that some additional key areas would likely have to be added to this to ensure full representation and to ensure viability of some sensitive species, so the final total is likely to be slightly higher.

A series of projects have been undertaken that attempt to 'rewild' North America (Soule and Noss 1998). These examples apply the theory of identifying and protecting special elements (e.g. concentrations of rare elements), maintaining representative ecosystems and meeting the needs of focal species particularly carnivores and other large-ranging species. There are two thorough examples which are ecologically relevant to British Columbia. Miller et al. 2003 identified the reserves required to maintain biodiversity values in the Southern Rocky Mountains. In that conservation assessment they recommended 62% of the total ecoregion was required to maintain ecological integrity, of which 26% was recommended to be designated full Protected Areas with the majority of the remainder of the landbase as compatible use areas.

In a second example for the Greater Yellowstone Ecosystem, the combined result of representation, single species, and special element protection resulted in a total of 70% of the region being recommended as required to maintain the ecological integrity of the region (Noss et al. 2002).

In a review of conservation targets identified using recommendations from comprehensive planning such as those outlined for Florida, for the Southern Rockies and for the Greater Yellow Ecosystem, Svancara et al. (2005) note that ***"these high percentages, while still considered unrealistic by many are increasingly seen as credible estimates of what it takes to meet a broad suite of conservation goals"***.

2.4 TARGETS: RISK LEVELS AND UNCERTAINTIES

'Risk' is an approach to thinking about both the implications of different decisions, and the influence that uncertainty can have. Typically, risk consists of two variables – first, a probability that something will happen, and second a level of significance associated with the negative outcome. In Environmental Risk Assessment (e.g. MoE 2000; Holt and Sutherland 2002; Holt 2004) the level of significance aspect is turned to a constant by defining risk as an 'adverse outcome' which is then defined. In an analysis of coarse filter representation on Haida Gwaii, the adverse outcome is defined by loss of ecological integrity resulting from significant deviation of the landscape from natural condition (Holt 2004). This leaves risk defining the 'probability' or chance that this adverse event will occur. 'High risk' is then a high probability that a significant negative outcome will occur.

Uncertainties arise at every level of planning. They can't be avoided, but identification of key uncertainties and then interpreting information appropriately is a vital part of successful management. Within the realm of target setting, in each of the three categories outlined above, there are clearly many uncertainties. Uncertainties include mismatches between scales of data and reality, missing data, lack of knowledge regarding the interactions between species, and the unknown future effects of stochastic events such as unforeseen habitat loss or climate change.

Risks and uncertainties work together. For example, science literature identifies an increasing number of species crossing ecological thresholds as the amount of habitat is reduced from the natural level (Price et al. 2007). This is shown graphically in Figure 2 as the solid linear line. However, we hypothesise that the uncertainty associated with this trend is non-linear. At very high levels of 'naturalness' (in Figure 2 measured as level of old-growth) we are quite certain that ecological integrity will be maintained. Similarly, at very low levels of 'naturalness' we are quite certain that ecological integrity will not be maintained. However, in the midrange, although it must clearly move between these two states, we are uncertain of the shape of the relationship, so targets in the mid-range (e.g. 50% of habitat) may be lower risk than 30%, or higher risk than 60%, but the certainty that either hypothesis is true becomes lower.

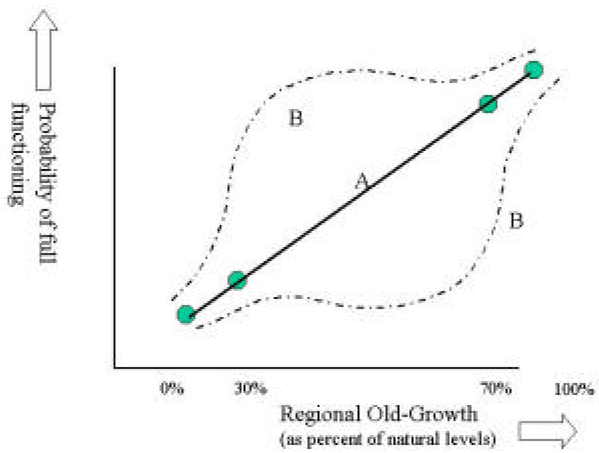

Figure 2. Predicted risk levels and uncertainty (from Holt and Utzig 2002). Line A represents the linear relationship between the probability of functioning and the level of habitat maintained. Dotted lines B represent uncertainty around the relationship.

Within decision-making, an alternative way to read Figure 2 is to think about what level of risk might be reasonable, and how much certainty is required. Table 3 makes inferences from the figure to aid in interpretation. Note that no data are available to quantify these statements, and they are simply hypotheses based on logic.

Table 3 outlines the hypothesis that different levels of risk have differing levels of uncertainty associated with them. The 'lack of certainty' that a particular action may have negative environmental outcomes has often been used as a reason for undertaking the action 'regardless' of the potential harm since economic or social negative outcomes often appear easier to predict. The 'precautionary principle' has been devised as a way to avoid this conundrum and states that if an action may cause serious or irreversible harm then, in the absence of scientific consensus (or certainty), that the burden should fall on the individuals taking the action to demonstrate that significant harm will not be caused.

Table 3. Estimated ranges of protection associated with different risk and certainty levels. Inferred from review of thresholds (Price et al. 2007) and hypotheses about uncertainty.

Range of habitat protection	Estimated maximum risk level	How much certainty?
70% plus	**Low**	High
60% - 70%	**Low – Moderate**	Moderate
50% - 60	**Moderate**	Moderate – Low
40% -50%	**Moderate**	Moderate – Low
30% - 40%	**Moderate - High**	Moderate – Low
<30%	**High**	High

Within a conservation planning exercise, identifying the number and the extent of key uncertainties, and how they may influence probability of success (either at the single reserve level, or in relation to overall targets) is an important first step.

2.5 TARGETS: SCIENCE VERSUS POLICY?

Section 2.0 thus far has discussed scientific approaches to setting conservation targets. However, many (if not most) targets are actually set within a policy context, that is they may be based on either no science at all, or on science recommendations that have been altered in light of economic or social input without the implications to environmental values being assessed.

A review of conservation targets across a wide range of different ecosystems was undertaken in order to assess how biologically-driven targets differ from policy-driven target setting (Svancara et al. 2005). In their review, of 162 targets, 17 were made politically, and the remainder were 'evidence-based' (33 were threshold driven and 112 were results of conservation assessments). The conclusion from the review of 159 articles which compared targets set in 222 cases showed that the average percentages of area recommended for evidence-based targets was nearly three times as high as those recommended in policy-driven approaches. A wide-range of results were found in all categories (though the range was considerably smaller for the political targets). Figure 3 shows the mean conservation targets recommended (+/- 95% confidence intervals) and the ranges found in all cases.

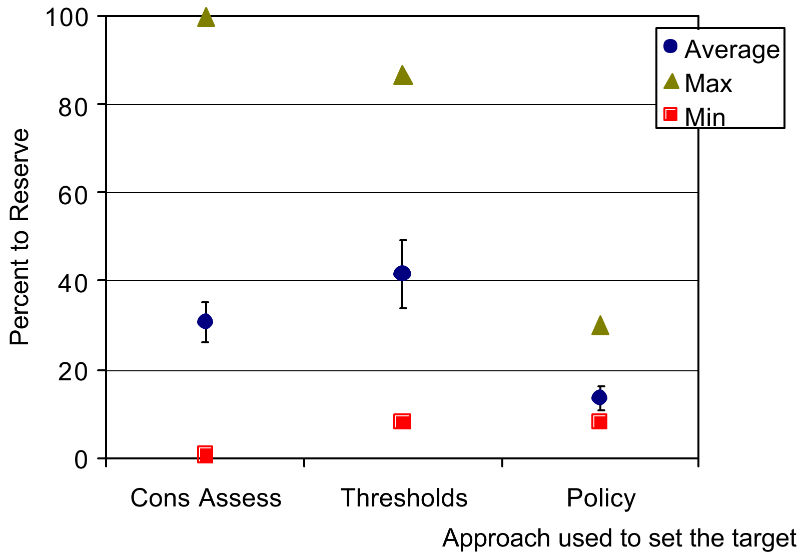

Figure 3. Average +/- 95% confidence intervals, plus ranges of conservation targets. The scale of projects and range of ecosystems included is extremely wide. Redrawn from data presented in Svancara et al. 2005

In addition, the review assessed the average percentages of protected area recommended as necessary to conserve various features of interest. Figure taken from Svancara et al. (2005).

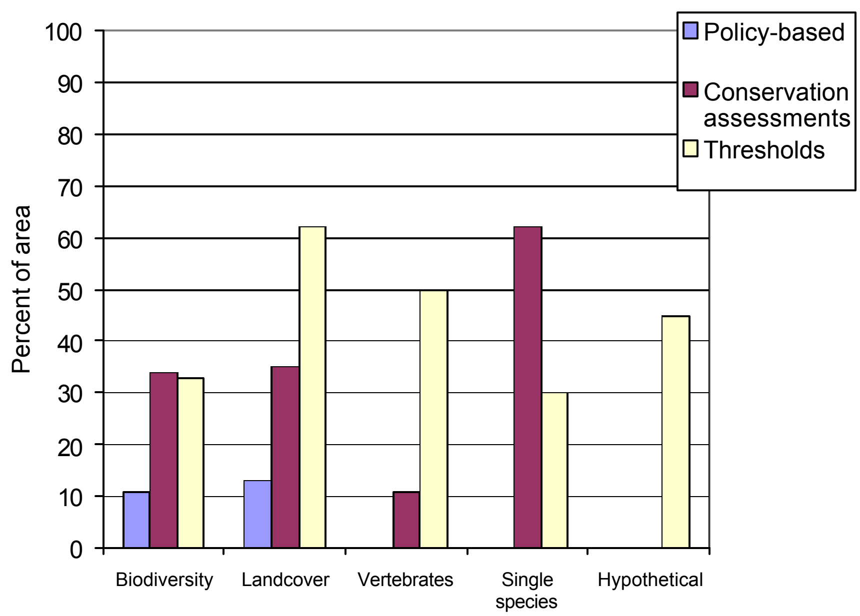

Figure 4. Percentages of protected area estimated to be required to meet a number of different values of interest (redrawn from Svancara et al. 2005).

From the range of conservation articles considered, different elements of biodiversity have been attributed a wide range of different levels of area targets for protection. For example, land cover (representation) based on threshold analyses has an average of approximately 60% area protection, compared with approximately 38% of the area identified using a conservation assessment. This is compared with around 15% based on policy-driven targets.

2.6 SUMMARY

Different approaches to setting targets result in different targets. Starting with an ecosystem representation target, adding in special elements and checking the target using focal species has been used most widely, and is likely the most applicable to the CDF. The total amount of habitat allocated towards conservation in these examples tend to be high (50% plus). Although many papers do not specifically outline the level of risk they are accepting (or hypothesising), the work for the CIT suggests that the regional conservation plans that identify high levels of habitat are likely to be in, or close to, the low risk category. However, many of the policy-driven targets are considerably lower than levels identified as likely to maintain ecological integrity and therefore are likely to be in the high risk category.

Identifying what level of risk is considered 'appropriate', and understanding the uncertainties associated with determining risk levels is a key part of the process of planning.

3.0 APPLICATION TO THE COASTAL DOUGLAS FIR ECOSYSTEM

The Coastal Douglas Fir (CDF) ecosystem is located in the Leeward Island Mountains within the Eastern Vancouver Island Ecoregion and Georgia Depression Ecoprovince. The CDF is characterised by low precipitation and tends to have dry summers and mild winters. This region is highly ecologically diverse, with a diversity of forested and non-coniferous forested ecosystems (Garry oak, wetlands), and grass-dominated ecosystems on some sites, many of which are associated with a large number of rare species. The region also supports endemic species because the area remained ice-free during the last ice-age.

Forest development history on southern Vancouver Island is some of the longest in the Province. Crown land is very limited in extent (approximately 7% of the total), with much of the remainder of the landbase is held as private land. Protected Areas are some of the lowest in the province (2.6% of the landbase – 2007[2]).

Primary land use consists of forestry, agricultural and some of the highest density urban, suburban and rural development to be found anywhere in BC. As a result, the landscape is a matrix of second growth forests, small pockets of old growth attributes, and development. Understanding the landscape context is important because the 'hostility' level of the matrix affects reserve design.

Conservation science has outlined a number of different, but complementary approaches for reserve design (Section 1.0). The following section outlines a number of steps that are key pieces of undertaking a regional conservation planning exercise. A preliminary assessment of data sources and key uncertainties is provided.

3.1 GOAL SETTING

Typically, in this type of conservation planning a broad goal is set that reflects something like:

Maintain ecological integrity[3]

[2] B. Zinovich, ILMB, pers. comm.
[3] For example, this is the ecological goal set for coastal EBM planning by the Coast Information Team (2004).

Being clear about the goal is important because objectives and strategies 'flow' from this goal and will differ depending on how broad the goal is.

Ecological integrity is the abundance and diversity of organisms at all levels, and the ecological patterns, processes and structural attributes responsible for that biological diversity and for ecosystem resilience. It is reasonable to have a broad yet 'impractical[4]' overall goal, but also important to identify measurable, quantifiable subgoals, or objectives within the broader goal. Examples may include objectives such as:

- Maintain representative forest ecosystems adequate to maintain ecological processes[5]
- Maintain ecologically viable[6] and resilient populations of all native species,
- Maintain (all) hotspots of endemic, rare or threatened species.

<u>Goal Setting</u>

Identify an over-arching goal. This sets the vision and does not need to be quantifiable. However subgoals should be quantifiable, e.g. at least three occurrences of each species, 1500 ha of each vegetation type, etc. (Pressey and Cowling 2001).

Set quantitative targets for minimum size, connectivity and other design criteria. Make explicit assumptions regarding what might constitute viability. This allows hypotheses to be tested and assessed through time.

Identify additional preferences (e.g. minimise effects of invasive species or grazing etc).

3.1.1 EMPLOYING STRATEGIES TOWARDS REACHING THE GOAL

In order to meet these goals and objectives, a series of strategies are needed, and this is the role for conservation planning.

As outlined in Section 2.0, it is well established that using a coarse filter / fine filter approach is an efficient process for conservation planning. The coarse filter is intended to maintain the vast majority of species, ecosystems and processes and implicitly acknowledges that we do not know or understand how much of the natural world functions and interacts. The fine filter is intended to 'pick up' the elements that are unlikely to be captured by the coarse filter, and is supposed to be focused on elements that are known to have specific requirements.

The first step is to identify appropriate elements of the coarse filter.

A second step to identify appropriate fine filter elements.

Step 1 and Step 2 together are approaches to identifying potential conservation patches from which choices must be made.

Step 3 is to determine the extent of existing Protected Areas and identify gaps.

Step 4 is make practical decisions about which specific parcels of land meet the objectives most efficiently.

Although presented as a series of steps, a real-world conservation planning process is likely to be an iterative process.

[4] Impractical in the sense that it is not easily quantifiable or measurable.
[5] It is possible to measure for at least some processes.
[6] Ecologically viable populations are those that maintain critical interactions within the species and with other species. Population sizes required tend to be much larger than those estimated required to simply persist over time (see Peery et al., 2003).

The following text outlines a discussion for each step, with identification of key action items, data needs and uncertainties highlighted in box text.

3.2 STEP 1 – IDENTIFYING THE COARSE FILTER

For conservation planning within a (relatively) large area such as the Coastal Douglas Fir zone, the coarse filter is the most important element of planning.

The coarse filter involves maintaining adequate and representative ecosystems across the landscape, and requires a number of questions to be answered:

- What is the appropriate scale to define ecosystems?
- What is an appropriate target for each?

3.2.1 WHAT ARE APPROPRIATE ECOSYSTEMS FOR REPRESENTATION?

The definition of ecosystem used for planning should be appropriate to the spatial scale of the planning area, and the level of natural variability present in the area. British Columbia has one of the best hierarchical ecological classification systems and this biogeoclimatic ecosystem classification can be used to define ecosystems.

For this level of planning a suitable level for describing ecosystems is site series. Within this, it may also be appropriate to 'group' site series into broader classes using 'dry', 'mesic', 'wet' groupings within a particular biogeoclimatic variant. When looking to groups site series it is important to maintain sufficient numbers of groups to adequately capture the range of ecological variation. For example, if there are 9 site series within a biogeoclimatic variant, making three groups might be appropriate; if there are 17 site series then more groups might be needed to adequately capture the ecological variability range.

If groups of site series are used, it is important to ensure that rare site series are not included in a group, or that targets for rare site series are met independently of other site series (see fine filter elements).

Within the site series definition of ecosystems, it is possible to add seral, or structural stage to this definition. Considering old-growth, rather than young, mid, or mature seral stage, adds a temporal component, as opposed to simply reserving any examples of the ecosystem, irrespective of seral stage. Adding this component, for forested ecosystems, can be considered including a condition factor into the analysis (See Section 3.5.1). Given the current condition of the entire CDF, where conditions are generally poor, restoration will be key aspect of the planning. Meeting two goals is therefore important: representation of ecosystems in good condition (older forest, or high structural attributes present) and representation of ecosystems in poor condition but which have high probability of restoration.

Biogeoclimatic ecosystem classification does not adequately identify aquatic ecosystems. Applying the new wetland classification system should provide adequate representation of these features.

Other ecosystems are also not well captured by the primarily forest biogeoclimatic classification system. However, the CDF has seen extensive identification and mapping of additional ecosystems through the Sensitive Ecosystems Inventory (Ward et al. Sensitive Ecosystem Inventory 1993) which provides extremely valuable information with which to a) to check for representation of different ecosystems, and b) to identify fine filter 'special' elements for protection.[7].

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[7] See discussion under fine filter –distinction between representation of smaller ecosystems and the 'fine filter' is somewhat semantic.

Appropriate ecosystems for representation:

- Use site series as the basic group for representation. Apply complex polygons on an area-weighted basis.
- Identify aquatic ecosystems based on available data (new classification system is available – apply using TEM?).
- Assess ecosystems identified in the Sensitive Ecosystem Inventory and 'interface' ecosystems not identified elsewhere (e.g. shoreline ecosystems) and consider representation of these types over and above site series representation (as representation / or special elements depending on the scale and distribution of the ecosystem).
- Cross-reference this with fine-filter elements identified.
- Data needs include: TEM for site series (soon to be available), SEI inventory, ID of Aquatic Ecosystems (from TEM), ID of other interface ecosystems (e.g. shoreline).

3.2.2 SETTING TARGETS FOR ECOSYSTEM REPRESENTATION

As outlined in section 2.0, the representation target is typically considered the most important, and can be cross-referenced or 'checked' using species viability models.

For example, the old-growth target by ecosystem was considered the most important for the mainland coast of BC. However, in addition, a mid-seral maximum was identified based on information relating to grizzly bears and known landscape hostility issues.

The specific target, or range of targets, used depends upon the level of risk that is considered acceptable to society.

In order to move into a low risk model, suggest basing targets for representation on the review of literature summarised in Section 2.1, and modifying them based on natural disturbance information for the different ecosystems.

In an ecosystem such as the CDF which is characterised by relatively frequent natural disturbance events, and also has very little forest remaining in older age classes, it is appropriate to define targets for different seral stages (or at minimum, for different categories of older forests).

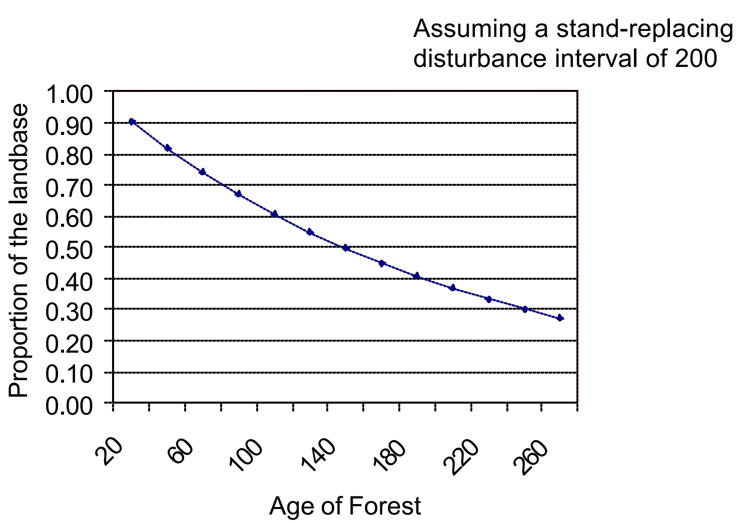

Figure 5. Guidance on targets for different ages of forest, based on predictions from

the natural disturbance regime. Predicted proportion of the landbase by forest age is shown (see Table 4 for targets).

Natural disturbance regimes can help in determining what proportion of the landbase would naturally be in each age-group. For example if it is assumed that the disturbance frequency for stand-replacing disturbances is around 200 years (as outlined in the Biodiversity Guidebook), then Figure 5 outlines what proportion of the landbase would be expected to be in each age range.

Applying a percent based on the level of risk required, to each age category then provides specific targets. For example, in Table 4, assuming a 'low risk' target of '70% of natural', assuming that naturally 37% of the forest would be in ages older than 200 years[8]. Applying the target then, 70% * 37% results in 26% of the landbase in forest >200 years old.

Table 4. Cumulative targets for forests of different ages. This approach helps to identify which parts of the landscape require additional effort or restoration in order to meet a low risk target.

Age of forest	Estimated proportion of landbase	For example, using a target (at 70%) – low risk.
>250 years	29%	20%
>200 years	37%	26%
>140 years	50%	35%
>80 years	67%	45%

Target Levels:

- Current protection levels in the CDF are very low (even lower than typical policy-driven targets), and current land use status will exacerbate the effect of this on ecological integrity. This suggests that the CDF is in a high risk category, with a high likelihood that ecological integrity will not be maintained into the future (Holt and Mackinnon 2001 ; Ward et al. 1993).
- Moving out of the high risk category will require a significant increase in the current level of protection.
- Moving into the low risk category with any certainty will require an even higher level of protection, which likely requires a combination of reserve plus management activities over other areas that are compatible with maintaining biodiversity values.
- Specific target depends on level of risk considered appropriate. Low risk for forested landscapes are likely to be around 70% of the natural levels of old forest present. Predicted amount of forest greater than 250 years old, under a disturbance frequency of 200 years (Biodiversity Guidebook 1995) is around 29%. The low risk target for forests >250 years would therefore be 29% * 70% = 20%. Repeat this process for different ages of forest (as per Table 4).
- For other ecosystems such as wetlands or Garry oak, apply targets as a percent of total (e.g. 70%) of occurrences for low risk. Refine using expert workshops, which consider amount and distribution of historic losses to provide an ecologically relevant target today.

[8] Province of BC Biodiversity Guidebook – applying the negative exponential equation.

- For rare ecosystems, typically, protection levels should be higher than for common ecosystems. Protecting 100% of truly rare ecosystems and elements would represent low risk. Considering refining using expert workshops, which consider history and extent of loss to date to provide an ecologically relevant target today.
- Identify species which may provide a 'check' on the overall target amount suggested.
- Explore setting a target for short and long-term benefits (i.e. to include the current successional stage/ condition of the forest, and condition of other ecosystems (see Section 3.5.1).
- Data required: refined information on natural disturbance. Low or mixed severity fire regimes are more likely to define certain regions, rather than stand replacing events (Holt and Mackinnon 2003). Determine level of risk considered appropriate.
- Uncertainties: applying risk targets in this way is uncertain, and should be considered a hypothesis. However, the approach is beneficial because it requires explicit assumptions to be made. Typically these assumptions remain hidden and therefore are never tested or examined. Consider key uncertainties, particularly climate change and how this may alter ecosystem distribution and processes in future.

3.3 STEP 2: IDENTIFYING FINE FILTER ELEMENTS

There are a number of approaches to identifying fine filter elements, which typically involves considering

- Specific habitats or ecosystems which are not fully covered by the 'coarse filter' definition used.
- Ecosystems which may require increased or decreased targets, compared with the coarse filter.
- Species which may not be adequately maintained by the coarse filter.

Fine filter elements are typically those which may be missed using a coarse filter approach. An existing summary of species relevant to the CDF comes from Stevens (1995). It outlines that at that time there was 409 vertebrate wildlife species, including 11 amphibians, 9 reptiles, 322 birds and 67 mammals use the CDF for habitat.

Table 5 suggests a preliminary set of criteria for identifying potential fine filter elements, and actual identification of specific elements will require additional work. Potential data sources are identified.

Table 5. Preliminary list of potential fine filter elements relevant to the CDF.

Element	Rationale	Data
Rare plant communities	Limited distribution. Highly vulnerable. Consider historic distribution.	CDC lists
Rare plant species	Limited distribution. Highly vulnerable. Additional emphasis on species limited to zone.	CDC occurrences
Rare animal species	Limited distribution. Highly vulnerable. Additional emphasis on species limited to zone.	CDC occurrences
Endemic or biodiversity hotspots	High value. High responsibility in this zone.	New Mapping as part of Biodiversity

Element	Rationale	Data
		Strategy
Wide-ranging species, with specific habitat requirements.	E.g. Marbled Murrelet which likely requires habitat restoration to maintain populations.	Local modeling
Medium sized mammal	Check area requirements for a medium sized mammal to determine whether level of protection and distribution appears adequate. Larger mammals are extirpated from this zone, so focus on medium sized mammal is critical to ensure lower levels are not lost.	Local modeling
Special habitat elements	e.g. hibernacula / bat roosts / rare plant communities.	?
Critical interface areas, e.g. haul-out zones for marine mammals associated with CDF.	Highly critical habitat. Maintaining species across boundaries between realms (marine / terrestrial) that tend to fall between jurisdictional cracks.	Mapping?
Vulnerable ecosystems	We are assuming here that habitat such as estuaries, ponds, wetlands, shoreline forests will be encompassed under the coarse filter approach. Pick up elements that were missed in that approach.	SEI

Fine Filter:

- Refine Table 5 using local expert opinion. Use that process to Identify fine filter elements to be focused on in the initial phase of reserve design.
- Identify locations, or potential locations where they can be found and include in the suite of potential reserve patches. Include a 'condition' ranking for these patches, in relation to their particular element of interest (e.g. Ministry of Environment 2006).
- New mapping is being developed as part of the development of the provincial biodiversity strategy. Determine whether it is at a suitable scale for use in this planning.

3.3.1 SETTING TARGETS FOR RARE ECOSYSTEMS OR SPECIAL ELEMENTS

For non-forested ecosystems, maintaining some proportion of the available habitat is required. There is no rationale for changing the target for these types, except that the target should apply to total target, rather than to the seral stage. Therefore, the low and high risk approaches outlined above likely apply.

Should the target differ for different ecosystems?

Rare ecosystems

- generally need higher levels of protection, because it is assumed that their small area needs higher protection to be viable. This follows logically because if only 10ha of something exists, maintaining a percentage of it is unlikely to result in a viable conservation unit. Many other conservation plans have typically provided a gradation of increased protection for rare ecosystems – e.g. 100% of red-listed ecosystems protected, and 50% of blue-listed ecosystems (CIT handbook 2004). However, this needs to consider historically impacted sites, as well as ecosystems in good condition today[9].

- Defining what is rare is then also required. Listed ecosystems (red and blue-listed, CDC) clearly qualify, but a number of other ecosystem types also might classify as rare (including SEI types). Specific local definitions of rare ecosystems should be developed.

- Identify locations, or potential locations where they can be found and include in the suite of potential reserve patches. Include a 'condition' ranking for these patches, in relation to their particular element of interest (e.g. Ministry of Environment 2006). Identify which ecosystems or elements are 'truly rare' (which may include all red or blue listed ecosystems, or not, and other ecosystems). Suggest a target of 100% protection for truly rare elements.
- Vulnerable elements (e.g. blue-listed ecosystems) may be maintained using a lower target (e.g. 70% of total), but should be assessed for their vulnerability and historic impacts.
- For species, modeling may be required to determine what constitutes a high likelihood of maintaining a viable population for a limited number of key / unique species.
- Data: CDC, SEI data.
- Uncertainties include: historic distribution of ecosystems that have seen significant impact. Many uncertainties in determining level of protection required to maintain viable populations, particularly in the face of a changing landscape and climate. Uncertainties relating to the effect of landscape hostility on different values, and how this should influence the level of protection. Uncertainties associated with invasive species.

3.4 EXISTING PROTECTION GAP ANALYSIS

Protected areas and reserves already exist in the CDF, and these will form the core of a future conservation strategy. It is therefore necessary to undertake a gap analysis to determine how much representation of each ecosystem, and in what spatial layout, is already protected.

This is a relatively simple GIS exercise, once the appropriate layers are finalised.

Gap Analysis:

- Use Terrestrial Ecosystem Mapping to undertake a site series level representation analysis. Apply an area-weighting to complex TEM polygons so that data are not lost. Compile information (area and percent) on the following: a) area of each site series; b) full protection by site series, c) soft protection by site series (e.g. reserves other than full Pas), d) land tenure distribution for each site series (so opportunities are known), e) condition class distribution for each distribution (i.e. seral stage / structural stage as appropriate for the ecosystem).
- Repeat from above, using the SEI.
- Use output from the gap analysis to get basic information about what gaps require 'filling' in terms of protection.
- Data: as outlined above.

[9] Historic loss of a particular structural stage can result in complete loss of a particular ecosystem from the landscape. Protection of some percent of what's remaining can therefore suffer from the moving benchmark phenomenon (Pauly 1995)

- Uncertainties: existing protected areas may not have sufficiently fine-scaled data to perform these analyses. (Is TEM coverage including parks?). The extent to which non-protected areas may add to conservation is also not included at this stage (though it could be – however this will increase the scope of this exercise considerably).

3.5 STEP 3: THE PRAGMATIC ASPECT - MAKING CHOICES BETWEEN POTENTIAL PATCHES.

The combination of above three steps should result in a) a confirmation of ecosystems, fine filter elements and targets and b) an identification of the gaps in existing protection that need to be filled by new protection.

The next steps are to assess the suitability of new patches to meet this shortfall.

The following are factors relevant to undertaking this process, though actual planning details will change determining on whether any GIS tools are being considered for implementation (e.g. optimisation algorithms), and whether the specific approach is directed by new or existing policies[10].

Once Steps 1 and 2 are completed, suggest a workshop format with planners, conversation biologists and local biology experts to develop the specific methodology for undertaking the process. Consider the following:

3.5.1 CURRENT CONDITION

Conservation planning requires thinking on a long timescale. There are two main goals which may or may not be complementary a) to maximise immediate conservation value and b) to maximise long-term conservation value.

Identification of representative ecosystems in current good condition (e.g. old-growth, or functional ecosystem complexes) is the strategy to maximise immediate conservation benefit. Secondly, identification of representative ecosystems, irrespective of current condition but maximising factors that will result in long-term value is the approach for maximising long-term conservation benefit. Clearly, maximising both options is best, however with limited funds trade-offs likely have to be made. Typically, maximising immediate benefit is the best strategy, to maintain condition as high as possible in the short-term, however options to gain a large long-term benefit should not be overlooked.

In the CDF, current landscape condition is relatively low. Few options for capturing high condition old growth remain (Holt and Mackinnon 2001), and loss of sensitive ecosystems has long been identified as an issue likely to compromise conservation across the region (Ward et al. 1993). Planning for long-term benefit will therefore be a key feature of planning in this ecosystem, and for some ecosystems restoration may be the only significant option remaining today.

Definitions of condition for different ecosystems need to be developed. At one level, forest condition can be estimated by seral or structural stage information, for example, in meeting an old-growth target, younger forest may be necessary to meet that target as there is likely insufficient old-growth available – within the younger forest category, mature forest can be thought of as being in better 'condition' to meet an old forest target, whereas early seral forest would be in poor condition.

An alternative approach to considering 'condition' is to include all the other factors that influence how a particular patch may function in future, and identify some measure of the 'probability of persistence'

[10] For example, the current approach to plan first on crown land can be used to 'drive' the process (i.e. the steps could be taken on crown land alone), or planning for the entire CDF could be undertaken, and then actions taken only on crown land. This latter approach, considering the whole landscape, is likely to result in the more comprehensive plan but will require more resources and effort upfront.

(see Section 1.0). These include size of the patch, matrix that the patch is located within (hostile, or non-hostile), presence and extent of invasive species, connectivity to other patches etc.

A landscape level approach to identifying patch value in relation to its surroundings has been developed (Holt and MacKinnon 2001), and can be used in a broad way to assess the potential value from different patches, based on coarse landscape level features of the patch.

A more detailed approach for assessing the conservation value of a particular patch, which encompasses many of these ideas for a particular element has been developed for the CDF (BC Ministry of Environment 2006.) and can be used as part of the package for developing recommendations for the viability of individual elements within potential conservation patches.

Patch Condition

- Identify the current and potential future condition of the suite of potential conservation patches.
- Consider the potential future condition in decision-making.

3.5.2 PATCH SIZE

The literature suggests that all other things being equal, larger sized patches are more effective for conservation in the long-term than are small patches.

Patch size:

- Identify the largest areas that are potentially available for conservation.
- Prioritise those that contain the most (highest number, diversity, or large area) examples of under-represented ecosystems
- Prioritise those that have the highest condition. Do not discount 'low condition' patches which have the potential to fill representation gaps.
- Cross-reference smaller patches associated with special elements.
- Some data exists for sections of the CDF, such as the Islands Trust work which identifies the largest areas of existing habitat using recent air photo interpretation[11].
-

3.5.3 SPATIAL LAYOUT

Conservation literature suggests that fragmentation of patches, or conversely lack of connectivity between patches has increasing significance as the amount of reserves declines. Also, fragmentation of patches appears to have increasing significance as matrix hostility increases.

Fragmentation of remaining intact ecosystems is high in the CDF (Ward et al. 1993) and matrix hostility for most organisms is likely to be high. Managing for spatial layout is therefore likely to be a very important factor in the development of an efficient conservation plan.

Spatial Layout

[11] Information at: http://www.islandstrust.bc.ca/map/ecosystem.cfm#methods

- Identify known movement corridors for species where information exists,
- Identify other potential important corridors, e.g. riparian buffers, connectivity between wetlands, sensitive ecosystems, Garry oak remnants etc.
- Where single-species modeling is available, examine landscape level connectivity for a suitable wide-ranging species.
- Consider generic landscape permeability and plan for a wide distribution of reserve / conservation patches across the landscape.

3.5.4 ELEMENTS MAINTAINED BY THE MATRIX

Consider how different elements may be maintained by different types of land status. For example, the target values for habitat 'protection' can be thought of being overall targets for the different types of protection afforded to different parts of the ecosystem. In reality, a range of land management approaches can be used to meet the targets, including:

- Forests of different ages, in different levels of protection
  - Hard reserves (protected areas / ecological reserves)
  - Soft reserves (areas identified within management plans as reserves that are legislated, or monitored)
  - Private land managed in a manner compatible with biodiversity maintenance
- Non-forested ecosystems managed in a manner compatible with biodiversity maintenance.

Identify the extent to which values are maintained, or are likely to be maintained by this variety of approaches and use to prioritise a) which elements are truly at risk and b) where alternative approaches may provide conservation benefits.

3.5.5 ADDITIONAL ELEMENTS

As outlined in Section 1, there are a number of other conceptual tools that can be used to aid in this process. As outlined there, Within the broad approach of the 'three R's, consider the following:

- Threats: Consider vulnerability of the habitat – vulnerable areas are those at high risk of immediate loss through some type of development.
- Uniqueness: consider irreplaceable areas – which are those that have are in some way unique and therefore have a high probability of being required to complete the conservation design.
- Patch size: larger patches maintain more species, all other things being equal. Small patches with rare elements remain important however.
- Persistence: Avoid areas where the prognosis of persistence is low. This could include areas that are small, contain many invasive species, are embedded in highly hostile matrices, have high probability of future disturbance, are isolated etc.
- Life-history: Consider the life-history traits of the species of interest, and modify reserves accordingly.
- Population parameters: - consider population and metapopulation dynamics for key vulnerable species.
- Efficiency: - use a complementarity approach where feasible. Ensure new reserves add new elements where possible.
- Pragmatism: Consider areas where risks are highest and options are most limiting (i.e. a

combination of threat and uniqueness)

- Connectivity: Consider connectivity across the landscape, both theoretically (as permeability for general species) and specifically for species known or predicted to be movement limited.

4.0 SUMMARY

Many areas of the world have understood the need for regional conservation planning in an effort to ensure that short-term developments do not foreclose future conservation options to maintain functionning ecosystems. Areas where large-scale, multi-million dollar projects have been undertaken include Florida, California, South Africa, Australia and New Zealand (and many others).

Approaches for choosing between potential reserve areas has received much attention and methods using algorithms to make efficient choices between different patches have been successfully employed in this wide range of political climates. These approaches have also been criticised (e.g. Prendergast et al. 1999) for requiring managers to focus on getting datasets in order rather than making pragmatic conservation decisions while time is short. This dichotomy has not been resolved, but the authors of many such reserve designs that were hinged on using algorithms vigorously defend their use in that they require only as good a data as are available, and do provide systematic outcomes that can be used to guide further 'pragmatic' manager-driven planning (Pressey and Cowling 2001).

Whichever technical approach to planning is used (modeling based, or more 'human labour' type) a number of messages can be taken away from the literature and reviews undertaken here:

1) Setting appropriate targets is one important aspect of effective conservation design. Determining specific targets will vary for different ecosystems (in relation to natural disturbance history, historic impacts and levels necessary to maintain focal species). Specific assumptions around the level of risk considered appropriate are necessary for targets to be set in meaningful ways.
2) For the CDF, a low risk representation target for forests greater than 200 years old, (based assumptions outlined by the CIT 2004 and Price et al. 2007) can be expressed by a '70% of natural' target[12], i.e. approximately 70% of 37% = 26%.
3) Maintaining all examples of truly rare/ unique ecosystems is typically equated with low risk.
4) Maintaining a high percentage of otherwise vulnerable ecosystems is typically equated with low risk.
5) Using population modeling of key species is an appropriate way of refining / checking the levels of protection suggested.
6) Random reserve selection (i.e. opportunistic with no guidance) is the least efficient approach to maximising diversity protected within a constrained budget,
7) For planning, it seems impossible to recommend one particular method over another unequivocally (e.g. Virolainen et al. 1999). However, focusing on a single approach (e.g. habitat availability versus genetic analysis) may fail to provide effective conservation. Ensure multi-discipline teams are involved at all levels.

[12] Assuming stand replacing disturbance of 200 years – this information should be refined using newer ecosystem-based information where possible.

8) Thoroughly analyse conservation problems before providing solutions: different types of conservation scientists should be engaged in the planning to provide the most robust solutions (e.g. Asquith 2001).

9) Consider whether individual reserves are likely to meet specific objectives. The concept of avoiding areas that are least likely to be effective, even if they appear to be on offer, is an important move towards overall effectiveness.

Next Steps: Moving forward with conservation planning at this scale must be a collaborative process. Planners, conservation biologists, field biologists, ecosystem experts must work together to collaborate on the details of a robust approach. A workshop approach could be used to confirm status of on-going projects (e.g. TEM mapping, what questions will this solve / not solve), identify other available data sources that are not included in this very preliminary overview of an approach.

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