

# Automated Integration of Aquatic and Terrestrial Conservation Areas in Conservation Planning: A New Method

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## Abstract

The integration of conservation area designs for aquatic and terrestrial species has been a challenge for planners. The difficulties of crafting a single suitability index which reflects the landscape condition relative to all species, terrestrial and aquatic, and choosing assessment units appropriate for both realms, have made integration especially problematic. Here I will introduce a new technique, vertical integration, which allows planners to analyze aquatic and terrestrial targets simultaneously by using separate layers of assessment units, crafted to match the natural boundaries of the targets being assessed, with suitability indices incorporating impacts specific to those targets. Conservation Areas identified through a vertically integrated solution are efficient, and offer specific information about where to capture each target group individually, and where to capture them together. Examples of the use of this technique in planning will be presented for the Pacific Northwest Coast and the Alaska-Yukon Arctic bioregions.

**Key words:** Planning, Conservation area design, Integration, ANWR

## Introduction

Planning has emerged as one of the fundamental steps in conservation, with the aim of making sure conservation targets are protected with maximum efficiency. As planning has evolved, a wider variety and mix of targets have been brought into planning. Some of the earliest conservation plans focused only on imperiled species. Later plans have focused on all known species, and/or vegetation types. Most recently, aquatic systems and ecological processes have been included in the targets and goals of conservation plans. Whatever the targets may be, some sort of simulated annealing automated site selection algorithm (e.g., *SITES*, *MARXAN*, Kirkpatrick et al. 1983, Otten et al. 1989) is commonly used to create a map of conservation priority area (Andelman et al. 1999, Ball et al. 2000, Possingham et al. 2000).

One of the biggest challenges in planning is how to incorporate aquatic and terrestrial targets into a single suite of conservation areas. Some plans have analyzed terrestrial and aquatic species and systems separately then attempted to merge the results manually. Others have analyzed both target types together in one layer of assessment units (AUs) and allowed the computer to find an optimal solution. A third approach is to merely overlay the outputs of each assessment. All of these approaches have serious shortcomings. Manual integration may be feasible for small areas, but large-scale planning efforts often cover millions of hectares. It is simply impossible to synthesize enough information to ensure reasonable outcomes. Analyzing both aquatic and terrestrial realms with the one-layer approach pushes a large portion of the solution into sub-optimal territory for each set of targets. Site selection algorithms look at the world through the lens of a suitability index which incorporates a combination of factors such as road density, percent land conversion or monetary value. An index crafted for an aquatic species will have little relevance for upland terrestrial systems. Similarly, an index crafted for both realms will tend to mask impacts specific to a single realm. The simple overlay of the independent assessments is perhaps the most robust solution, but often leads to massive conservation area designs, as identifying areas where it makes good sense to work on both aquatic and terrestrial systems at the same time is not an overt criteria. Many opportunities for efficiency will be overlooked.

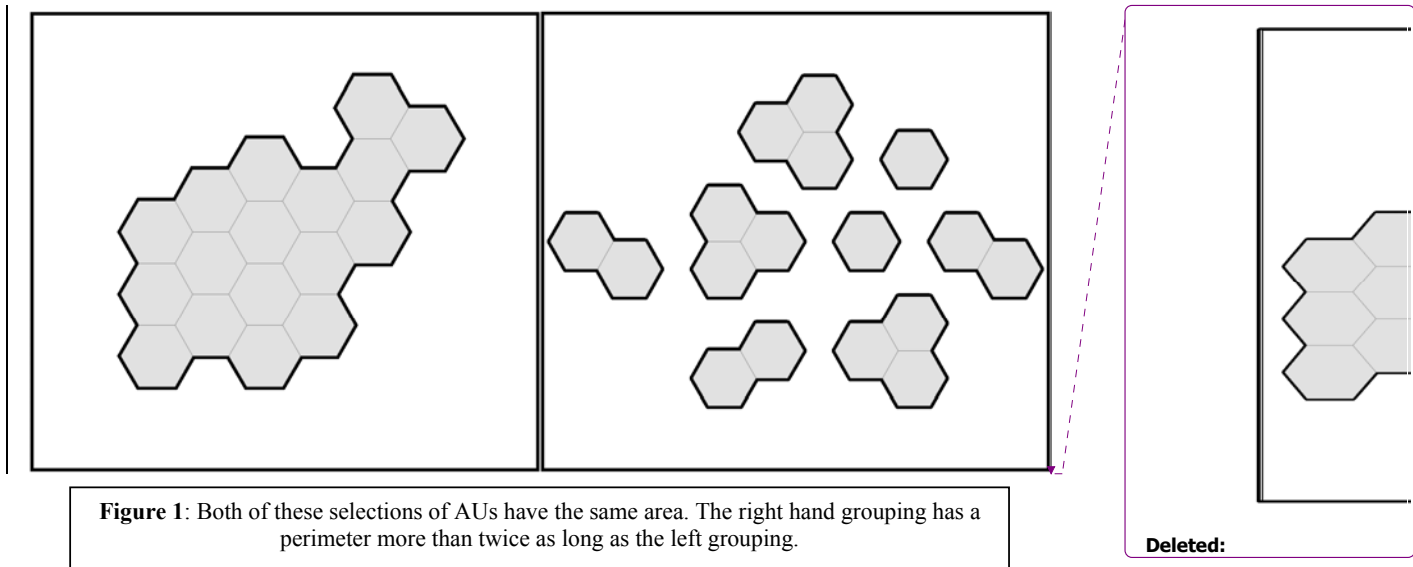
Site selection algorithms require that all species and System information for a planning area be attributed to wall-to-wall coverages of AUs, usually small-scale watersheds or hexagons of several thousand hectares. A computer then examines millions of AU combinations, and chooses the best combination from among them that meet the goals at the smallest cost. This cost is the combination of the sum of the suitability index for all the selected AUs and the sum of penalties for not achieving desired goal levels, combined with the sum

of the boundary length, a measure of the outer perimeter of all selected AUs. Boundary length is directly proportional to fragmentation. A conservation area design comprised of many small, isolated patches will have a larger boundary length than one comprised of fewer, large patches. The best output of the site selection algorithm then becomes the departure point for human planners to review, modify and craft a final suite of conservation areas.

In this paper I will introduce a technique that allows planners to analyze different target types simultaneously by using multiple layers of AUs crafted to match the natural boundaries of the targets being assessed with suitability indices incorporating impacts specific to those targets. This technique, vertical integration, enables planners to identify conservation areas which capture the best locales for each target group, while simultaneously looking for efficiencies by seeking overlap in areas where multiple target types may be effectively conserved at once.

### The Mechanics of Vertical Integration

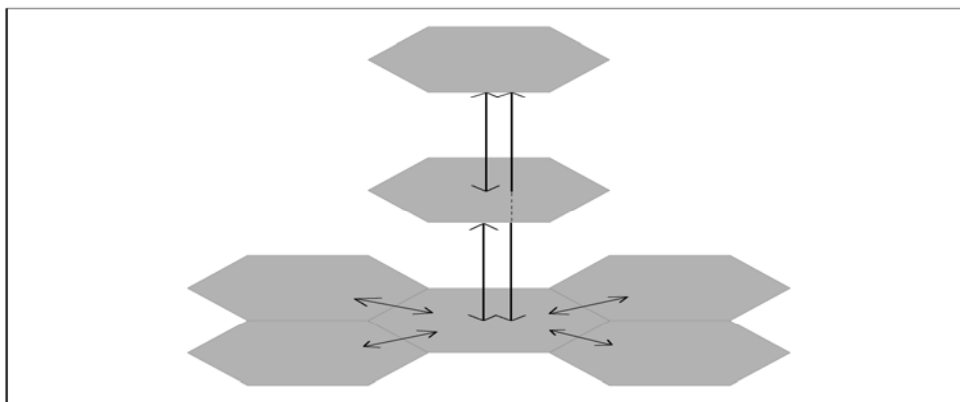
One of the focal concerns of conservation area planning is the design of protected areas that are not so fragmented that even though they may contain all of the species of interest now, over time the species are likely to disappear as a result of habitat fragmentation. In order to address this concern, automated assessments utilize the length of the conservation area perimeter to apply a penalty for fragmentation. Groupings of contiguous AUs have a shorter total perimeter, as the edge/area ratio is smaller than in a Conservation Area comprised of isolated AUs.



The ultimate Conservation Area would be circular to maximize area while minimizing boundary. Site selection algorithms utilize a “boundary modifier” option to modify the clustering in a conservation area design. This works by altering the penalty for fragmentation. As the computer examines possible AU combinations, the tendency to prefer solutions with contiguous groupings of AUs increases as the boundary modifier is increased.

In our new analytical technique, vertical integration, the boundary relations between AUs are used to allow the model to recognize that two or more polygons stacked upon each other are also adjacent. In these situations, the model attempts to minimize the length of the total solution boundary by clustering vertically through a stack of AUs. If the boundary modifier is set to 0, the solution will pick the minimum number of AUs from each layer to meet the goals with no regard for adjacency. As the boundary modifier is increased,

the importance of clustering, horizontally as well as vertically, is increased. This 3 dimensional approach mimics GIS analysis, though no spatial analysis is involved in the selection algorithms.



**Figure 2:** A schematic demonstrating the boundary relations between stacked and horizontally adjacent AUs. Each AU must relate to all other AUs above or below it, and in some cases, from side to side.

A major advantage of vertical integration is that it frees planners from using the same AU polygons for all targets. It is often quite useful to use polygons which more closely match the natural expression of a target type. Aquatic Systems, for example, are often classified as nesting polygons of increasing watershed size. Tributary and headwater drainages (Class 1) nest within small river drainages (Class 2), which in turn nest within large river drainages (Class 3). These classes of watershed can all be represented by polygons depicting their full contributing area. Their nesting is utilized with the vertical analysis so that each polygon is aware of all the polygons contributing to it, or which it contributes to. This larger, landscape scale context is a key advantage of this technique. The selection of the larger watersheds is greatly influenced by their attraction to basins with a greater selected proportion of their constituent tributaries. Techniques which rely on only one layer of AUs will often only select isolated reaches with no regard for their relation to the larger stream network.

Multiple AU layers allow specific, relevant information for each target group to be factored into the suitability index. In the one-layer approach, a single suitability value was expected to account for all conditions which may impact any target group. This works well for pristine or heavily degraded AUs with similar degrees of impact to all targets, but fails where impacts are specific to one target group. A fish hatchery, for example, may threaten a wild salmon stock, but present no danger at all to a ridgeline plant species. In the one-layer approach, several AUs can have similar suitability values, but each may be inappropriate for one target group while well suited for conservation of another. With vertical integration, the aquatic suitability index can factor in the hatchery, while the terrestrial index is free to ignore it.

The majority of AUs for any target group are interchangeable in that many different combinations of AUs can meet similar proportions of goals at similar costs. Vertical integration attempts to maximize the overlap between layers, allowing the site selection algorithm to actively seek efficiencies while maintaining the discrimination to avoid sites where conditions are unsuitable for a specific target group. The outputs from a vertically integrated solution offer more specific information about the conservation area design. Where does it make sense to capture all targets or to capture target groups individually?

## Methods

Site selection algorithms utilize a file that contains the lengths of shared boundaries between adjacent AUs to determine how to cluster AUs into conservation areas. This file is the key to the proper functioning of vertical integration. Let's examine the simplest vertical integration, two spatially identical AU layers: one

for aquatic and another for terrestrial targets. The length of each boundary between all adjacent terrestrial AUs is measured. These relations are then stored in the boundary relations file. The aquatic AUs will then be related to the terrestrial AUs they overlap. In this case the aquatic and terrestrial AUs are spatially identical; the length of their shared boundaries could be measured as the area of the polygons, or set at some synthetic value. We will initially set all of the aquatic-terrestrial boundaries at the mean of the terrestrial to terrestrial boundaries, so the model will generally be as likely to clump upwards through the stack as from side to side within a layer. These relations will also be stored to the boundary relations file. Two components will be part of the complete boundary relations file; the traditional boundary relations between the terrestrial AUs, and the relations of the aquatic AUs to the terrestrial AUs they overlap.

An iteration of a site selection algorithm analysis begins with any "locked in" AUs that should be part of any conservation area, and a partial random selection of additional AUs. All selected AUs will then be scored for how well they meet target goals, the total cost of the solution, and total length of boundary. All exposed boundaries of selected AUs are included in the boundary length score. In vertical integration, those exposed boundaries will also include the values relating a selected AU with other non-selected AUs above or below it. For example, we are using 2 layers of AUs stacked in our analysis. If a terrestrial AU and the aquatic unit above it are both selected, there will be no penalty in the vertical plane, while a terrestrial unit selected without any corresponding aquatic AU would accrue a penalty. Similarly, the aquatic AUs would accumulate penalties for the unselected terrestrial AUs beneath them. Solutions which maximize the overlap between AU layers will be favored by the algorithm. However, the algorithm is not forced to select overlapping AUs in all cases. If the costs of an AU are prohibitive, or if the conservation targets in an AU are no longer required to meet goals, the algorithm can choose to forgo its selection even when the unit above or below it has been selected.

Another advantage of utilizing the boundary for integration is that the weight of the boundary penalty can easily be changed in the site selection algorithm. If the weighting is set to 0, AUs required to meet the goals at a low cost are selected without regard for adjacency. At low weightings the effects of clustering will begin to be seen. A high weighting will clump so tightly that virtually every selected terrestrial AU will correspond with a selected aquatic unit, and the patch size of the terrestrial conservation areas will increase dramatically. It is important to remember that as the weighting increases more extraneous AUs will be selected merely to reduce the exposed boundary of the conservation area. Iterative runs, with increasing boundary penalty weightings, will allow the planning team to select the level at which clustering is appropriately balanced with the size of the total conservation area.

### **Planning in the Alaska Yukon Arctic**

The Alaska-Yukon Arctic (AYA) bioregion covers more than 30,000,000 hectares, stretching from the Brooks Range to the North and South Slopes along the Chukchi and Beaufort Seas. The Arctic National Wildlife Refuge (ANWR) and the National Petroleum Reserve-Alaska are included within the planning area.

This was the first large scale conservation area plan to use vertical integration as an analytical method. A simple, two-layer approach was used for transparency and ease of trouble shooting. All terrestrial target data was attributed to 5,000 hectare hexagonal AUs. The aquatic systems were maintained in their native polygonal format, watersheds ranging from 40 km<sup>2</sup> to 100,000 km<sup>2</sup> in size. Suitability indices were crafted for the terrestrial and aquatic AU layers, and boundary relations were built between adjacent terrestrial AUs, as well as between overlapping aquatic and terrestrial AUs.

Because of the remote nature and large size of this bioregion, comprehensive data was not available for all of the aquatic or terrestrial species across the planning area. The data available for the terrestrial realm included life-history maps for 85 species, including data for each of the 4 caribou herds within the planning area, and species richness for 89 bird species, 29 terrestrial mammals and 438 vascular plants (The Nature Conservancy Alaska, June 2004). 36 Terrestrial Ecological Systems were also used (Jorgenson, M. T., et al. 2003). For the aquatic realm, 36 aquatic systems were mapped across the region, and anadromous fishes (where available) were attributed to the appropriate aquatic AU (The Nature Conservancy Alaska, March 2004).

Iterative analysis runs were performed to establish appropriate boundary and suitability ranges for the two AU layers. The first run, for example, had a perfect coincidence between selected aquatic and terrestrial AUs. Looking at the output table containing the components of the objective function, it was revealed that the boundary values were swamping the suitability values in the equation. Multiplying the suitability values for all AUs by a factor of 10 gave them parity with the boundary relations in the objective function. Boundary and suitability values in the objective function were well balanced for all subsequent runs.

Three goal-level scenarios were analyzed by the site selection algorithm, 25%, 50% and 75% capture of the representation of all targets (Figure 3). The vertical integration performed well, meeting a very substantial proportion of target goals at reasonable cost, with a large degree of overlap between selected terrestrial and aquatic AUs. However, at the 75% goal level so much of the planning area was selected there was no benefit from the vertical integration; a very high proportion of all AUs were required to meet a 75% goal level for all targets.

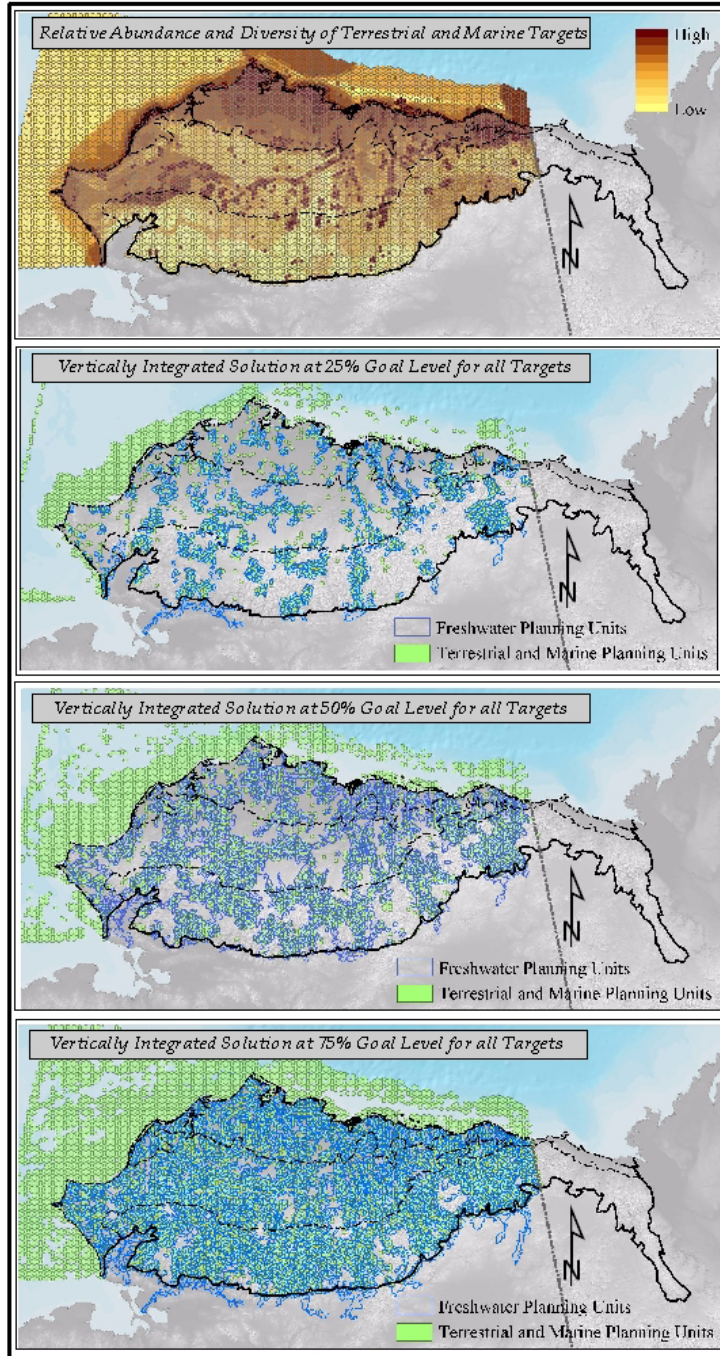
Because the bioregion is relatively pristine and many of the targets are free to range over large expanses, a nearly infinite number of AU combinations can meet goals. For these reasons, no comparison was performed with a single-layer analysis for the entire bioregion. However, some areas do contain disproportionate amounts of habitat for some species. The Beaufort coastal plain, including the Arctic National Wildlife Refuge (ANWR) and the National Petroleum Reserve-Alaska, is just such a region.

A one-layer analysis was performed just for the terrestrial targets within the Beaufort coastal plain, specifically to measure the relative importance of the biological resources of the Teshekpuk Lake portion of the National Petroleum Reserve-Alaska to the wider coastal plain. 11% of the 85 primary species included in this assessment are heavily represented in the Teshekpuk Lake area, and of those, 5 species are very dependant on the area for life-history stages. Black brant, Canada, white-fronted and snow geese exclusively use the Teshekpuk Lake region for molting, a crucial life-history phase. Almost half of all black brant nests are also found there. The local caribou herd only utilizes this area for mosquito relief during the summer months, and over half of their caribou calves are born there (The Nature Conservancy Alaska, August 2004).

The Beaufort coastal plain is also very important for many of the aquatic species within the planning area. The majority of deepwater lakes, which provide over-wintering habitat for many fish species, estuaries, and the connections to the marine environment required by anadromous fishes, are found within this portion of the planning area.

Various scenarios could also be studied with this data and the vertical integration technique. AUs corresponding with proposed development, for example, could be locked out, preventing the algorithm from selecting them. Subsequent outputs would then show which species can no longer meet specific goal levels with those AUs removed, or how an optimal reserve design might shift. Extreme seasonal weather fluctuations modify the region's habitats, and the species that use them. Seasonal reserve designs might also be a useful conservation tool.

**Figure 3:** Alaska-Yukon Arctic Assessment: Relative Biodiversity and automated solutions for all targets at 3 goal levels



## Planning for the Pacific Northwest Coast

The Conservation Area analysis for the Pacific Northwest Coast (PNWC) was the most exhaustive integrative exercise yet attempted in Conservation Area planning. The targets were broken into several groups, terrestrial, estuarine, freshwater aquatics (3 size classes), and near-shore marine. Assessment units were crafted for each group and separate suitability indices were calculated for each. Each target group was analyzed in a stand-alone fashion to see what the ideal automated solution might be for that group. All target groups were then run in a vertically integrated analysis, the solutions decomposed into their constituent layers and compared back to their original stand-alone runs to gauge the sacrifices made by any target group to accommodate integration with the others. Iterative runs also allowed us to weight the groups appropriately (by scaling their suitability and boundary values) so no one target group was dominating the outcomes. The final Conservation Area design met goals for virtually every target, with all targets having an influence in the outcome.

The terrestrial group was attributed to small-scale watersheds approximately 2,500 hectares in size. These were chosen because they cover the full extent of the ecoregion, and make ecological sense to many of our partners and reviewers.

The aquatic group was represented by three classes of nesting polygonal watersheds, tributary and headwater drainages less than 100 square kilometers (Class 1), small river drainages between 100 - 1000 square kilometers (Class 2), and large river drainages more than 1000 square kilometers (Class 3). These three classes of watershed were all represented by polygons depicting their full contributing area. The Class 3 polygons contain the Class 1 and 2 polygons contributing to them, and the Class 2 polygons encompass the Class 1 polygons which contribute to them. Some watersheds don't drain into others, for example, when a small coastal creek flows directly into the ocean. For the vast majority of watersheds, however, this nesting was a key to the analysis as each polygon was made aware of all the polygons contributing to it, or which it contributed to.

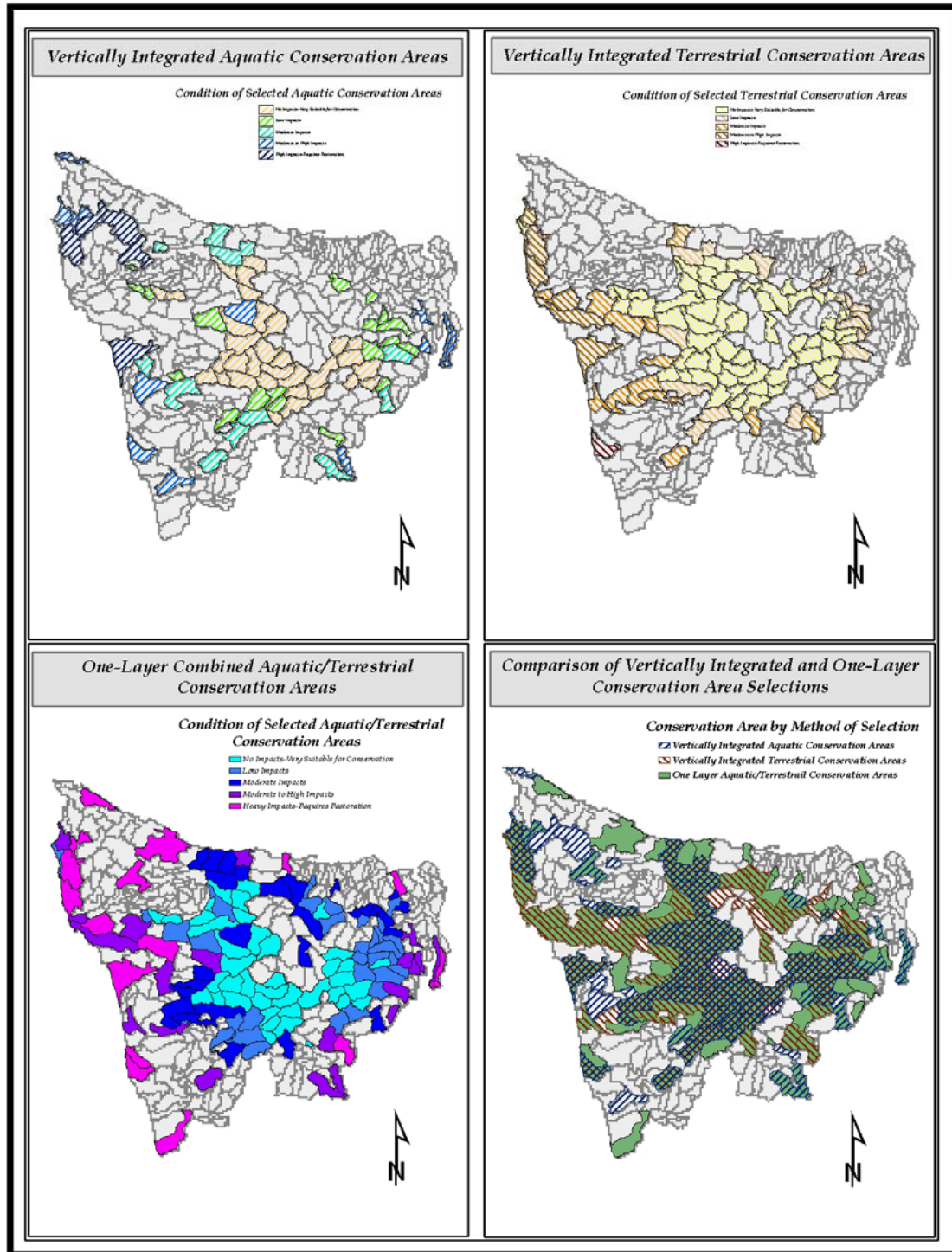
The near-shore marine AUs were line segments corresponding to reaches of shore-zone habitat; unique combinations of substrate, wave exposure, and biotic assemblage.

Estuaries were represented by polygons. In the US portion of the ecoregion, those polygons were defined by salinity zones and estuarine vegetation. On Vancouver Island they were merely polygonal depictions of the extent of each estuary. Vancouver Island estuaries tend to be quite small, as they often occur at the heads of narrow fjords, and are fed by smaller streams. To give our model the context to discriminate between these estuaries the sum of the shore-zone habitats intersecting each was attributed to the polygons.

Each of these planning unit layers had suitability information tailored specifically for the targets within them. Each group was run in a stand-alone analysis, with the "best" output of each (10 runs, 5,000,000 iterations each, boundary modifier 0.1) saved as the benchmark to gauge future solutions during the integration process.

All target layers were combined into one analysis using the "vertical integration" technique. We had earlier determined that a boundary modifier of 0.1 was optimal to achieve appropriately sized clumps in our terrestrial solution without many extraneous AUs. However, we wished to ensure that the overlap between layers was maximized in the integrated solution without sweeping lots of extraneous AUs into the solution. Increasing the boundary modifier would unfortunately have that effect. Instead, we held the boundary modifier at 0.1, and increased the boundary values between layers in the boundary relations file. The initial boundaries between layers were set at the overlap of AU polygons in hectares. Iterative runs were performed and the inter-layer boundaries were increased at each run by 20%. This iterative process was repeated until the costs of one of the constituent solution layers began to spike. The run previous to that spike, in this case the fourth iteration, was then used to identify the integrated Conservation Area. As the values of the boundaries between layers increased, the area of overlap between layers also increased, while the costs of the solutions remained fairly flat. The solutions were shifting to allow targets, for which multiple combinations of planning units at similar costs could meet goals, to accommodate integration.

**Figure 4:** Comparison of automated Conservation Area designs between vertically integrated and one-layer methodologies for the Olympic Peninsula region of the PNWC.



As a comparison, all targets were attributed to a single layer of AUs for a traditional one-layer analysis. Suitability values for these AUs were set at the average of the corresponding terrestrial and aquatic AU's suitability scores. All other weightings and settings were held constant. The outputs for both scenarios were compared for the Olympic sub-section of the PNWC assessment. This subsection was chosen as it had the tightest coincidence between the aquatic and terrestrial sub-sectional boundaries (Figure 4).

The goals were generally met well by both analyses (Appendix 1). The combined footprint of the vertically integrated terrestrial and aquatic conservation area within the Olympic Peninsula sub-region was 521,677 hectares. The footprint for the one-layer conservation area was 558,202 hectares, 7% larger (Figure 4). A better comparison of the performance of the different analysis may be the Elwa River. The vast majority of the Elwa River drainage is within Olympic National Park. The uplands surrounding the river are in exquisite condition with large tracts of old growth forest. Unfortunately, one of the largest dams in the PNWC sits low in the watershed, providing hydropower for the region. 25,000 hectares of the Elwa watershed were selected by the one-layer methodology, applying all of the aquatic systems they contained towards the goals. In the vertically integrated approach, none of the Elwa appears in the aquatic solution, but large portions are in the terrestrial portion of the solution. This is a classic example of the blindness of a suitability index crafted for all targets to appropriately assess impacts for an individual target group.

## Discussion

Vertical integration, since its inception 2 years ago, has been used by several planning teams in the United States and Canada. Aquatic planning teams, most specifically, have found it beneficial because it has solved the problem of connectivity. In the one-layer approach, no AU is aware of any other AU it does not touch. The one-layer approach is inherently unable to link many contributing watersheds together to form continuous aquatic conservation areas. Because the vertical integration technique, when used with nesting watersheds, creates relationships between larger size classes and all of their smaller contributing watersheds, it is able to build these connections. There are, however, some considerations a team must be aware of when attempting to utilize this technique.

An automated portfolio is a mathematical solution for a conservation area design problem. Planners must realize that any automated output only represents the solution with the smallest value of the objective function. The numeric value of the objective function is largely a dynamic tension between the sums of the suitability scores and sums of the boundary penalties. If either factor is weighted too heavily it will dominate the outcome. Therefore, planners are urged to look at the tabular outputs of their analysis, specifically the component values of the objective function. If, for example, a solution has nearly perfect overlap between selected terrestrial and aquatic AUs, the boundary values in the objective function will probably far exceed the suitability scores. In this case, the team may also notice the aquatic targets are generally far exceeding their goals.

Similarly, AU layers with greatest relative costs will have the largest impact on the value of the objective function, and therefore have the greatest influence on the conservation area design. Therefore, when designing your analysis, layers which contain the most robust information, or layers of special conservation interest, may be weighted more heavily to allow them more influence in the outcome. The actual influence a layer has can somewhat be gauged by the cost shift of the other AU layers when compared against their stand-alone runs. In the PNWC analysis, for example, we didn't want the shore-zone segments to have a very large influence on the conservation area design. Costs were scaled down relative to the terrestrial and aquatic AUs. During the integrated runs, the costs of the aquatic and terrestrial components of the vertical solution showed no significant difference compared to the stand-alone runs for those layers. The shore-zone portion of the vertical solution, on the other hand, showed an average 23% increase in costs compared to its stand-alone counterpart, after accounting for the shore-zone cost scale change. The shore-zone component of the vertical solution was being forced into less favorable areas to accommodate integration with the aquatic and terrestrial layers.

The geometries of AUs can also greatly influence the outcome. Hexagons, for example, cluster much more easily, and at lower boundary modifier levels, than irregularly shaped AUs like watersheds. In all cases I

recommend planners build the terrestrial AU boundaries, experiment with ranges of boundary modifiers and suitability values that produce reasonable outcomes, then create boundary relations and suitability values for other layers based upon the ranges established in the terrestrial analysis. With aquatic analysis, we have learned that using synthetic values for boundary lengths is beneficial. Because any watershed of a type counts toward goals as much as any other watershed of that same type, area need not be a factor in the boundary relations. Basing boundary values for the aquatic layers upon the mean of the terrestrial boundary lengths produces a more robust integrated solution. For example, if the mean of the terrestrial boundaries is 3000, any Class 1 to terrestrial AU, Class1 to Class 2, or Class 1 to Class 3 boundary relation should be set near 3000, Class 2 to Class 3 relations perhaps twice as much. In the stand-alone aquatic solutions, the suitability values can then be scaled up or down until they are appropriately balanced against the boundary values of the objective function. Class 2 and 3 suitability values need not necessarily be the sums of their constituent Class 1s, they can be scaled independently such that the average Class 2 is twice the cost of the average Class1, and the average of the Class 3s three times the cost of the average Class 1. Iterative runs, with careful scrutiny of the objective function constituents, and goal attainment of the solutions, will assist the planner in achieving the appropriate balance.

Linear features, like the shore-zone habitats used in the PNWC analysis, can also be used as layer in a vertical analysis. As line features have no true area, boundary relations should be proportional to the length of the segment's intersection with other AU layers, and scaled to be appropriately balanced against those other layers.

An early criticism, partially based upon fears that vertically integrated solutions would be less efficient, was that if targets are split between multiple AU layers, the algorithm would only receive credit for that portion of the targets in the selected AUs. In other words, if an area is selected only for terrestrial targets, and conservation resources will be applied to those targets, wouldn't the aquatic resources there also benefit, and therefore shouldn't they be counted towards goals as well? As our Elwa example demonstrates, it is not necessarily advantageous to count all targets which occur on the landscape every time an AU is selected. In fact, this is a chief failing of the one-layer methodology; areas are often selected for one group of targets that may be unsuitable for another group. Additionally, the specificity of the vertical outputs is very useful information. The overlap between terrestrial and aquatic solutions is the area where it does make sense to work on both target groups. AUs which appear in only one portion of a solution may have management and conservation strategies applied to them which are specific to those targets. In a world where human and financial resources are tight, tailoring conservation solutions efficiently and appropriately is paramount.

Stand alone analysis for terrestrial and aquatic realms are valuable exercises in themselves. They reveal patterns of biodiversity, possible conservation opportunities for targets, and help identify threats to those same resources. If considerations for integration, like ranges of cost and boundary values, are used when building the stand alone analyses, the boundary relations between AU layers are the only additional piece required. All other tables can be cut and pasted together with no additional modification. This is much easier than having to rebuild all data from scratch to fit all targets into a single AU layer.

Finally, it should be noted that any automated output is only as good as the information the algorithm was given. Data is a snapshot in time, often a snapshot taken 10 years ago. Peer review of any automated output is critical if we wish the conservation area design to truly meet the needs of the targets over time.

**Appendix 1: Comparison of goal attainment between vertically integrated, and one layer site selection model for the PNWC**

	Amount Available	Goal	Proportion of Goal Captured by "One-Layer"	Proportion of Goal Captured by "Vertical Integration"
Conservation Target				
Astragalus australis var olympicus	9	5	140.000	140.000
Astragalus microcystis	2	2	100.000	100.000
Carex pluriflora	3	3	100.000	100.000
Cimicifuga elata	1	1	100.000	100.000
Dodecatheon austrofrigidum	1	1	100.000	100.000
Pellaea breweri	2	2	100.000	100.000
Plantago macrocarpa	8	7	114.286	114.286
Saxifraga tischii	2	2	100.000	100.000
Sparganium fluctuans	2	1	200.000	200.000
Synthyris pinnatifida var lanugino	19	17	105.882	105.882
Accipiter gentilis	16	9	111.111	144.444
Ardea herodias fannini	2	1	100.000	100.000
Brachyramphus marmoratus	670	338	126.627	111.243
Dicamptodon copei	51	8	412.500	450.000
Euphydryas chalcedona perdiccas	15	13	107.692	100.000
Falco peregrinus	28	13	146.154	146.154
Haliaeetus leucocephalus	197	67	179.104	150.746
Hemphillia burringtoni	31	10	150.000	100.000
Hemphillia glandulosa glandulosa	33	5	300.000	240.000
Histrionicus histrionicus	51	4	800.000	800.000
Icaricia icarioides blackmorei	8	6	116.667	133.333
Incisalia mossii mossii	2	1	200.000	200.000
Lycaena mariposa charlottensis	2	1	100.000	200.000
Oeneis chryxus valerata	10	8	125.000	112.500
Parnassius smintheus olympianus	13	13	100.000	100.000
Plebejus acmon spangelatus	2	1	200.000	200.000
Plethodon vandykei	20	9	166.667	144.444
Progne subis	3	1	200.000	200.000
Rana cascadae	4	4	100.000	100.000
Rhyacotriton olympicus	76	24	225.000	237.500
Speyeria zerene bremnerii	5	4	125.000	125.000
Strix occidentalis caurina	232	119	125.210	113.445
Oncorhynchus gorbuscha	122941	36882	173.998	73.431
Oncorhynchus keta pop ?	155532	77766	40.469	34.914
Oncorhynchus keta pop ?	228952	68686	58.846	43.953
Oncorhynchus keta pop 4	2279730	683919	11.577	12.091
Oncorhynchus kisutch pop ?	698498	209549	81.268	47.260
Oncorhynchus kisutch pop ?	1953219	585966	130.269	135.326
Oncorhynchus kisutch pop 1	4698839	1409652	1.266	2.072
Oncorhynchus mykiss pop ?	1155963	346789	146.647	157.535
Oncorhynchus mykiss pop ?	452456	135737	125.869	78.464
Oncorhynchus nerka	34400	34400	81.728	93.534
Oncorhynchus nerka	6107	6107	99.995	99.995
Oncorhynchus nerka	84075	84075	100.000	100.000
Oncorhynchus tshawytscha	3092704	927811	51.340	56.318
Oncorhynchus tshawytscha	1042244	312673	122.810	145.621
Oncorhynchus tshawytscha	486454	145936	158.147	182.357
Oncorhynchus tshawytscha	199922	99961	96.824	72.409
Salvelinus confluentus	135223	67611	160.153	168.345
North Pacific Coastal Herbaceous Bald And Bluff	23	3	600.000	500.000
North Pacific Dry And Mesic Alpine Dwarf-shrubland And Meadow	22749	2275	718.683	648.902
North Pacific Hypermaritime Sitka Spruce Forest	295795	88739	124.509	133.719
North Pacific Maritime Dry-mesic Doug Fir-western Hemlock Forest	195965	58790	170.906	135.374
North Pacific Maritime Wet-mesic Doug Fir-western Hemlock Forest	241841	72552	148.667	136.164
North Pacific Montane Riparian Woodland And Shrubland	3	3	100.000	66.667
North Pacific Mountain Hemlock Forest	125003	25001	320.145	316.606
North Pacific Western Hemlock-silver Fir Forest	196807	39361	312.743	285.359
Coast Tributaries - Outwash, Low Elevation, Moderate Gradient	32	11	63.636	54.545
Coastal Upland - Glacial Till, Low Elevation, Low To Moderate Gradient	42	14	107.143	135.714
Coastal Upland - Sandstones, Low Elevation, Moderate Gradient	40	13	69.231	100.000
Olympics - Sandstones, High Elevation, High Gradient	12	4	275.000	300.000
Olympics - Sandstones, Mid Elevation, High Gradient	31	10	190.000	150.000
Puget Lowlands - Outwash, Low Elevation, Moderate Gradient	9	5	60.000	40.000
Haliaeetus leucocephalus wintering area	1	1	100.000	100.000

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