AN UPDATED PROTECTED AREAS DATABASE FOR THE UNITED STATES AND CANADA

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Abstract: Protecting biodiversity in a network of reserves has been a major goal of conservationists for more than a century. However, there is much uncertainty regarding just how much and what level of protection is required to meet representation goals in the United States and Canada. We provide an updated protected areas database (PAD) that is useful in tracking national efforts in meeting protected areas goals at various spatial scales (e.g., state, province, country, ecoregion, and biome), can be readily accessed by conservationists, and easily housed within national mapping projects such as the National GAP program and the Canadian Conservation Areas Database. The PAD provides nearly three times as many protected areas polygons than previous databases (e.g., Managed Areas Database), accounting for state parks and other protection

categories and protected areas in Alaska and Canada previously omitted. Using the PAD, just 5.1% of the land area of the United States and 5.3% of Canada have been set aside in strictly protected reserves such as National Parks and Monuments, Wilderness Areas, and Provincial Parks (i.e., GAP 1 protection); an additional 5.2% of the United States and 1.2% of Canada are in more relaxed levels of protection characterized by greater human activities (e.g., Provincial Parks with some development, National Wildlife Refugees with increased human activities: GAP 2 protection). Amount of protection for individual states varied from <1.0% for most of the eastern and central United States to about 35.0% for Alaska, and from <1.0% for New Brunswick to roughly 12.0% for British Columbia. In addition, 30 ecoregions in the United States and Canada were considered to have biodiversity attributes (e.g., species richness, endemism) distinctive on a global scale yet protection for these ecoregions averaged about 6.0% with four ecoregions having <1% of their total area protected. Nation-wide (United States and Canada), most (97%) protected areas were <10,000 ha and only a small proportion (0.64%) were considered large enough (>100,000 ha) to withstand large-scale disturbances or to provide refugia for disturbance intolerant species (e.g., large carnivores). Our results validate the concerns expressed by conservationists that each country expand its protected areas network to achieve representation goals reflective of international conservation accords (e.g., Convention on Biological Diversity signed by Canada, Montreal Process) and national conservation commitments. They also illustrate the importance of standardizing and periodically updating national protected areas databases to accurately report on progress in meeting representation goals and other national conservation targets.

Key words: Canada; biome; ecoregion; globally outstanding ecoregions; protected areas database; United States

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INTRODUCTION

Determining just how much area to set aside in permanent protection is the subject of intense debate among conservationists, governments, and the general public. Deciding what level of protection counts towards meeting various conservation objectives (see Noss and Cooperrider 1994) also poses uncertainties given that degree of protection can vary from limited extraction of natural resources and development in some parks (e.g., Provincial Parks with golf courses and ski areas) to strict protection in others (e.g., National Parks, Wilderness Areas). National mapping projects, including the U.S. Geological Survey Gap Analysis Project (GAP, Scott et al. 1993) in the United States and the Canadian Conservation Areas Database (CCAD 1998) in Canada provide standardized approaches useful in assessing the extent of protection for particular parcels based on intensity of use. However, these projects are either available to the general public for only several states (GAP) or not available at all (CCAD 1998). Currently, only one spatial geographic information system (GIS) database is available for the United States that depicts federal and state level protected areas though only for the coterminous United States (McGhie 1996). This managed areas database (MAD) provides information on extent of protection for most federal land holdings (e.g., National Parks, National Forests, Wilderness Areas) and some state managed areas in the form of GAP (Scott et al. 1993) and World Conservation Union (IUCN 1994) land management status codes. However, a course map scale (1:2 million) of MAD and incomplete state-level

coverage makes it suitable for only coarse level analyses on federal lands only. In Canada, World Wildlife Fund Canada has been compiling spatial data on protected areas since 1993 at comparable scales as part of their Endangered Spaces Campaign, which seeks to assess ecosystem representation throughout various natural regions of Canada (Hummel 1995).

Given recent advances in computer mapping technologies and prevalence of its use, additional detail on protected areas is becoming more readily available allowing for refinements in protected areas mapping and regional conservation assessments. New land management databases are being developed and updated at map scales ranging from 1:24,000 to 1:100,000 allowing for conservation assessments and analyses at several different map scales (e.g., ecoregion, state, province, and nation). Improvements in our knowledge about size, areal extent, and spatial arrangement of protected areas allows us to: (1) account for new protected areas that are not just federal; (2) more accurately report on progress in meeting protected areas goals as stated in international conservation accords (e.g., International Convention on BioDiversity) and national conservation commitments (e.g., Tri-Council Committee's pledge in Canada to protect at least 12% of Canada's land mass; Hummel 1995); (3) inform governments regarding deficiencies in reserve networks at multiple spatial scales; (4) provide the conservation user community with a standardized database that can be readily accessed and periodically updated; and (5) provide a "seamless" map of protected areas straddling multiple political boundaries (e.g., United States and Canada). For these reasons, we constructed an updated Protected Areas GIS Database (PAD) for the United States and Canada containing detailed protected areas information including level of protection (GAP and IUCN codes) for

federal, state, provincial, and even some private land holdings. Using this new database, we examined some fundamental questions about protection status for the United States and Canada organized by ecoregions (with special emphasis on the Global 200) and Major Habitat Types (MHTs), which are analogous to major biome types and defined by Ricketts et al. (1999). This database is not intended as a substitute for national mapping projects underway such as GAP and CCAD, rather it provides additional information on protected areas where available that can be complimentary to a broader array of conservation initiatives.

While there is no formal government commitment in the United States for completing a reserve network (i.e., the United States was not a signatory to the International Convention on Biodiveristy at the Rio Earth Summit in 1992), the Canadian Council of the Ministers of the Environment, Canadian Parks Ministers Council, and the Wildlife Ministers Council of Canada (also known as the Tri-Council Committee) pledged in 1992 to complete an ecologically representative reserve network covering at least 12% of its land mass in fulfillment of its signatory obligation (Hummel 1995). The Canadian pledge was initially based on the recommendations of the World Commission on Environment and Development (1987). The commission suggested that to conserve species and ecosystems and to achieve a representative sample of the Earth's ecosystems in protection, the amount of land in protection would need to be at least tripled globally from protection levels at that time (4%), amounting to each nation of the world setting aside at least 12% of its land mass.

Determining representation targets, however, needs to be based on fine scale analyses (e.g., within ecoregions) as is currently underway through national mapping

assessments such as the National Gap (Scott et al. 1993) and Endangered Spaces Campaign of WWF Canada (Hummel 1995). Further, targets such as 12% have been highly controversial, though they may have a valid place as initial steps toward broader conservation goals. While the international credibility of the World Commission on Sustainable Development did help gain political commitment for the 12% guideline in Canada, efforts since then to designate new protected areas have demonstrated that adequate representation typically involves much higher levels of protection to achieve representation targets at regional scales within Canada (Hummel 1995, World Wildlife Fund Canada 1999). For instance, using GAP analysis procedures, WWF Canada has calculated that on average 44% of 35 natural regions of Canada needs to be placed in reserve status to achieve adequate representation. Similarly, Noss and Cooperrider (1994) argue that 25-75% of a particular region is required to achieve representation and even the low end of these estimates has yet to be attained in most regions of the United States (Ricketts et al. 1999, Scott et al. in prep) or Canada (Hummel 1995). Others (Soulé and Sanjayan 1998) have criticized the minimum 12% target because if implemented it may actually accelerate species declines based on species-area relationships and continued habitat destruction outside reserves. Therefore, in this paper we document the relative extent and degree of protection for comparative purposes only and not as a representation target. While our analysis is useful for reporting on each nation's progress in meeting the internationally recognized target of 12% minimum protection, we assume that 12% is not enough to achieve representation at the ecoregion level and instead rely on more conservative estimates (25-75%; Noss and Cooperrider 1994) as a reference level for comparisons among ecoregions. We also report on degree of protection based on both the

"strictest" level of protection provided where no commercial extraction and development is allowed (e.g., Wilderness Areas, National Parks: GAP 1 designated areas; Scott et al. 1993) as well as more "relaxed" levels of protection where limited types of development may occur (e.g., Provincial and State Parks with some development activities, National Wildlife Refuges with varying degrees of human use: GAP 2 designations; Scott et al. 1993). However, we do not consider lands managed for multiple use purposes (e.g., most National forest lands) as protected since commercial extraction and development activities are allowed (i.e., GAP 3 designations; Scott et al. 1993) and such activities have substantially degraded ecosystem functions and biodiversity in many cases (Noss et al. 1995).

METHODS

Database construction

The CBI/WWF Protected Areas Database (PAD) was constructed using a geographic information system (GIS) and existing digital data. We performed all GIS operations using ESRI NT ArcInfo™ version 7.1.2 and ESRI NT ArcView™ version 3.1 software. GIS data is seldom constructed using ecologically meaningful boundaries - the area of interest is usually defined by political boundaries - in this case by state or province. We therefore assembled the PAD by obtaining existing digital land management datasets from each state in the United States with the exception of Hawaii (which is currently unavailable) and for each Canadian province and territory.

In the United States, our main focus was on protected areas at the federal and state levels; however, we included county, city, and private reserves whenever data were available. We used GAP stewardship datasets whenever possible because they contain

both federal and state-owned areas with the most current ownership information and have already been assigned GAP protection codes. When these datasets were not available electronically over the Internet, we contacted state and federal agencies to acquire them. In some cases, we were unable to locate existing digital information for specific protected areas or, in a few other cases, for entire states (e.g., South Dakota). In these instances, we used the protected areas from MAD. The data sources and map scales we used are listed by state in Appendix A.

Datasets were constructed independently for each state and, when completed, were re-projected to Lambert Azimuthal Equal-Area. This map projection was chosen because it preserves the area of individual polygons, and only minimally distorts polygon shape (see ESRI 1992). After each dataset was obtained, they were joined together with all neighboring datasets and manually cleaned along all boundaries. The final coverage was then clipped with the terrestrial ecoregion boundaries as described by Ricketts (et al. 1999). We used this ecoregion classification approach because it was the only one available for both the United States and Canada, and it contained information on the relative importance of ecoregions based on a global comparison of biodiversity attributes.

For this assessment, an "ecoregion" was defined as a relatively large unit of land or water containing a geographically distinct assemblage of natural communities that share a large majority of their species, ecological processes, and environmental conditions (Olson and Dinerstein 1998, Ricketts et al. 1999). Ecoregion boundaries were derived in a related study (Ricketts et al. 1999) from intensive regional analyses of biodiversity patterns using recognized ecoregion classifications in collaboration with regional experts. Terrestrial ecoregion boundaries were based largely on Omernick (1995), the Ecological

Stratification Working Group (1995), and Gallant et al. (1995), and were modified in some cases to better reflect biogeographic patterns (Ricketts et al. 1999). Using this approach, Ricketts et al. (1999) divided North America (north of Mexico) into 116 ecoregions that were nested within 10 major habitat types (MHTs). Roughly analogous to biomes, MHTs consist of sets of ecoregions with comparable climatic regimes, vegetation structure, and spatial patterns of biodiversity (Dinerstein et al. 1995, Olson and Dinerstein 1998, Ricketts et al. 1999). Specific location of ecoregions and MHTs used in this study are described in detail by Ricketts et al. (1999).

In this analysis, we used 110 of the 116 ecoregions to assess extent and degree of protection (6 were dropped because of the exclusion of Hawaii and Puerto Rico) and we paid particular attention to ecoregions considered to have exceptional levels of biodiversity (i.e., "globally outstanding;" Ricketts et al. 1999). Based on comparisons of biodiversity attributes among ecoregions (e.g., species richness and endemism), Ricketts et al. (1999) identified 32 of the 116 ecoregions in North America as having biodiversity values worthy of global recognition (also see Olson and Dinerstein 1998). Thirty of these ecoregions overlapped with our study area.

In Canada, we used the most recent Designated Areas Database from World Wildlife Fund Canada (WWF Canada 1999). The file is a compilation of dozens of datasets at various map scales, and it represents the most readily accessible protected areas dataset currently available for Canada. The database was compiled using a network of regional coordinators across the country that assigned all designated areas specific codes based on interpretation of IUCN (1994) land use classifications and whether they met the goals of the Endangered Spaces Campaign of WWF Canada (e.g., only areas

removed from logging, mining, and hydroelectric development were considered strictly protected). The standards are described in the most recent Progress Report (WWF Canada 1999). This dataset also was projected to Lambert Azimuthal Equal-Area, joined to the United States dataset, and clipped with the WWF ecoregion boundaries.

Assigning protection codes

The PAD contains many different types of protected areas that exist in the United States and Canada, including information on land stewardship and size. The PAD database can be queried by any of the attributes listed in Appendix B. Both the GAP (see Crist et al. 1998) and IUCN (1994) management classifications were used to assign degree of protection for each protected area identified in the PAD. GAP classifications provide a standardized framework for assigning management codes to land designations based on degree of protection in the United States, while the IUCN codes are recognized globally. We used the existing GAP codes from GAP stewardship datasets when available. For the remainder of the states and for all the provinces and territories, we assigned GAP codes using the criteria defined by Scott et al. (1993) (Appendix B). To achieve consistency in accounting for protected areas in each country, we imported IUCN codes from the WWF Canada database and assigned them equivalent GAP codes. This resulted in some omissions of sites that currently have some form of interim permanent protection but are not legally designated at this time. Thus, in some cases, our estimates of degree of protection differ from those reported by WWF Canada (1999) due to differences in interpretation of protection codes and interim status of some areas. However, WWF Canada, through its extensive network of regional coordinators, has identified managed areas within their jurisdiction that meet strict protection standards (no

logging, mining, hydrological development). This level of rigor ensures compatibility of approaches and datasets since areas identified as strictly protected in Canada are equivalent to GAP 1 designations.

For the United States, we assigned IUCN codes based on the IUCN's categories for conservation management (IUCN 1994; Appendix B). In general, parcels with a GAP code of 1 corresponded to IUCN categories I-III; GAP code 2 corresponded to IUCN categories IV and V, and GAP code 3 corresponded to IUCN category VI. We were most interested in describing areas that have some level of protection from commercial extraction activities and development such as mining, logging, and hydroelectric development; therefore, we deleted all areas designated as GAP 4 from our PAD. Because there was no practical way to contact each manager of every protected area to determine management practices as suggested by Crist et al. (1998), we were forced to assign protection levels categorically. Because of this, it is possible that some parcels were classified incorrectly since specific management practices will vary within and among states, provinces, and territories for any given designation making the categorical classification inaccurate. Assigning protection codes was particularly difficult in a few instances and thus we used our judgement in interpreting some designated sites.

Scale issues

We assembled the PAD from dozens of separate datasets of varying scales; therefore, it is difficult to assign a final map scale to PAD. Most statewide datasets were at 1:24,000 or 1:100,000-map scale (Appendix A). However, Alaska was assembled at 1:250,000, and Canada at 1:2 million. In addition, the limited MAD polygons that we used when more recent data were lacking were originally assembled at 1:500,000 to 1:2

million map scale, although the rest of the state dataset may be at a much finer scale. Therefore, map scale of data used from the PAD will depend upon the extent of the data, and will be documented in accompanying Federal Geographic Data Committee (FGDC) compliant metadata files (available as a CD-ROM from the second author). For these reasons, we recommend using the PAD data at the national, state, provincial or ecoregion level; the PAD may not be suitable for conservation planning at finer scales in all areas (see Appendix A). Thus, we queried the new PAD database to ascertain the level of protection organized by political boundaries (states and provinces), MHTs, and ecoregions (with special emphasis on the Global 200) as defined by Ricketts et al. (1999). Summary statistics were tabulated for each.

RESULTS

Comparison with MAD

The major differences between the PAD and MAD are in map scale, map extent, and completeness at the state level. In a large-scale analysis, the MAD and PAD perform similarly. However, the PAD contains nearly three times as many protected areas, more than twice as many state parks, and over 2,000 more Wildlife Management Areas in the United States than the MAD (Table 1). It also includes a number of protected area types (GAP 1 or 2) that are not found in the MAD, including Bureau of Land Management Areas of Critical Environmental Concern, Research Natural Areas, Conservation Areas, and Natural Areas. Although not illustrated in this paper, the PAD allows for finer-scale analyses over much of the United States and provides more complete coverage for Canada than existing databases (e.g., CCAD, McGhie et al. 1996).

The United States

As a nation, the United States has slightly over 5.0% of its land mass strictly protected (GAP 1) and an additional 5.3% in more relaxed types of protection (GAP 2; Table 2). However, the amount of land protected varies widely from state to state. Of the 49 states included in our PAD, only Alaska (GAP 1 and 2) was within the 25-75% protection levels. Notably, Alaska exerts a major influence on the final number for the United States as a whole. When Alaska is excluded from the analysis, only 5.05% of the coterminous United States is protected in areas classified as GAP 1 or 2 and most is in the western states. The central and eastern United States contributes many small areas, but few that attain sizes that would allow for complete natural ecosystem composition, structure, and function.

Canada

As a country, approximately 5.2% of Canada's land area is strictly protected from development and extractive uses (GAP 1) and an additional 1.2% has more relaxed degrees of protection (GAP 2; Table 3). Extent of protection for Canadian provinces and territories ranged from <1% for New Brunswick to 11.7% in British Columbia (GAP 1 and 2). None of the provinces or territories was within the 25-75% protection range for either GAP categories.

Major Habitat Types (MHTs)

WWF recognizes 9 distinct MHTs within the extent of our PAD, each comprised of ecoregions that function similarly (Table 4). The seven largest MHTs (based on percent of the study area) had relatively low levels of protection ranging from 0.8% (Temperate Grasslands/Savanna/Shrub) to 14.2% (Tundra; GAP 1 and 2). The two

smallest MHTs (Flooded Grassland, Tropical Moist Broadleaf Forest) were fairly well protected (>43% in GAP 1 and 2). However, this was because both of these MHTs have relatively small areal extents compared to the other MHTs and one MHT (Flooded Grassland) is largely contained within the Everglades National Park.

Ecoregions

In general, the percentage of total area protected as GAP 1 or 2 in each ecoregion ranges from <1% to 74%, and averages 8% for all ecoregions combined (Figure 1). In general, however, only 17 (15%) ecoregions were within the 25-75% protection range based on GAP 1 and 2 designations and only 9 (8%) were within this range based on GAP 1 designations.

Level of protection (GAP 1 and 2) for ecoregions considered globally outstanding ranged from 0.02% (Eastern Canadian Shield Taiga) to 60.03% (Aleutian Islands Tundra) and averaged about 6.0% protected (Table 5). Notably, four globally outstanding ecoregions had protection levels below 1%, including Southeast Mixed Forests, Central Tall Grasslands, Flint Hills Grasslands, and Eastern Canadian Shield Taiga, and only two (Sierra Nevada Forests, Everglades Flooded Grasslands) had protection levels that fell within the 25-75% level of protection (see Figure 1 for locations).

Protected Areas Size Classes

Not surprisingly, protected areas in both the United States and Canada are not distributed equally among size classes (Figure 2). The vast majority (97%) of ecoregions in our PAD are protected (GAP 1 and 2) in reserves <10,000 ha and only a small number (n=136, 0.62%) of the reserves are>100,000 ha. Of the small reserves, 74% are <200 ha.

DISCUSSION

The CBI/WWF PAD represents an updated and improved version of the existing MAD that was constructed in 1996. We have constructed the PAD at a much finer map scale and added substantially more state-managed areas and some private holdings. The addition of Alaska and Canada to the database also represents a major expansion compared to MAD that focused only on the coterminous United States. For example, Alaska accounted for more than half the total protection of the United States while adding Canada ensured continuity of the database as many protected areas extend across national boundaries. Given the increased number of protected areas and finer mapping scale provided by the PAD, we recommend that it be housed with national mapping projects such as GAP and CCAD for periodic updating and complimentary representation assessments. In addition, the PAD could be combined with other related continental or ecoregional assessments such as EcoMap in Canada (see CCAD 1998), various ecosystem monitoring projects of federal agencies in the United States (e.g., Forest Health Monitoring and Forest Inventory Assessment; USDA Forest Service), and for reporting on national level criteria and indicators of sustainability as part of the Montreal Process (1996).

The coarse scale of our analysis, however, may indicate that some areas or regions are well off because of their relatively high levels of protection. In particular, the state of Alaska with 35% of its land in protection (GAP 1 and 2) has yet to achieve a representative network of reserves for some habitat types of high conservation value such as low-elevation, old growth forests (DellaSala et al. 1996a, Schoonmaker et al. 1997). Moreover, while 43% of flooded grasslands have been protected in the United States, this

MHT illustrates one important caution in using the PAD or any other protected areas database, particularly when trying to draw conclusions about levels of protection based largely on extent and degree of protection or representation goals. It is widely known that the Everglades National Park has suffered substantial losses in the abundance of many species (see Kushlan 1979) due largely to the changes in hydrologic regimes from sources outside the park boundaries. Both the Everglades and the MHT that it is contained within are at peril even though a large portion of the land area is designated as protected. If we knew as much about the other protected areas as we do about the widely publicized Everglades, we would be able to assign GAP codes to each site with more specificity. As it is, we were forced to assign sites categorically and deal with the problems in interpretation that causes.

Both the United States and Canada have achieved milestones in protected areas designations beginning in 1872 with Yellowstone National Park (United States) and Mount Royal Park (Canada). Since then, the United States has added more than 45 million ha of National Parks and Wilderness Areas and Canada has added 51 million ha of equivalent new reserves based on GAP 1 designations. However, it is widely acknowledged that neither country has achieved an ecologically representative network of reserves (Noss and Cooperrider 1994, Hummel 1995, Ricketts et al. 1999, Scott et al. in prep.) despite concerns expressed by conservationists for more than a century (Noss 1996). Our findings support these concerns by documenting substantial deficiencies in the extent of protected areas at higher levels of analysis, including major habitat types and ecoregions for the United States and Canada. They also support the need for establishing

a representative reserve network in fulfillment of international accords and national conservation agreements.

While the United States was not a signatory to the Convention on Biological Diversity, the government is participating in the Montreal Process (1996) through a roundtable committee recently convened by the Chief of the Forest Service (the senior author is a member of this roundtable) to comply with the internationally recognized criteria and indicators of sustainability established under the Montreal Process. Criteria under consideration include the degree and extent of protection, a subject which this study can address. Moreover, the National Wildlife Refuge System Improvement Act (1996) established a policy in the United States for administering a national network of lands and waters for the conservation, management, and restoration of flora and fauna. Our results support the need to more fully implement this policy through additions to the reserve network.

Perhaps, of greater importance, however, the United States and Canada together have 30 ecoregions considered of global significance (Ricketts et al.1999) yet protection levels for these extraordinary ecoregions averaged just 6.0% (GAP 1 and 2) with four ecoregions having levels of protection below 1% of their total area. The global significance of natural resources in the United States and Canada is further illustrated by the combined forest coverage of these two countries. Both countries together contain about 21% of the world's forests (World Conservation Monitoring Centre 1997), nearly 1/3 of the boreal forests (National Atlas of Canada 1995), and 1/2 of the temperate rainforests on earth (Alaback 1991, DellaSala et al. 1996a, Schoonmaker 1997). Yet GAP 1 and 2 protection levels for these forest types (MHTs) ranged from 8.44% of boreal

forests/taiga to 11.30% of temperate coniferous forests (including both temperate rainforest and other temperate conifer forest ecoregions). Moreover, extensive logging and other disturbances outside protected areas in many of the ecoregions within these important MHTs has substantially degraded ecosystem functions and reduced the extent of many forest types considered of high conservation value (e.g., low-elevation forests, various old-growth forest types in Canada and the United States; Noss et al. 1995, Ricketts et al. 1999).

Our results also demonstrate the need for expanding each nation's reserve networks not just in terms of percent protected but in size of reserves as well. While each country has many small (<10,000 ha) reserves, <1% of the reserve network is >100,000 ha. Small reserves may not function as intact ecosystems especially for wide ranging species like large carnivores (Noss and Cooperrider 1994) and interior dwelling songbirds (Whitcomb et al. 1981, Wilcove et al. 1986, Finch 1991). This is particularly true in the eastern United States where most land is under private ownership and few large reserves exist. Physical forces such as geologic processes and hydrologic regimes shape most terrestrial ecosystems, and most protected areas in both the United States and Canada are not large enough to allow these forces to operate naturally. In addition, many reserves in fire-adapted regions may be too small to act as refugia during large-scale disturbance events. Fire in the intermountain region of the United States (Agee 1993) or dry forest regions of Canada (Johnson 1992) typically operates over large landscapes (10,000-100,000 ha) and thus reserves smaller than this may not provide adequate refugia during such disturbances (Noss, 1996, DellaSala et al. 1996b). Shugart and West (1981) indicated that a landscape needs to be 50-100 times larger than the average disturbance

patch to maintain a “quasi-equilibrium” of seral stages over time. Moreover, large reserves have a lower probability of major shifts in landscape structure that could threaten the persistence of some species (Turner et al. 1994).

While it is difficult to estimate the proportion of land in protection in other regions of the world due to differences in data availability and quality, the IUCN (1994) classifications are useful in assessing level of protection for comparisons among different geographic regions. Most governments participating in international biodiversity accords (e.g., Montreal Process 1996) also recognize IUCN categories. Currently, there is only one published international database available for comparing degree of protection estimates among geographic regions of the world using IUCN classifications (I-III) that are equivalent to GAP 1 designations (World Resources Institute et al. 1992). The World Conservation Monitoring Centre and World Wildlife Fund International (pers. commun., M. Adlrich, World Wildlife Fund International) are currently updating this international database. However, according to the World Resources Institute et al. (1992), Australia and the South Pacific have protected 8.79% of their total land area, followed by the United States (5.24%), Canada (3.77%), South America (3.27%), Africa (2.93%), Asia (including Russia, 1.32%), Europe (0.77%), and Antarctica (<1%). We note that the protection estimates for Canada differ between this study (5.2%) and those of the World Resources Institute et al. (1992), and that the PAD database used in this study reports slightly lower protection levels for Canada than the recent estimate of 6.4% reported by WWF Canada (1999) for equivalent GAP 1 designations. Such discrepancies likely exist for two reasons: (1) older databases than PAD were used by the World Resources Institute et al. (1992); and (2) the PAD does not include recent additions to the Canadian

reserve system (as of January 1999) that are not yet available in digital format. This illustrates the importance of periodically updating and housing national databases on protected areas using standardized accounting approaches.

The comparatively low-level of protection reported for Canada and the United States using the PAD supports concerns raised by developing nations (particularly in the tropics) that the wealthiest nations in the world are not fulfilling international obligations to protect their share of the earth's biodiversity. The need for additional protection is increasingly urgent in light of projected increases in human population, explosive natural resource consumption, global climate change, and accelerated rate of extinction predicted over the next century (Wilson 1992:191,280; Pimm et al. 1995). Many nations, including the United States and Canada, share ecoregion boundaries, underscoring the need for greater cooperation in cross-border management of protected areas, compliance and participation in international biodiversity accords, and improved coordination in meeting representation targets.

CONCLUSIONS

While this study provides a necessary database for assessing and establishing a baseline for adequate protection, determining just how much to set aside in reserves for any given nation or ecoregion is best accomplished through follow-up GAP analysis techniques aimed at defining extent of protection needed to achieve representation rather than basing protection levels on politically driven targets (e.g., 12%). In addition, determining what level of protection counts in meeting conservation goals will continue to be debated by the general public based on societal acceptance of protected areas, philosophical differences regarding the role of humans in ecosystems, human desire for

naturalness and capacity for restraint, and the science of reserve design. Many conservationists advocate for the strictest levels of protection given that even moderate human activities can be associated with biodiversity declines and that some of the strictest protected areas (e.g., National Parks) have lost many of their characteristic fauna such as large mammals (Newmark 1985). Therefore, we elected to report on both strict (GAP 1) and more relaxed (GAP 2) levels of protection in our estimates, recognizing that meeting international and national conservation goals should largely be based on some combination of GAP protection levels to achieve representation targets and land zonations that allow for varying degrees of human activities (Noss and Cooperrider 1994). However, we believe that progress in completing a representative protected areas system should rely on the use of the most conservative estimates of protection as a reference or baseline for evaluating when sufficient land has been secured to maintain species habitats, ecosystem functions, and to slow declines in biodiversity. This is particularly true for ecoregions having global and international conservation importance because of their relative rarity and uniqueness (Ricketts et al. 1999).

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Endangered Spaces Campaign of WWF Canada was initiated in 1989, Canada has doubled its protected areas largely due to efforts of these and other conservationists.

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