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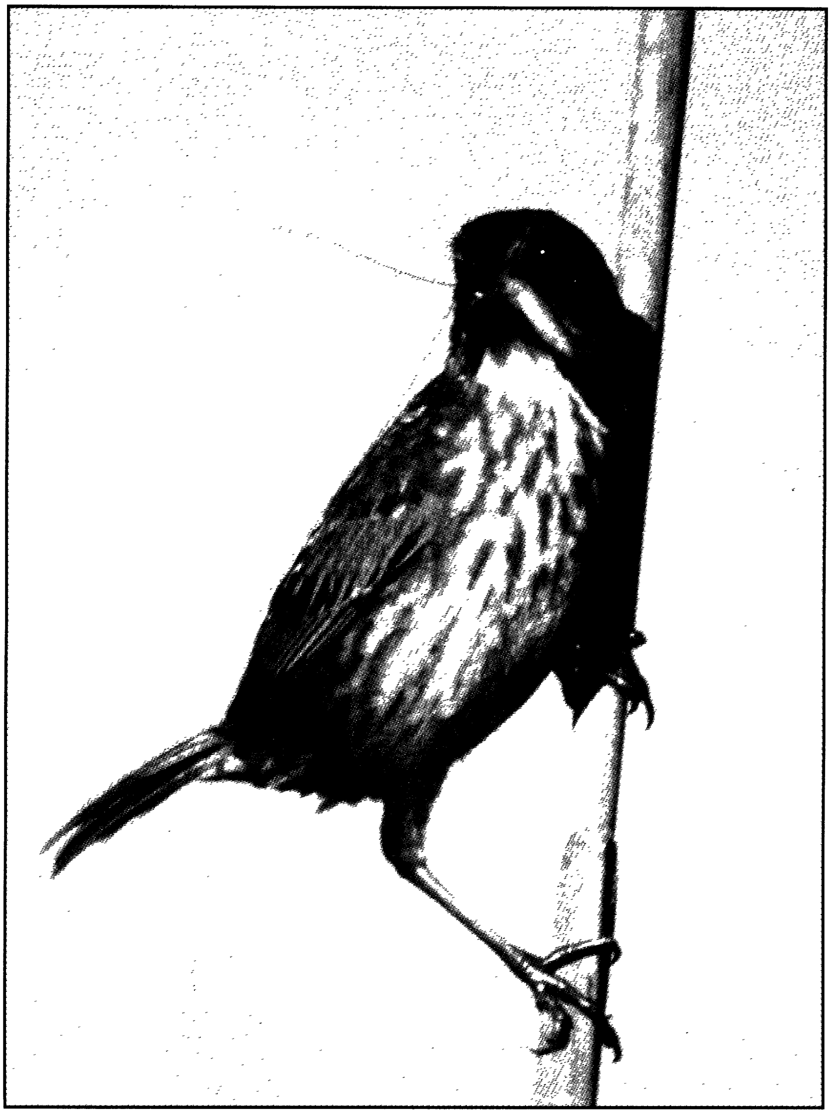

The State of the Southern Rockies Ecoregion: A Look at Species Imperilment, Ecosystem Protection, and a Conservation Opportunity

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Abstract
The Southern Rockies Ecoregion contains a rich diversity of native plants, animals, and natural communities. The ecoregion, however, has not escaped human-caused biological degradation. Several species native to the Southern Rockies have been extirpated and hundreds more are considered to be of conservation concern, including at least 20 species listed as Threatened and Endangered under the Endangered Species Act (ESA). To assess the relationship between the ecoregion's land protection status (e.g., national parks) and its major ecosystem types, we used a Geographic Information System (GIS) and employed methods similar to those used by the U.S. GAP Analysis Program. This analysis determined the relative level of ecosystem type protection. We then examined the ecosystem type content of the ecoregion's remaining unprotected roadless lands, to determine what conservation values these areas might hold. We also examined slope, elevation, and known locations of rare and imperiled species occurrences in both analyses. The results demonstrate that a general disparity in protection levels exists in the Southern Rockies between biologically-rich, lower-elevation ecosystem types and less species-rich, higher-elevation ecosystems. Only 31% of the collective protected land area is below 10,000 feet in elevation, and only 3 of 13 major ecosystem types native to the Southern Rockies have more than 10% of their total area within protected lands. In addition, the vast majority of rare and imperiled species occurrences lie within less-protected land ownership types, such as multiple-use public lands and private lands. In contrast to protected lands, unprotected roadless areas contain a significantly higher proportion (62%) of collective land area below 10,000 feet in elevation. By permanently protecting these roadless areas, 11 of 13 native major ecosystem types could be represented in protected areas above a 10% level, 5 of 13 could be protected above a 25% level, and hundreds of additional rare and imperiled species locations would be included. While additional analysis is required, roadless area protection may also fulfill additional reserve selection and design criteria that complement representation objectives, including protecting special biological elements (e.g., biodiversity hotspots), meeting the needs of focal species (e.g., wide-ranging carnivores), and establishing habitat connectivity. These results also demonstrate the importance of the Clinton administration's recent proposal to provide formal protection for the nation's remaining unprotected national forest roadless lands. The findings presented in this report are also included in the State of the Southern Rockies Ecoregion.

Introduction
The State of the Southern Rockies Ecoregion report, to be released in early 2000 by the Southern Rockies Ecosystem Project, provides a first-ever ecological assessment of the Southern Rockies Ecoregion (SRE), a large expanse of land (63,654 square miles) stretching from southern Wyoming through Colorado to northern New Mexico (Figure 1). The report examines land use history, social and economic settings, species diversity, terrestrial and aquatic ecosystem conditions, and the status of protected lands and roadless areas, and encourages a large landscape-scale framework to promote further conservation planning

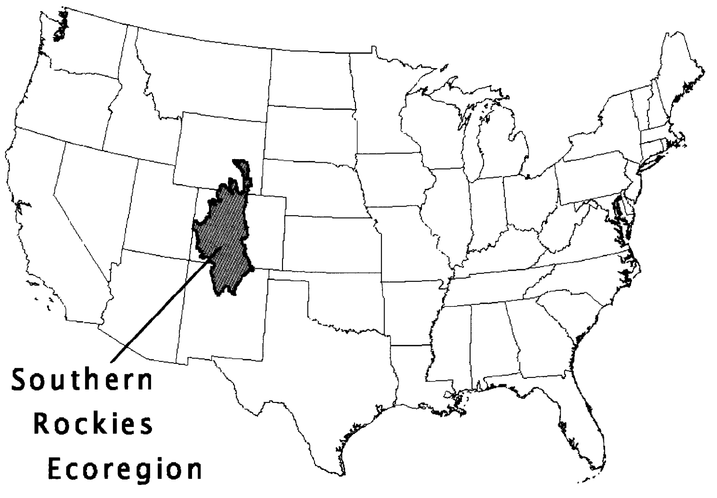

Figure 1. Location of the Southern Rockies Ecoregion in the coterminous United States.

and biodiversity protection efforts. It also reveals the general disparity in protection levels between biologically-rich, lower-elevation ecosystem types and less species-rich, higher-elevation ecosystems. In this article, we highlight this disparity and examine one opportunity to rectify this inequity in ecosystem type representation: preservation of the ecoregion's remaining unprotected public lands roadless areas.

Obtaining adequate ecosystem type representation in protected areas complements other reserve selection methods, including protection of special elements (e.g., old-growth forests, rare and imperiled species habitat) and securing habitat needs for focal species (e.g., wide-ranging, human sensitive species), whose protection will benefit numerous other species (Noss et al. 1999). As conservation priorities are identified via these three methods, biologically crucial landscape elements can be integrated into a carefully designed reserve system that will protect biodiversity and maintain ecosystem health more effectively than the ecoregion's current, largely *ad hoc* system of protected lands. Reserve design considerations include factors such as reserve size, spatial configuration, and habitat connectivity between reserves, as well as appropriate management of surrounding multiple-use lands (Noss et al. 1999). Thus, this article also represents a first step in designing a more effective reserve system for the Southern Rockies.

Species diversity and conservation status in the Southern Rockies

The Southern Rockies' rugged and diverse topography is matched by its diversity of ecosystems, including alpine tundra, coniferous and deciduous forests, shrublands, grasslands, wetlands, lakes, and streams, which offer habitat for charismatic wildlife species such as bighorn sheep (*Ovis canadensis*), elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), black bear (*Ursus americanus*), mountain lion (*Felis concolor)*, cutthroat trout (*Oncorhynchus clarki*), bald eagle (*Haliaeetus leucocephalus*), and peregrine falcon (*Falco peregrinus anatum*). Lesser known species also call the Southern Rockies home, such as the western small-footed myotis (*Myotis ciliolabrum*), Woodhouse's toad (*Bufo woodhousii*), and the tundra draba (*Draba ventosa*). Based on expert review and Natural Heritage Program data, we have identified 328 extant native vertebrate species and subspecies that are tightly associated with the ecoregion's foothill, mountain, and valley habitats, including 203 birds,

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Cover: Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*). Photo by Julie Lockwood, 1996.

The views expressed in the *Endangered Species UPDATE* may not necessarily reflect those of the U.S. Fish and Wildlife Service or The University of Michigan.

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Table 1. The number of vertebrate species (excluding fish) that are found or potentially found within each major natural ecosystem type in Colorado (some species are not associated with the Southern Rockies). The sum of these numbers do not represent a total number of vertebrate species for Colorado, as any one species may occur in more than one ecosystem type. (*Data Source*: Colorado Division of Wildlife Latilong Database 1999).

Ecosystem	Number Species
Wetland/Riparian	459
Piñon-Juniper Woodland	181
Lowland Grassland	167
Mountain Shrubland	161
Semi-Desert/Sagebrush Shrublands	157
Ponderosa Pine Forest	129
Mountain Grassland/Meadow	98
Spruce-Fir Forest	89
Lodgepole Pine Forest	83
Douglas Fir Forest	81
Aspen Forest	73
Limber Pine/Bristlecone Pine Forests	63
Alpine Tundra	51

90 mammals, 18 fish, 10 reptiles, and 7 amphibian species. When "peripheral" species are added to this list, the total grows to well over 500. The region also has a rich diversity of plants, plant communities, and invertebrates. For instance, with over 270 species of butterflies and an estimated 5,200 species of moths, the SRE is the second leading hotspot in North America for species richness in the insect order *Lepidoptera* (Paul Opler, pers. comm.).

Two vertebrate animal subspecies native to the Southern Rockies are known to be extinct, the yellowfin cutthroat trout (*Oncorhynchus clarki macdonaldi*) and New Mexico sharp-tailed grouse (*Tympanuchus phasianellus hueyi*). At least seven species have either been extirpated from the wild in the ecoregion or limited evidence of remaining individuals indicate there are likely too few to support viable populations. These include the bison (*Bison bison*), grizzly bear (*Ursus arctos*), gray wolf (*Canis lupus*), black-footed ferret (*Mustela nigripes*), wolverine (*Gulo gulo*), lynx (*Felis lynx canadensis*), and river otter (*Lutra canadensis*) (Fitzgerald et al. 1994). The state of Colorado is currently attempting to restore the lynx, and the river otter has been successfully reintroduced to portions of its former range in the ecoregion. At least ten vertebrates, two invertebrates, and eight plant species native to the ecoregion are listed as federally Threatened or Endangered under the US Endangered Species Act, such as the recently listed Preble's meadow jumping mouse (*Zapus hudsonius preblei*).

In addition to Threatened, Endangered and extirpated species, hundreds of other native species in the Southern Rockies are considered to be of conservation concern according to the standardized, species-imperilment ranking system developed by The Nature Conservancy and the Natural Heritage Programs (Master 1991). For instance, by using Colorado Natural Heritage Program (CNHP) state conservation ranks as indicators of a species' status in the ecoregion (except in the case of one New Mexico endemic), of the 328 vertebrate species tightly associated with Southern Rockies ecosystems, a significant portion are listed as vulnerable, imperiled, or critically imperiled by CNHP and are likely at risk in the ecoregion including: more than 1/2 of all amphibian species; nearly 1/2 of all fish species; more than 1/4 of all bird species; and 1/5 of all mammal species.

Based on Natural Heritage Program ranks, roughly 5% of all Southern Rockies vertebrate species are also considered globally vulnerable or imperiled. For these species, such as the boreal toad (*Bufo boreas*) and Gunnison sage grouse (*Centrocercus urophasianus* subspp.), extinction is a serious threat. Although it is uncertain how many plants native to the Southern Rockies are at risk, roughly one-sixth of all vascular plant species native to Colorado are ranked as rare, vulnerable, or imperiled at the global level, based on comparing Natural Heritage Program ranks to a total number of species from a catalog of Colorado flora (Weber and Wittman 1992). Numerous invertebrates are also at risk, but because invertebrate species are not as well studied in the ecoregion, percentages are uncertain. Finally, almost one-third of the known natural communities occurring in the Southern Rockies are considered rare, vulnerable, or imperiled at the global level under Natural Heritage Program ranks.

Species distribution

Some species in the Southern Rockies require very specific habitat types to meet their life history needs, such as the Abert's squirrel (*Sciurus aberti*) which requires relatively dense and mature ponderosa pine forests (Allred and Gaud 1994). Other Southern Rockies species, such as elk, are habitat "generalists" and can be found in every major ecosystem type in the

Southern Rockies (Fitzgerald et al. 1994). Significantly, however, species richness is not evenly distributed among Southern Rockies ecosystems. Species richness is generally much higher in wetland/riparian and lower elevation ecosystems, such as grasslands, shrublands, and lower elevation forests, than in upper elevation ecosystems, such as alpine tundra and spruce-fir forests (Table 1).

These distribution patterns are an important consideration as we assess both the relative human impacts to lower versus higher elevation ecosystems and the level of protection for these ecosystems. For instance, Figure 2 shows that higher concentrations of known at-risk species occur mainly in major watersheds along the western slope of the ecoregion and near the foothill/prairie ecotone on the eastern slope of the Southern Rockies. Although this distribution of known rare and imperiled species occurrences likely reflects more intensive biological survey efforts in these areas, it also likely reflects greater human impacts, such as urban development and agriculture on these generally species-rich, lower-elevation ecosystems.

Protected lands

Based on our mapping analysis, almost 11% of the ecoregion is currently within National Parks and Wilderness Areas. While this proportion is higher than most other regions in the U.S. (Noss and Cooperrider 1994), historically, most protected lands in the Southern Rockies were not selected to represent the diversity of ecosystems and species. Rather, these areas were typically chosen for scenic and recreational values or to protect charismatic wildlife such as elk, and were also often selected because they had little economic value (Foreman and Wolke 1992; Pressey 1994). The result is that today many of the Southern Rockies' ecosystems and species are not well-represented in the existing system of publicly owned nature reserves. Because the Southern Rockies' protected areas mainly capture scenic, high-mountain landscapes, ecosystems such as subalpine forests and alpine tundra are relatively well-protected. In contrast, less glamorous but biologically richer landscapes, such as low elevation riparian areas and shrublands, are not well-represented in the current system of strictly protected nature reserves.

Analysis

Thus, to more accurately assess the relative protection status of the Southern Rockies' ecosystems, we employed a technique developed by the U.S. National Gap Analysis Program (Scott et al. 1993) to analyze each major ecosystem type in relation to current levels of land stewardship. Specifically, we used geographic information system (GIS) technology to measure the percentage and area of each major ecosystem type within various classes of land protection (stewardship). We also assessed the relationship between these land stewardship levels and elevation and slope, to determine if steep, high elevation areas in the ecoregion have been favored for protection over more topographically accessible, low-elevation areas, as many conservationists have maintained (Foreman and Wolke 1992). Finally, as a coarse measure of stream and riparian habitat protection, we also looked at whether or not higher elevation streams have been better protected than lower elevation streams, by examining the relationship between stream orders and land stewardship classes (this analysis was performed for Colorado and Wyoming portions of the ecoregion only, as stream order classifications were not available for New Mexico).

To accomplish this, we first followed established vegetation classification schemes (e.g., Benedict 1991) and reclassified detailed vegetation/land cover maps produced by the Colorado, Wyoming, and New Mexico GAP Analysis projects into 13 major Southern Rockies native ecosystem types (see Table 1). We then categorized the Southern Rockies into land stewardship cat-

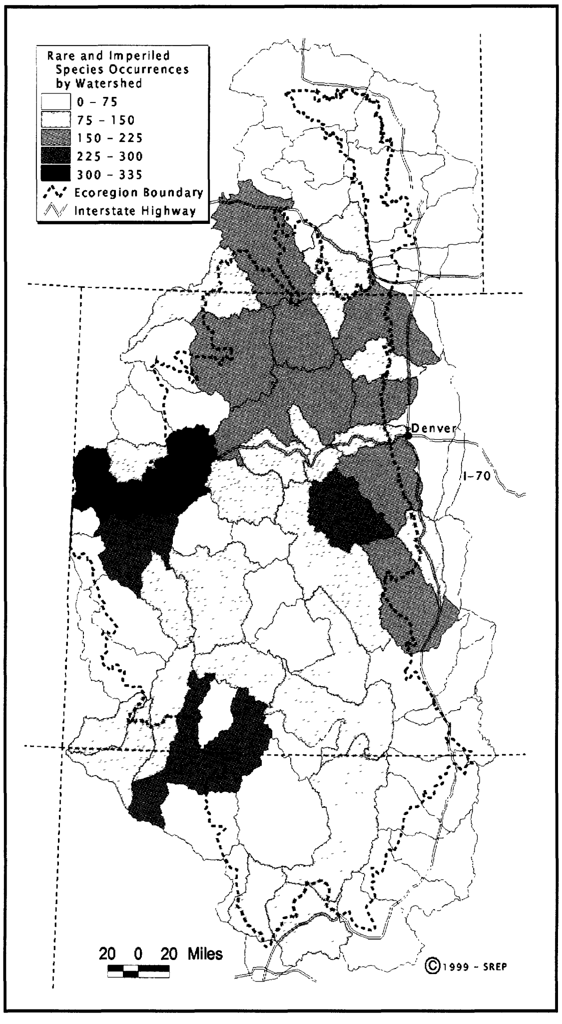

Figure 2. Number of rare and imperiled species by fourth order watersheds based on recent (within the last 15 years) species occurrence data collected and/or mapped by the state Natural Heritage Programs. (*Data Sources:* Colorado Natural Heritage Program, New Mexico Natural Heritage Program, and Wyoming Natural Diversity Database, 1999).

Table 2. The major ecosystem types in the Southern Rockies Ecoregion, listed by: total area, area/percent in unprotected roadless lands, area/percent in status 1 and 2 protected lands (e.g., National Parks and Wilderness Areas), and percent of each ecosystem type in both unprotected roadless and protected lands. 10 of the 13 major ecosystem types in the Southern Rockies would achieve a 10% or greater level of representation in status 1 lands if unprotected roadless areas were permanently protected (e.g., as Wilderness Areas). General/mixed conifer forests were examined as a natural cover type in this report, but not analyzed as an ecosystem type, due to vague classification criteria used in GAP Analysis mapping efforts. Results for wetland/riparian ecosystems are suspect, because the coarse-level mapping by the GAP Analysis projects was not adequate to delineate the numerous fine-scale aquatic ecosystems.

Ecosystem Type	Total Area of Ecosystem	Ecosystem Area within Unprotected Roadless Lands		Ecosystem Area within Status 1 & 2 Protected Lands		% of Ecosystem Type in Protected Lands and Unprotected Roadless Lands
		Acres	% of Total	Acres	% of Total	
Aspen Forest	3,211,359	968,778	30.2	269,334	8.4	38.6
Douglas-Fir Forest	956,899	208,366	21.8	33,518	3.5	25.3
Limber Pine/Bristlecone Pine Forests	177,616	8,821	5.0	13,741	7.7	12.7
Lodgepole Pine Forest	2,736,615	649,476	23.7	376,751	13.8	37.5
Lowland Grassland	2,004,174	18,252	0.9	53,189	2.7	3.6
General/Mixed Conifer Forest	2,217,422	426,754	19.2	385,322	17.4	36.6
Mountain Grassland/Meadow	1,851,787	97,831	5.3	75,511	4.1	9.4
Mountain Shrubland	2,306,905	188,523	8.2	59,803	2.6	10.8
Piñon-Juniper Woodland	5,176,970	512,309	9.9	178,795	3.5	13.4
Ponderosa Pine Forest	4,523,020	384,234	8.5	208,200	4.6	13.1
Semi-Desert/Sagebrush Shrublands	6,208,661	378,918	6.1	295,982	4.8	10.9
Engelmann Spruce-Subalpine Fir Forest	4,881,660	1,350,007	27.7	1,486,941	30.5	58.2
Alpine Tundra	1,892,642	558,944	29.5	1,066,244	56.3	85.8
Wetland/Riparian	136,668	10,639	7.8	12,382	9.1	16.9
TOTALS	**38,282,398**	**5,761,852**	**15.1**	**4,515,712**	**11.8**	**26.9**

egories based on relative levels of legally mandated protection of native species, natural communities, and ecosystem processes. Using GIS, we integrated existing GAP Analysis land stewardship maps for New Mexico and Wyoming with a Bureau of Land Management "Surface Management Status Map" for Colorado (the Colorado GAP Analysis land stewardship mapping had not been completed at the time of this analysis). By closely following GAP Analysis land stewardship mapping procedures, we reclassified these maps to develop a single, comprehensive land stewardship layer for the entire ecoregion.

Four land stewardship classifications were developed and include (in order of protection level, high to low): *status 1* lands—national parks, federally designated wilderness areas, and U.S. Forest Service research natural areas; *status 2* lands—state wildlife areas and U.S. national wildlife refuges; *status* 3 lands—multiple-use public lands such as U.S. Forest Service, Bureau of Land Management, and remaining state lands; and *status*

4 lands—mainly private lands. This classification scheme offers a representation of protection status at a coarse-scale, and may not accurately reflect the status of some individual parcels, such as private lands within conservation easements.

Based on these land stewardship categories, 47.5% (19,329,406 acres) of the Southern Rockies consist of status 3 lands. Status 4 lands constitute 41.3% (16,806,013 acres) of the Southern Rockies, and status 1 and 2 make up 10.3% (4,194,479 acres) and 1.0% (391,216 acres) of the Southern Rockies, respectively. Most of the protected areas (status 1 and 2 lands) are small- to medium-sized parcels (for instance, 69% of National Parks and Wilderness Areas fall under 100,000 acres). Sixteen large (greater than 100,000 acres) protected areas, however, collectively constitute a significant land area, at roughly 3.1 million acres total.

Results

High-elevation ecosystems in the Southern Rockies have a much higher proportion of their total area protected in status 1 and 2 lands than lower elevation ecosystems. For instance, 56.3% of alpine tundra is within protected lands, compared to just 3.5% and 3.7% for piñon-juniper woodlands and low-elevation grasslands, respectively (Table 2). Status 1 and 2 protected areas also tend to be much higher in elevation and have steeper average slopes, when compared to less-protected areas. Sixty-nine percent of status 1 lands lie above 10,000 feet elevation, while only 22% and 4% of status 3 and 4 lands, respectively, are over 10,000 feet. Moreover, more than 63% of status 1 and 2 protected lands have a greater than 10 degree slope, compared to just over 31% for status 3 lands and 11% for status 4 lands. Thus, protected areas are often too high, cold, and steep (and likely have generally less productive soils) to offer much in the way of profitable resource extraction.

A similar pattern emerges when we consider protection of riparian and stream ecosystems. Using stream order as a surrogate for these two ecosystem types, we discover that 4,437 miles of the highest elevation streams (11% of 1st and 2nd order streams) in the Colorado and Wyoming portion of the ecoregion are within status 1 and 2 areas, and only 51 miles of the larger, lower-elevation streams (4% of 5th-7th order streams) fall into these two highest protection categories. As a further indication of the lack of adequate stream protection, only 200 miles, or 0.6%, of perennial rivers in the Southern Rockies are protected under the Wild and Scenic Rivers Act (USDI National Park Service 1999). Thus, biologically diverse, lower elevation riparian and stream ecosystems are not well represented in protected areas.

A conservation need

These results demonstrate, at least on a coarse scale, that numerous species' habitats are not well represented in the existing protected areas (Tables 1 & 2). Individual species associated with lower elevation ecosystems, such as the federally Threatened Mexican spotted owl (*Strix occidentalis lucida*), have very little habitat representation in protected areas. In fact, at the state level, the New Mexico and Wyoming Gap Analysis projects have demonstrated that many biological hotspots and individual species' habitats are not well protected by the existing system of protected lands. For instance, by mapping potential habitat for vertebrate species, the Wyoming Gap Analysis project discovered that 50% of all amphibians, 31% of all reptiles, 22% of mammals, and 14% of bird species require greater levels of protection (Merril et al. 1996). Although we were not able to examine potential habitat for species for the ecoregion (due to the unavailability of Colorado Gap Analysis species range maps), and the Wyoming results are not directly transferable to the Southern Rockies, the under-representation of ecosystems in protected areas discovered in our analysis indicates that a similar deficiency in species protection also occurs. In fact, by overlaying the stewardship map layer with a map of rare and imperiled species occurrences, we discovered that 85% of the recent occurrences (within the last 15 years) of rare and imperiled species tracked by the state Natural Heritage Programs fall onto

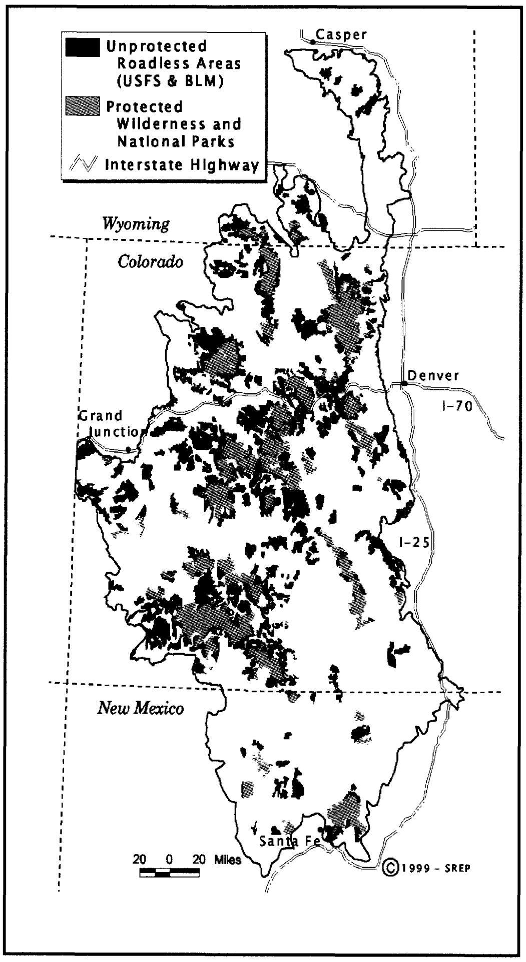

Figure 3. All remaining roadless lands (protected and unprotected) in the Southern Rockies, based on roadless area inventories by the U.S. Forest Service (USFS), Bureau of Land Management (BLM), National Park Service (NPS), and conservationists.

status 3 and 4 lands. Some of the most at-risk species' habitats largely fall onto private lands, which are rapidly being converted to human-dominated landscapes due to dramatic population and housing growth in the region.

Using a modest proposal that at least 10% of any ecosystem type in a given region be represented in protected areas to ensure an adequate coarse-filter approach to biodiversity conservation (Scott 1999), 10 of the 13 major ecosystem types in the Southern Rockies deserve greater levels of protection (Table 2). Only alpine tundra, spruce-fir forest, and lodgepole pine forest ecosystems could be considered adequately protected. With a more conservative requirement of at least 25% ecosystem type representation in status 1 and 2 lands, only alpine tundra and spruce-fir forest ecosystems can be considered adequately protected, and only alpine tundra is adequately protected with a 50% requirement. Some have suggested that as much as 25-75% of a region's natural habitat may require protection in reserves to ensure adequate biodiversity protection (Noss and Cooperrider 1994).

A conservation opportunity: Roadless lands

Yet, there is still a tremendous opportunity to further the conservation goal of ecosystem type representation for almost all of the Southern Rockies' major ecosystem types, and in doing so, protect significant habitat for many rare and imperiled species. We examined the vegetation composition and elevation of the region's roughly 5.8 million acres of remaining unprotected public lands roadless areas (Figure 3). These roadless lands have been identified by federal land management agencies and local conservation organizations.

These unprotected roadless lands are lower in elevation on average than existing protected lands, with 62% of the area below 10,000 feet compared to only 31% for status 1 lands. These roadless lands also contain significant amounts of under-represented ecosystem types, including species-rich, low- and middle-elevation ecosystems (Table 2). For instance, while only about 30,000 acres of Douglas-fir forests are currently protected in status 1 areas, over 200,000 acres, or 22%, of Douglas-fir forests fall onto unprotected roadless lands. Also, nearly 350,000 acres of ponderosa pine forests, over 500,000 acres of piñon-juniper woodlands, and nearly 1,000,000 acres of aspen forests are contained within the ecoregion's unprotected roadless areas. Significantly, if these roadless areas were to receive permanent protection (e.g., as federally designated Wilderness Areas), 10 of the Southern Rockies' 13 major ecosystem types would attain a 10% or greater level of protection under status 1 and 2 lands, and 5 of 13 could be protected above a 25% level. These unprotected roadless areas may also contain valuable habitat for specific rare and imperiled species. For instance, based on our analysis of Natural Heritage Program data, over 650 recent occurrences of rare and imperiled species and subspecies are known to exist in these areas, over 200 of which represent species considered globally vulnerable or imperiled, as well as more than 80 occurrences of federally listed Threatened and Endangered species.

Discussion

While some native species in the Southern Rockies are capable of adapting to various levels of human dominated landscapes and may not require strict habitat protection, sensitive species and natural communities that are significantly under-represented in the ecoregion's current system of protected areas will require further levels of protection. Equally important, just because certain ecosystem types are relatively well-represented in protected areas doesn't necessarily mean all species associated with these ecosystems are sufficiently protected. For instance, despite millions of acres of protected high-elevation forest and alpine tundra in the ecoregion, many of these protected forest and alpine areas may be too small and isolated on the landscape to meet the habitat needs of wide-ranging, human sensitive, or interior-dependent species, such as the wolverine (Seidel et al. 1998). In addition, areas with high rates of endemism, imperiled species, or other special biological elements may not be captured by a reserve system developed solely on a coarse-filter, representation approach. Thus, using fine-filter approaches to identifying special elements and researching focal species habitat needs complement a representation approach (Noss et al. 1994).

The Southern Rockies' roadless areas may provide the "building blocks" for a more complex and effective future reserve system, by not only helping to meet representation objectives, but also by potentially fulfilling reserve design goals and providing other biological benefits. For instance, if these lands were protected as federally designated Wilderness Areas, when combined with the roughly four million acres of existing protected lands, nearly one-quarter of the ecoregion could have protected status, including several large roadless areas (e.g., the 700,000+ acre Weminuche Wilderness Area/ roadless complex). These areas could potentially perpetuate important natural disturbance regimes, such as fire or flooding, which are critical natural processes to incorporate in reserve design (Baker 1992). These large wilderness complexes may also potentially support viable populations of a full suite of native species, including human-sensitive species that require remote habitat and wide-ranging predator species, as was determined in recent restoration research for the extirpated wolverine

(Seidel 1998) and gray wolf (Bennet 1995) in the Colorado Portion of the Southern Rockies. Many of these roadless areas also provide linkages between existing protected areas, and connectivity between protected habitat is essential to facilitating species movement for dispersal and resource needs, and providing opportunities for gene flow (Dobson et al. 1999). In addition, unlike more heavily utilized, roaded landscapes, roadless areas often contain relatively "pristine" ecosystems, such as old-growth forests, areas where fire suppression efforts have been minimal, less polluted aquatic ecosystems, and areas relatively free from exotic species (Noss et al. 1999). Finally, protected roadless lands also provide excellent "baselines" or "living laboratories" by which to judge the ecological impacts of land management on ecosystems open to more intense multiple uses (Leopold 1941). Additional research is required to identify roadless lands, and non-roadless lands, that fulfill the above objectives.

Conclusion

Public roadless land protection is not a panacea for biodiversity conservation. Further conservation planning objectives, such as ecosystem restoration, sensitive management of multiple-use public lands, and conservation efforts on private lands will also need to be addressed in any serious effort to protect biodiversity in the Southern Rockies. However, roadless areas offer significant species conservation values and may serve as "building blocks" for a more effective reserve system in the Southern Rockies based on: relative abundance of lower and middle elevation ecosystem types, lightly used and relatively healthy habitats; ability to support and maintain natural processes; potential for containing rare and imperiled species habitats; potential for supporting wide-raging and sensitive species; and ability to maintain connectivity between other protected habitats. Roadless areas may also provide less expensive, low-maintenance opportunities for many native species' conservation, especially when compared to the often intensive and costly human intervention required for protection of species at risk of extinction on heavily used landscapes.

The U.S. Forest Service has recently been directed by President Clinton to formulate a rule to address the need for protection of the nation's 40-60 million acres of roadless national forest lands (See President Clinton's "Memorandum for the Secretary of Agriculture: Protection of Forest "Roadless" Areas, October 13, 1999). We've identified roughly 4.9 million acres of these roadless areas on USFS lands in the Southern Rockies. Yet, the details of this plan are in progress, and it is not certain what level of protection will be provided to these lands (if any). Moreover, roadless lands on national forests with recently completed revised management plans, "unofficial" roadless lands (i.e., those not identified by the USFS), and roadless areas under 5,000 acres may be exempted from any future rule and remain at risk to development, such as logging and off-road vehicle use. Our analysis, which included both "unofficial" and sub-5,000 acre roadless areas, indicate that these unprotected roadless areas may hold conservation values disproportionate to their total acreage, and further justifies protection for these areas.

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The Recovery of the Cape Sable Seaside Sparrow through Restoration of the Everglades Ecosystem

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Abstract
*The Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) has been listed as federally endangered since 1967. Its small population size and unique ecology have perpetuated conservation concern. The ultimate factor in this sub-species' decline is the alteration of the everglades ecosystem. Range-wide surveys conducted since 1992 have documented 90 percent declines within some sub-populations leaving the sub-species vulnerable to extinction in the near future. Although the life history of the sparrow is typical of grassland birds, its demographic characteristics leave it highly vulnerable to even short-term alterations of fire and flood regimes. A multi-billion dollar restoration plan has been launched in an effort to return everglades' hydrology to a more natural state. Even with this plan, however, the Cape Sable seaside sparrow is in danger of extinction. As shown for the plight of the Dusky seaside sparrow (*Ammodramus maritimus nigrescens*), a close and now extinct relative of the Cape Sable seaside sparrow, management actions must be swift to avert the extinction of short-lived, habitat specialists such as this sparrow.*

Introduction
Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*) population numbers have declined nearly 50 percent between 1992 and 1996 (Curnutt et al. 1998). This federally listed subspecies currently exists within the protected lands of Everglades National Park (ENP) and adjacent Big Cypress National Preserve. These two biological preserves (together nearly 8,500 km^2 in area) form one of the largest protected areas in North America, yet fail to function as a preserve for this and many other inhabitants (Mayer and Pimm 1998). Because large-scale hydrologic changes reflect patterns of population decline in the Cape Sable seaside sparrow, this bird is perceived to be an indicator of the health of the everglades ecosystem. At present, the 20-year plan to restore original everglades hydrology promises recovery of the ecosystem. For short-lived species such as the sparrow, however, special attention must be paid to interim protection.

Historical perspective
Historically, the everglades were a 'river of grass' encompassing an estimated 28,205 km^2 of unbroken, freshwater prairie (Mayer and Pimm 1998). Extending from Lake Okeechobee in the north to Florida and Biscayne Bays in the south, water drained across the flat terrain as a 'sheet,' its peak averaging 64 km wide and 0.5 m in depth (Mayer and Pimm 1998). The heaviest flows (up to six km/hr) occurred during the wet-season (June to January).

South Florida was sparsely populated before the turn of the century (Tebeau 1968). High variation in water flow made south Florida an unpredictable place for most economic ventures, especially commercial farming (Mayer and Pimm 1998; Snyder and Davidson 1994). In 1850 the U.S. Congress passed the Swamp Lands Act which encouraged development in south Florida by 'reclaiming' flooded lands for agriculture (Light and Dineen 1994). This act, and another passed in 1948 (the Central and South Florida Project), set in motion a series of hydrology changes culminating in the construction of 2,200 km of canals and levees and over 40 pumps and spillways (Mayer and Pimm 1998). Lake Okeechobee was impounded in the 1930s, permanently altering the hydrologic link between the lake and the freshwater prairies to the south (Light and Dineen 1994).

These changes enabled south Florida to become one of the largest producers of winter vegetables and domestic sugarcane in North America (Snyder and Davidson 1994). Coupled with flood control, economic growth enabled the human population to reach four million by 1990 (Light and Dineen 1994). As early as the 1940s, officials recognized that this growth created additional demands on available water. To meet this need, three Water Conservation Areas (WCAs) were included in flood control measures and established just north of ENP (Figure 1). These areas receive most of the run-off from Lake Okeechobee and the Everglades Agricultural Areas. They provide freshwater sources for agriculture, residential areas, and recreation. They also function as a 'filter' by removing agricultural run-off (e.g., phosphorous) from water entering natural areas such as ENP (Light and Dineen 1994).

Between the WCAs and federal biological preserves, 67 percent of the original everglades ecosystem is protected from urban development. Although nearly half of that area is managed largely for biological resources, there is a limit to preservation efforts as only the lands, not the historic water flows, were protected. Since the re-plumbing of south Florida, water flows from the WCAs into the principle tributary of the lower everglades (Shark River Slough) via six spillways (Figure 1). Levees split the slough into eastern and western halves (Light and Dineen 1994). Western Shark River Slough receives most of the water, while the eastern slough (and other eastern tributaries such as Taylor Slough) receives little. The result is that prairies fringing western Shark River Slough are unnaturally wet for longer periods each year and the eastern prairies have desiccated (Nott et al. 1998). These prairies are home to the only six subpopulations of the Cape Sable seaside sparrows known (A-E, Figure 2).

The Cape Sable seaside sparrow, a small, drably colored bird, has never been common (Curnutt et al. 1998). First described in 1919 by Arthur Howell, this subspecies was thought to exist only within the freshwater marshes that grew on Cape Sable early this century (Werner and Woolfenden 1983). A hurricane that made landfall over Cape Sable on September 2, 1935, forever changed the Cape's vegetation and landscape (Mayer and Pimm 1998; Curnutt et al. 1998). The sparrow was not found on Cape Sable after that event. In fact the species was believed extinct until L.A. Stimson's 1951 documentation of inland populations in freshwater prairies (Stimson 1956). Because most seaside sparrows live within tidal marshes, this discovery made the subspecies an ecological oddity (Post and Greenlaw 1994). As a likely consequence of the sparrow's phoenix-like identity and its unusual ecology, the U.S. Congress placed the Cape Sable seaside sparrow on the first endangered species list enacted in 1967 (Curnutt et al. 1998).

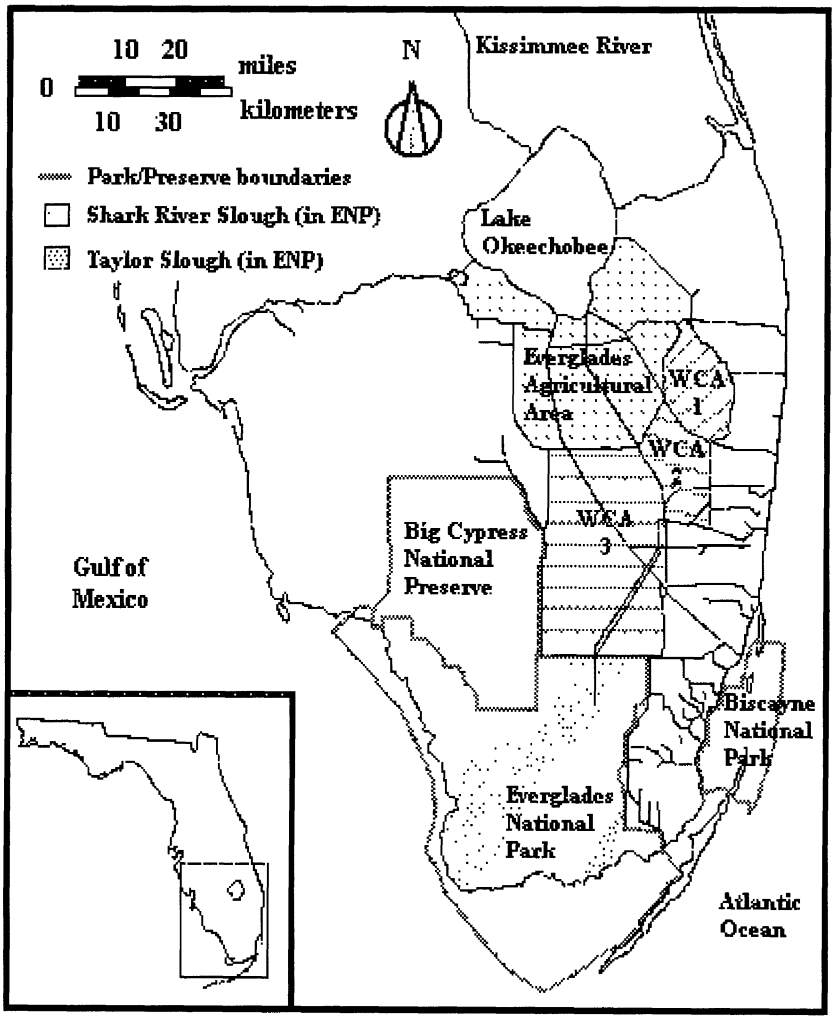

Figure 1. Map of the present Everglades watershed, including major canals, sloughs and political boundaries of parks and preserves (reproduced with permission from Mayer 1999).

Current status

In 1981, ENP researchers conducted range-wide point counts of the Cape Sable seaside sparrow breeding population. Points were located one km apart and accessed via helicopter (Kushlan and Bass 1983). This survey yielded sparrow population estimates of over 6,000 individuals, with more than 2,000 located in each of two 'core' subpopulations (A and B) (Kushlan and Bass 1983). Similar estimates resulted from the next survey in 1992. In 1993, however, estimates dropped 90 percent from 2,500

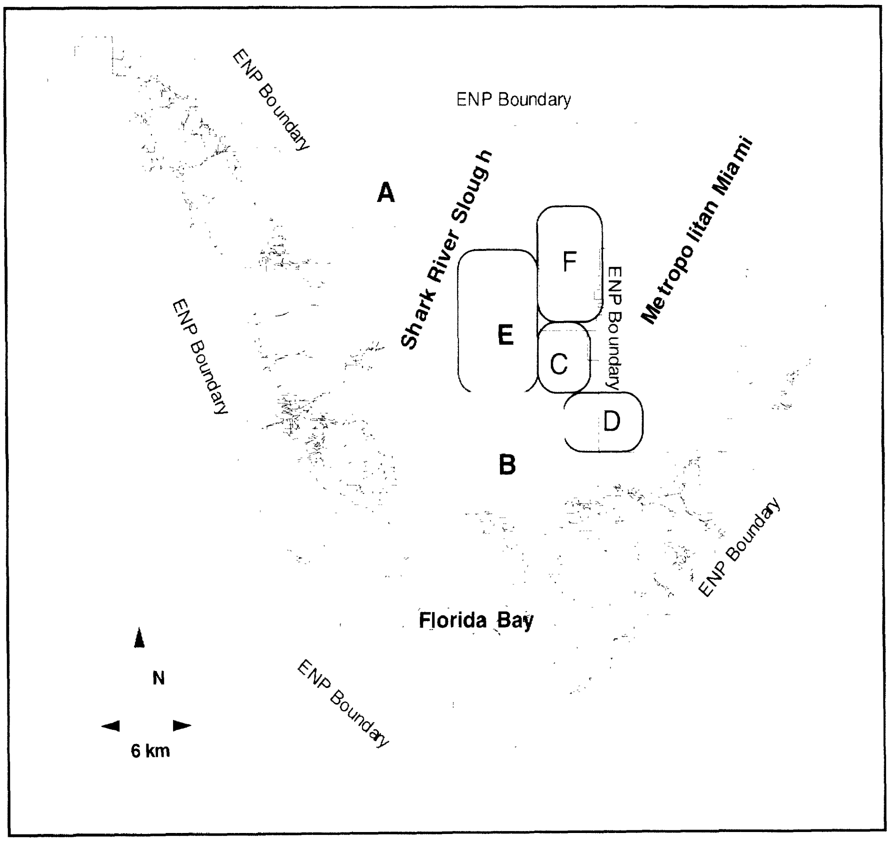

Figure 2. Location of Cape Sable seaside sparrow sub-populations within Everglades National Park and Big Cypress National Preserve.

to 400 individuals within subpopulation A (Curnutt et al. 1998). Subpopulations C, D, and F each declined from over 400 individuals to fewer than 80 in the ensuing years (Curnutt et al. 1998). Annual surveys since 1993 have shown no reverse in these declines (Pimm and Bass 1999). Only the central subpopulations (B and E) contain relatively stable numbers from year to year.

To understand these declines, we have monitored nests and color-banded individuals from nine study plots (each 0.50 km^2) within subpopulations A, B and E (Lockwood et al. 1999a,b). From six years of study, we know the following aspects of the sparrow's demography. The breeding season can last from late March to August depending on the onset of summer rains (Lockwood et al. 1997, Werner 1975). A pair can fledge at least three broods per breeding season. In early nesting attempts less than 50 percent of the eggs laid will result in fledged young and, in later attempts, less than a quarter of eggs laid will result in fledglings (Lockwood et al. 1999a). Sparrows prefer to nest in one meter-tall sparse sawgrass (*Cladium jamaicense*) stands mixed with bunchgrasses typical of seasonally dry areas (Lockwood et al. 1999b). Nests are built approximately 16 cm from the soil surface with a standard variation in height off the ground between two and 30 cm (Lockwood et al. 1999a; Werner 1975). Adults feed nestlings grasshoppers, spiders, dragonflies, and butterfly larvae, all locally abundant food sources (Lockwood et al. 1997). The principle threat to nests is predation, probably by water snakes or rats (Lockwood et al. 1997).

Adults are site fidelic, often returning to the same 200 m territory every year to breed (Lockwood et al. 1999a). When sparrows are not breeding they do not travel far. Using radio telemetry, Dean and Morrison (1998) recorded sporadic long distance movement over five km, but most tagged individuals stayed within one km of their nesting grounds. We have never re-sighted an individual banded in one subpopulation within another (Lockwood et al. 1999a). Half of all adults in any given year will die and four year old birds are rare (Lockwood et al. 1999a). Hatch-year individuals exhibit low survival their first year out of the nest but they are more likely to move over longer distances (up to one km) (Lockwood et al. 1999a).

Although these demographic attributes are typical of most grassland birds, they become a unique liability in the context of current alterations in Everglades water flow. In the western prairies of ENP, satellite images and ground-based hydrologic monitoring stations show several high water events between 1993 and 1996. In some years, water levels reached 50 cm above ground level (Nott et al. 1998). This exceeds the average nest height off ground by 34 cm and the highest nest ever recorded by 20 cm. These large water flows did not result from rainfall *per se*, but were due to released WCA water (Nott et al. 1998).

In the eastern prairies, altered hydrology has changed temporal fire patterns that, in turn, have impacted sparrow breeding habitat. Although periodic fires maintain freshwater prairies by preventing the encroachment of shrubs and hardwood trees (Kushlan and Bass 1983), comparisons between fire records and sparrow surveys demonstrate the following: 1) sparrows regularly occupy sights that have burned one year prior, and 2) historically occupied areas that burn every one or two years rarely hold sparrows today (Curnutt et al. 1998).

Since sparrows are short-lived, temporary disruption of reproduction (such as fire or flood) can significantly effect population numbers (Lockwood et al. 1999a). In areas where adult sparrows cannot breed for two or three consecutive years, most adults die without replacing themselves in the population. This situation is exacerbated by the sparrow's limited clutch size. A pair of adult sparrows averages two young per nesting attempt. Theoretically, if all adults in an area successfully fledge one brood, population numbers will simply remain stable. (In practice, population numbers still decrease due to the low survivorship of juveniles.) Population increases are only possible when individuals successfully fledge two to four broods per breeding season (Lockwood et al. 1999a).

Recovery is further hampered by the sparrow's limited dispersal over long distances. Immigration rarely occurs across subpopulations. Thus, there is little chance for the 'rescue effect' whereby individuals from a stable subpopulation immigrate into a declining one.

A final concern is that high water and frequent fires are causing long-term changes in habitat structure (Nott et al. 1998; Lockwood et al. 1999a). Known to be a habitat specialist, this subspecies will not breed in prairies lacking specific structural cues (Lockwood et al. 1999b).

Restoration and future management

Restoring water flows that mimic historical hydrology was a goal of a bill passed by the U.S. Congress in 1992 (USACE and SFWMD1999). The restoration plan aims to rectify environmental damage done by the 1948 Central and South Florida Project while maintaining adequate flood control and freshwater supplies for the local populous (Governor's Commission on a Sustainable South Florida 1995). Though the plan is promising, the task is monumental. Current estimates place the completion of the restoration at 20 years. The existent configuration of canals and levees simply provides no physical route to quickly redirect water flow from the over-flooded west to over-dry east (Pimm and Bass 1999).

Given the observed steep declines in Cape Sable seaside sparrow numbers between 1992 and 1995, there is no guarantee the sparrow can survive the 20 required to restore its breeding habitat. Consider the damage its close relative, the Dusky seaside sparrow (*Ammodramus maritimus nigrescens*), sustained between 1960 and 1980. The Dusky seaside sparrow was once found around Titusville, Florida. Like the Cape Sable seaside sparrow, the Dusky inhabited seasonally flooded marshes and existed in distinct geographic populations. Also like the Cape Sable seaside sparrow, the Dusky declined when hydrological changes left breeding grounds flooded or fire prone.

From an estimated 2,000 pairs on Merritt Island in the 1950s, DDT had already reduced populations 70 percent by 1957 (600 pairs) (Sykes 1980; Trost 1968). A bad situation was made worse when mosquito control impoundments flooded breeding habitat. The Dusky declined another 90 percent to 70 pairs by 1963 (Sykes 1980; Trost 1968). The threat was understood and the Dusky's habitat requirements documented (Trost 1968). Piecemeal studies to determine whether the birds would respond favorably to restoration of 'natural' hydrologic patterns satisfied endangered species legislation (Walters 1992) but left only one individual on Merritt Island by 1977 (Sykes 1980; Baker 1973; Sharp 1969).

The population of Dusky seaside sparrows located in the marshes along the St. John's river was estimated at 984 males in 1968 (Sharp 1970). Although it took two years to purchase U.S. National Wildlife refuge land here for the endangered bird, it took only one to gain a permit to build a highway through one densely populated colony (Walters 1992). Highways and development outside the refuge reduced the largest colony from 100 to 12 birds (Baker 1978). Inside the refuge, an open ditch drained Dusky habitat while six fires from neighboring farms burned over 4,000 acres. By 1977 fewer than a dozen birds of the 143 counted in 1970 were left on the refuge (Baker 1978). Despite urgent requests for fire lines as early as 1975, they were not completed (nor was the ditch plugged) until 1979. By that time, only nine males were left (Walters 1992). The last wild Dusky seaside sparrows were taken into captivity in 1980. The last individual, referred to as Orange for the legband he wore, died in captivity in 1987.

Conclusion

In many ways the current recovery prospects of the Cape Sable seaside sparrow mirror those of the Dusky in the early 1960s. Recovery seems feasible. The sparrow's demography and habitat requirements are known; the hydrologic changes that impact that habitat are understood. Unlike the Dusky, the Cape Sable seaside sparrow enjoys advantages such as higher population numbers, a range entirely within federally protected lands, and consensus on the need to restore the ecosystem on which it depends.

Nevertheless, these advantages do not guarantee success. With such obvious parallels between the management needs of the Dusky and those of the Cape Sable seaside sparrow it is incumbent upon managers to avoid the known pitfalls that lead to extinction. More than anything else, the story of the Dusky illustrates how critical the timing of management decisions are in dealing with short-lived habitat specialists. Each delay in decisions to purchase refuge land, construct fire lines, and seasonally drain impoundments, carried the cost of a few more Dusky seaside sparrows. Though the restoration of the everglades ecosystem is a commendable and significant undertaking, it in no way alleviates the need for short-term, and often difficult, management actions. Without such actions, the Cape Sable seaside sparrow may become a martyr for the threatened ecosystem about which it once raised awareness.

Acknowledgements

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Marine Matters

Atlantic Salmon on the Brink

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Abstract

Over the past 30 years Atlantic salmon in their natural range in Eastern North America have undergone a steep decline in numbers. In spite of many steps taken to regulate the harvest, in particular a virtually complete ban of the commercial fishery, the decline has continued. In the U.S. the Department of Interior proposed on November 17, 1999 that the salmon populations in eight rivers in Maine be classified as endangered under the Endangered Species Act (ESA). The State of Maine has opposed this action. The Atlantic Salmon Federation and Trout Unlimited have jointly filed a lawsuit in Washington, DC, to force an emergency listing under the ESA that would shorten the time for corrective action to be taken. In Canada, the Department of Fisheries and Ocean has submitted a request to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) that the salmon in the 33 rivers comprising the so-called Inner Bay of Fundy Rivers be listed as endangered. Unlike ESA, COSEWIC has no regulatory power to require corrective action to be taken following its listing decisions. This gap is to be addressed by proposed legislation in the Canadian Parliament of a Species at Risk Act, with regulatory powers.

The continued decline in salmon numbers appears to be caused by increased mortality in the sea. Possible anthropogenic-based explanations are depletion of the salmon's normal food source by commercial fisheries for forage fish, such as capelin, and exposure of juvenile salmon during their freshwater phase to the "endocrine disrupter" nonylphenol, which leads to mortality later in the marine phase. Interactions between wild and escaped farm-raised salmon can also be added to the suspect list. As for natural processes at work, there are several possibilities. These include predation by seals, disease, and large-scale oceanographic perturbations, in particular those involving temperature. Recent advances in acoustic telemetry, which for the first time allows the tracking of postsmolts many miles in the open ocean, hold promise for finding out where and when the as-yet unexplained increased marine mortality occurs.

The problem

Thirty years ago, about one and a half million small and large Atlantic salmon (*Salmo salar)* returned each year to spawn in their natal rivers in eastern North America (Marshal et al. 1998). Today, only about 350,000 do so. That's a reduction of more than 75 percent.

Population structure has changed too. In the 1970s, the proportion of small salmon called grilse (salmon which have spent one year at sea [1SW]) was about 45 percent. This has risen in the past few years to about 75 percent...the wrong direction for conservation purposes since it is the large salmon, which are mostly female and 2SW or older, which possess the bulk of the eggs for the next generation. While the number of salmon of North American origin has fluctuated, the stark reality is an unmistakable downward trend (Figure 1).

The picture would look even more alarming if we had reliable historical data to start the time series earlier, say at the end of the eighteenth century. Despite limited commercial salmon fishing off Newfoundland and Labrador by early settlers and Europeans, adult salmon of North American origin were likely at a population equilibrium, numbering well over the one and a half million estimated for 1969. Then came industrial progress, and the beginning of the decline. The

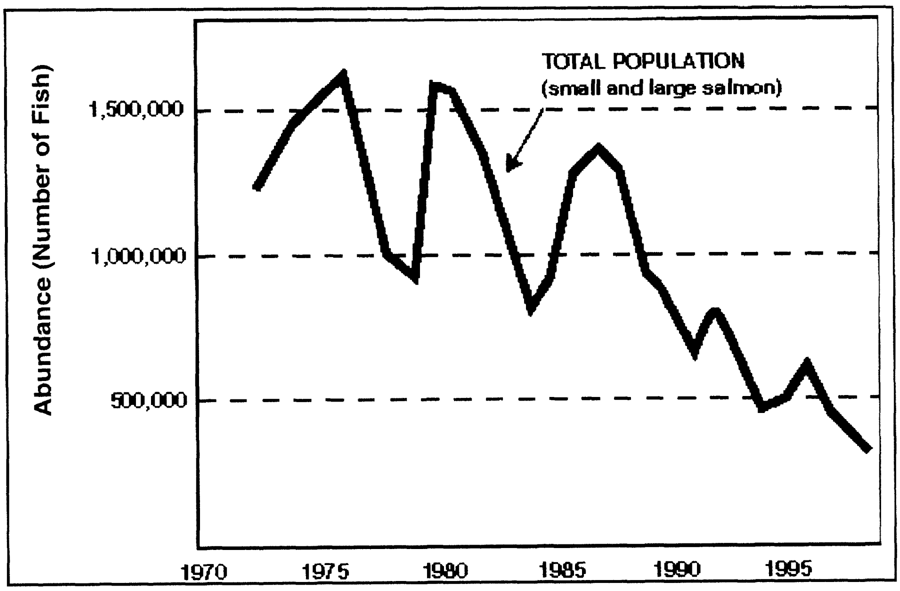

Figure 1. Numbers of Atlantic Salmon returning to North American Rivers.

early leading cause, particularly in New England, was dams that destroyed habitat, and denied access to much of whatever suitable habitat was left. A notable example was the first mainstem dam in 1794 at Hadley Falls, MA, on the salmon-prolific Connecticut River. Further depredation of the freshwater habitat followed from pollution from many sources, including industrial and municipal effluents, agriculture run-offs, forestry practices, and acid rain. The last salmon taken in Lake Ontario was in 1900. Commercial fishing by Americans and Canadians started taking its toll elsewhere in the twentieth century.

Species protection efforts

American states were forced to impose tough regulatory measures earlier than Canada. The last New England State to ban commercial salmon harvests was Maine in 1948. Regulations banning commercial salmon fishing in New Brunswick and the Gaspé region appeared in 1972. Virtually all commercial salmon nets had been lifted from the water by 1998. These regulations retired more than 10,000 licenses at a cost to federal and provincial treasuries of more than $70 million (Cdn). Furthermore, the west Greenland fishery, a once serious threat to salmon stocks, has been reduced to a small subsistence harvest through international treaty negotiations.

Tough regulations were applied to the recreational fishery as well. By the mid 1980s, conservation-oriented restrictions were imposed in Maine, the only state in New England where salmon angling was permitted, and all jurisdictions in Canada. These regulations included combinations of daily and seasonal bag limits, mandatory release of large salmon, and tagging retained fish to permit identification of poached salmon. By the mid 1990s, catch-and-release policies applied to all salmon caught in many areas, and a complete ban on salmon angling was imposed in other areas.

Listing

The presence of stringent conservation policies throughout the salmon's remaining range attests to the seriousness of the salmon's situation. Currently, populations in two areas are candidates for endangered species listing: the Down East region of Maine and the Bay of Fundy in Canada.

Maine

In New England, anadromous runs to once prolific salmon rivers such as the Connecticut, Pawcatuck, and Merrimack were extirpated in the 1800s. Current runs result from restocking with hatchery fish and thus are not eligible for listing, although they are low. Despite hatchery stockings of rivers, it is possible that some remaining salmon rivers and their tributaries still contain evolutionarily unique strains of salmon. Several lower tributaries of the Kennebec and Penobscot Rivers are suspected to contain unique salmon strains. Even the main stem of the Penobscot, despite the hatchery stocking of nonnative salmon, may also contain salmon with historical genetic lineage intact. More testing, however, is required to confirm this suspicion.

There are, however, eight rivers in Maine from the lower Kennebec River to the Canadian border, whose salmon have been determined to be wild and genetically distinct enough to qualify for listing (Figure 2). They are the Dennys, East Machias, Machias, Narraguagus, Pleasant, Cove Brook (a tributary of the Penobscot), Ducktrap, and Sheepscot.

A relatively new environmental group, Restore the North Woods, and two other groups petitioned the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) to list Atlantic salmon as endangered under the 1973 Endangered Species Act (ESA). In 1995 the FWS and NMFS jointly conducted a review that concluded that Distinct Population Segments (DPS) of the species, as defined in the ESA, were in danger of extinction. A subsequent listing under ESA would place stringent controls on the several industries, including angling, whose activities could negatively impact the salmon's health.

The State of Maine countered by developing a recovery plan through an Atlantic Salmon Task Force. The Task Force consisted of representatives from agriculture, aquaculture, forestry, recreational fishing, the University of Maine, and the Penobscot First Nation. The plan was ambitious. It called for stream management and habitat improvement in both tidal and uplands sections of the rivers. Aquaculture, agriculture and forest management were charged with ensuring adherence to management practices designed to have minimum ecological impact upon Atlantic salmon. The plan was sufficiently impressive to persuade the FWS and NMFS to accept the state's management plan in lieu of proposed protection under the ESA as a threatened DPS for Maine salmon in seven rivers, with the eighth added later.

Early in 1999 a public hearing was held to consider progress over the past two years on the state's conservation plan. This formed the basis for a required progress report to the FWS and NMFS. Critics, including the Atlantic Salmon Federation, which was represented on the Task Force, concluded that while the conservation plan was a good blueprint for recovery, it was not meeting its objectives. Criticism focussed on inadequate funding by the state, and unsatisfactory implementation of several key elements of the plan, in particular measures to minimize potential adverse affect from the blueberry and aquaculture industries. ASF and Trout Unlimited (TU) decided to take drastic action. In August 1999, both jointly filed a lawsuit in Washington, D.C., to force the federal government immediately to protect Maine's Atlantic salmon under the ESA.

In October 1999, the FWS and NMFS issued an exhaustive 225-page biological status review report that agreed the recovery plan was flawed (FWS 1999 [a]). Like ASF and TU, it expressed serious concern that potential negative impacts of commercial aquaculture were not being adequately addressed. The report concluded by reiterating the Services' 1995 observation that the Atlantic salmon in the rivers eligible for listing were in danger of extinction. Actually, the salmon themselves told the story. In 1995 as many as 500 salmon were estimated to have returned to the eight rivers in question. By 1999, this had plummeted to less than 50.

On November 17, 1999, the Department of Interior formally announced in the Federal Register its intention to list salmon in the eight rivers as endangered, an upgrade from its earlier proposal for a threatened classification (FWS 1999 [b]). Governor King of Maine expressed strong opposition to the proposal. The FWS and NMFS are required to hold public hearings on the issue (scheduled for January, 2000), and subject the announcement to a 90-day comment period before a final decision can be made. If the Services decide to list the DPS salmon as endangered as expected, however, the ESA requires the Services to develop a recovery plan with all stakeholders involved. This listing process could take another 12 to 18 months to complete. This lengthy timeline was unacceptable to ASF and TU. The jointly-filed lawsuit to force an emergency listing, which would require a much shorter process, is still in progress.

Bay of Fundy

Atlantic salmon in the Bay of Fundy, like their counterparts in the contiguous marine ecosystem of the Gulf of Maine, are also showing signs of extreme ecological stress (Amiro 1999). Within the Bay of Fundy there are two distinct groups of Atlantic salmon. The first group are from rivers ranging from the Saint John River westward to the Saint Croix River, the international border between Maine and New Brunswick. This area is known as the Outer Bay of Fundy rivers which contain a mix of 1SW and 2SW salmon which migrate to the North Atlantic Ocean, as far north as west Greenland for 2SW salmon. The salmon populations in these rivers are not in good health.

It is the second group of salmon in the Inner Bay of Fundy (IBOF) rivers—the 33 rivers extending clock-

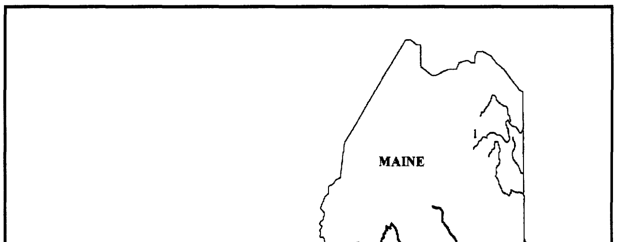

Figure 2. New England Atlantic salmon rivers highlighting eight in Maine (bold print and caps) whose salmon runs are proposed for ESA listing as Endangered (adapted from FWS 1999 [a]).

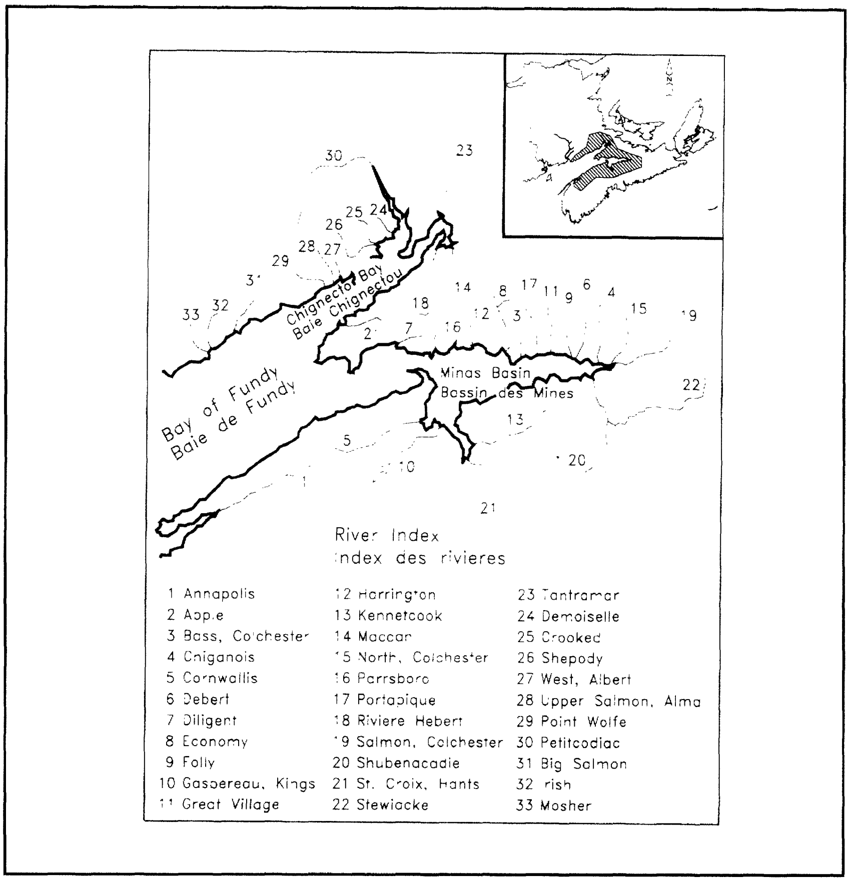

Figure 3. Map showing the Inner Bay of Fundy Rivers whose salmon runs may be listed as endangered.

wise from, but not including, the Saint John River in New Brunswick to the Annapolis River in Nova Scotia—that are being targeted for listing as endangered under Canada's Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Figure 3). The basis for concern is plain enough (Kenchington 1999). As recently as the mid 1980s, salmon runs in the IOBF rivers were as high as 40,000. The subsequent decline in salmon runs was so drastic that all fishing in IOBF rivers was banned after 1990. **By 1999 only a few hundred salmon returned, a decline of more than 99 percent in fifteen years.** As in the U.S., an essential factor supporting listing is a unique genetic make up of the population. Results from allozyme, microsatellite and mitochondrial DNA testing show that IOBF salmon have a distinct evolutionary lineage making them separate from other North American populations, including the Outer Bay of Fundy rivers.

Similar to the situation in the U.S., interactions among wild salmon and escaped farmed salmon from the Canadian Bay of Fundy aquaculture industry were an issue. Here, however, the magnitude of the interactions, and potential impacts, were clearer because of scientific research programs which had documented the number of wild fish, and escaped farmed fish, entering and spawning in rivers (Carr et al. 1997).

In October 1999, the Department of Fisheries Oceans submitted a recommendation to COSEWIC that Atlantic salmon in the IBOF rivers be listed as endangered. Federally, Canada, however, has no formal endangered species statute legislation at this time. COWESIC, while funded in part by government, has no mandate, much less regulatory ability, to force corrective action to be taken. In contrast, some provinces do. New Brunswick has had an Endangered Species Act since 1974 (revised in 1996). Nova Scotia enacted its first endangered species legislation in 1998. Rarely in Canada, however, have the powers in provincial statutes been invoked to rescue endangered species. This may change soon.

Since 1996, Canada's Wildlife Ministers have been considering the establishment of federal endangered species legislation. Previous attempts to enact legislation died in Parliament. A new accord was finally reached in 1999 for the establishment of a Species at Risk Act (SARA). It is expected to be brought before Parliament early in February, 2000. It is assumed that it will contain regulatory powers that will place it in the same league as ESA in the U.S. ASF has urged the Minister of Canada's Environment Department to place the IBOF Atlantic salmon stocks on the national strategic priority list for endangered species under SARA at its first reading.

Meanwhile, a special measure to save the IBOF salmon runs is underway. Wild parr from three-year classes—1996, 1997, and 1998—were collected from the Big Salmon River in New Brunswick and the Stewiake River in Nova Scotia, for hatchery rearing. They will be cultured to the adult stage as broodstock, with the first batch of eggs expected in 2000. The purpose of this live gene-bank program is to preserve the genome of the IBOF rivers. Only two of the 33 IBOF rivers are involved in the program, but it is a start. These fish are so valuable that they likely will be cultured throughout their development stages in a freshwater hatchery to prevent contagion from marine-borne diseases so difficult to protect against in a sea-cage setting, even with use of vaccines.

Understanding the problem

Commercial fishing

It was widely accepted in Canada that

wild Atlantic salmon stocks would recover naturally. This assumption drove the often unpopular, conservation-oriented fishery regulations imposed by government. An important source of support for the lifting of the commercial nets was ASF's advocacy efforts. Additionally, the Canadian salmon aquaculture industry provided fresh salmon year-round, keeping the price of wild salmon from escalating in times of scarcity. The industry's success made it financially feasible for the provincial and federal governments in Canada to buy out commercial fishermen at a cost of more than $70 million (Cdn). A significant rebound was predicted to occur after the closure of the entire insular Newfoundland fishery in 1992. Not only did this not happen (Figure 1), but the downward spiral continued, although probably not as drastically as would have been the case if the regulatory measures had not been introduced. The question is why?

There is some evidence that the principal problems are not in the freshwater development stage (Hawkins 1999). Smolt production as a function of spawning escapement has remained reasonably constant where this has been measured. This does not mean that improvements in the quality of the freshwater habitat are impossible or unnecessary; it simply means that barring further evidence the cause for the observed increase in mortality lies, by default, in the marine phase.

Other anthropogenic causes

Overfishing, particularly by the commercial fisheries, has been a major cause for the salmon's population decline over the last few decades. But regulations governing harvesting, and stock- and habitat-improvement programs, have not covered all the possible anthropogenic causes.

First, industrial fisheries threaten salmon's food source. More than 90 percent of the salmon's diet during its marine phase is fish, mostly pelagic, of which a large fraction is represented by "forage fish," so called because they are at the bottom of the food chain (Hislop and Shelton 1993). Two species, capelin *(Mallotus villosus)* and sandeels *(Ammodytidae)*, have come in for special attention. They form the basis of "industrial fisheries" for the production of fishmeal, and oil, used for, among other things, fuel in power plants. It is possible these industrial fisheries adversely affect survival of salmon postsmolts by significantly reducing their food source, but hard evidence is lacking. Testing such a hypothesis is difficult because there are many potential prey species for the salmon in the ocean, and the hypothesis has to deal with biological logic. Salmon are opportunistic feeders, so that should the abundance of a prey species decrease, for whatever reason, salmon would naturally turn to another food source. Whether these alternate prey are abundant enough, and at the right place at the right time to meet the needs of the salmon, are open questions.

Another possible anthropogenic, and unconventional, cause for salmon's increased marine mortality has recently been proposed (Fairchild 1999). Nonylphenols are a class of chemicals that have estrogen-mimicking effects on animals, hence the popular name "endocrine disrupter." A second look at data from the 1970s and 1980s suggests that exposure of Atlantic salmon juveniles to minute quantities of nonylphenol, used in an insecticide sprayed to control a forest pest in New Brunswick, resulted in poor marine survival of postsmolts from the Miramichi River. Because of its suspected effect on salmon, the formulation of the insecticide has since been changed to remove the nonylphenol. Nevertheless, this chemical is a popular surfactant added to detergents to lower surface tension and, therefore, must be in most waterways receiving domestic and industrial effluents. Thus, this unexpected insecticide story may have opened a whole new line of investigation.

Natural causes

Fluctuations in abundance of all living things are, of course, a natural norm. It is plausible that natural forces account for what has been happening to Atlantic salmon during its marine phase. A popular hypothesis centers on seal predation. In the Northwest Atlantic there are six species of seals, of which the Harp seal *(Phoca groenlandica)* is by far the most numerous.

The Harp seal, as are all seals, is a prodigious and opportunistic eater of fish. The likelihood of a seal encountering salmon in the sea, as opposed to other species, notably cod, is statistically remote. Therefore, seals are unlikely to pose a serious threat to salmon populations in the ocean. Analyses of thousands of seal stomachs confirms this assertion: salmon are found in the stomach with a frequency less than 1 in 10,000 (Beck and Hammill 1993). Seals may still affect salmon population, however, by eating large numbers of the salmon's food source, in particular capelin.

Disease is another possible natural cause of a decrease in marine survival. In the late 1960s, a disease decimated salmon populations in Ireland. *Columnaris,* a myxobacterium species carried up rivers by returning adult salmon, was involved but the etiology was never fully understood (Brown 1966). The disease gradually disappeared, and has not returned since. Recently a virus causing infectious salmon anemia (ISA), which has been a scourge to Atlantic salmon aquaculture operations on both sides of the North Atlantic, was found in wild salmon in Canada and Scotland. The Davis Strait area off west Greenland is a common feeding ground for 2SW Atlantic salmon from North America and much of Europe. At the time of writing planning is underway to include tissue samples for ISA testing in an international program monitoring salmon caught in the Greenland subsistence fishery.

Another possible explanation invokes a major climatic event affecting the marine environment. Two environmental factors, temperature and salinity, are prime candidates as provocative agents in oceanographic perturbations affecting the life history of Atlantic salmon...as well, undoubtedly, as other species. The problem for investigators has been trying to obtain enough data over such a vast expanse as the North Atlantic, and on a timely basis. Research vessels, and ships of opportunity, can sample only a small fraction of the ocean, and even then over relatively long time periods. Satellites, however, can cover huge areas, providing data to researchers continuously. They provide some hope for unraveling the Gordian knot as to what is happening to salmon in the sea.

Seldom does the environment itself directly kill organisms capable of movement, but variations in climatological factors, such as temperature, could nonetheless indirectly affect the ability of an animal to survive. About 80 percent of Atlantic salmon in the sea occur within temperature bounds of 4°-11°C (Reddin and Friedland 1993). The location and size of areas with the "preferred" marine temperature for salmon has been shown by sea-surface temperature satellite data to vary among seasons annually, and among years. Such variability could affect such things as migration routes, and the distribution of food resources and/or predators. Farming can be used as an analogy. As the number of cows that can be raised in a field is a function of the size of the fenced-in field used for grazing, so in nature the number of salmon that can be grown in the ocean depends on the size of the "grazing grounds" as determined by thermal boundaries.

These large-scale variations in temperature are thought to be driven by the so-called North Atlantic Oscillation (NAO), caused by atmospheric pressure differences between a low near Iceland, produced by westerly winds moving counter-clockwise, and a high near the Azores, produced by westerly winds moving clockwise. Physical oceanographers are attracted by the idea that one of their icons, NAO, may be playing an important role in the life of Atlantic salmon. Biologists are interested in satellite data because it allows them to test the hypothesis that the size and location of preferred habitat in the North Atlantic for Atlantic salmon are key determinants in the salmon's marine survival.

Figure 4. Atlantic salmon (*Salmo salar*), courtesy of Atlantic Salmon Federation.

Information gaps

The analogy has often been used that there are black holes in the ocean into which salmon disappear. It would help enormously in our understanding of the salmon's marine life if we had some idea where these black holes are (i.e. where and when the unexplained mortality is occurring). Recent advances in tracking technology hold promise for identifying the black holes. Miniature electronic sonic transmitters with unique codes, surgically implanted in the peritoneal cavity of salmon smolts, have recently undergone a major improvement in performance. Previously these transmitters allowed the tracking of seaward migrating smolts in rivers, but never far past the estuary into the open ocean. New transmitters have been developed with a life span of two or more months.

Also, newly improved automated receivers suspended in the water column from surface buoys can detect a tagged salmon within a half-mile range. Tagged smolt were released in 1999 from the Big Salmon River in New Brunswick and were successfully tracked across the Bay of Fundy a distance of 26 miles (Lee 1999). This is the longest by far for small fish in the open ocean.

Plans now call for a large-scale monitoring of post-smolt movement through the Bay of Fundy and perhaps out into the Gulf of Maine using the receivers in strategically deployed detection barriers. Tracking itself will not likely reveal why mortality occurs, but it should indicate where and when it occurs. Knowing the "scene of the crime" should then allow different questions to be asked directed at the cause of mortality. This advanced telemetry will also allow investigations on the effect on smolt in the sea of certain pre-smolt treatments, such as exposure to the endocrine disrupter, 4-Nonylphenol.

Conclusions

While the Atlantic salmon's current trouble appears to manifest itself during its marine phase—which does not preclude initiation of causal events in the freshwater phase—it is unlikely there is a single cause-and-effect vector at play. Some investigators point out that since the late 19th century, when reasonably accurate fishery and physical oceanographic records began to be kept, there is evidence that oscillations in abundance of Atlantic salmon were matched by oscillations in large-scale oceanographic data, in particular temperature (Dunbar 1993). If naturally occurring oceanographic perturbations are in any way involved in the present condition of salmon, the bad news is that not much can be done about it. There is good news, however, in the thought that cyclical oscillations imply peaks and valleys, and perhaps an upturn in the ecosystem favoring salmon is next. But this time nature may not be able to do it on her own. Every effort needs to be taken to ensure that endangered populations of Atlantic salmon do not become extinct because of a failure to take corrective action.

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Book Review

The Tanagers. Natural History, Distribution, and Identification.
By Morton L. Isler and Phyllis R. Isler. 1999, 2nd Edition, Smithsonian Institution Press, Washington, D.C., 406 p.

The Islers have have updated their landmark 1987 collection with a new paperback edition, *The Tanagers. Natural History, Distribution, and Identification.* Due to the rapid growth of available Neotropical avian research and knowledge, the Islers must have faced a difficult choice with the re-publication of *The Tanagers*: publish it as is while focusing on their own research or rewrite large sections of the book to incorporate this new work, a task on par with writing the original text.

They opted for the faster and simpler alternative with the addition of a summary of research published since 1987. While continuing to accumulate information and providing these references is laudable, the failure to incorporate new literature into species accounts for the new edition was disappointing. Nonetheless, this does add to what reviewers of the hardback version noted as a strength of the book, an extensive literature cited section especially for natural history information (B. 1988; Valburg 1988; Wiedenfeld 1988). The book also maintains one weakness noted previously, illustrations often lack the vibrancy in color that these birds show in actual plumage. As Valburg (1988) noted, however, the plates do have an artistic flair that adds an aesthetic quality without sacrificing accuracy and detail important for identification. Also, printing problems noted in the first edition (Wiedenfield 1988) seem to have been corrected in the new paperback edition.

Of the areas that the Islers set out to cover—natural history, distribution, and identification—the latter is probably the weakest. The book relies on plates and plumage character descriptions to aid in identification but each species account lacks a section discussing how to distinguish potentially confusing similar species. Distribution information is thorough and range maps detailed though lacking place names (Wiedenfeld 1988). For northern migratory species, however, the authors do not extend distribution or breeding range maps north of the Mexico border. This exclusion of information available in popular United States field guides is a common problem in neotropical field guides. This is only a minor problem for Tanagers because only a few breed or have ranges in northern North America. Nevertheless, it does diminish the completeness of this taxon specific book. While researchers from the north surely have additional references available at only a minor inconvenience, this may be a greater problem in areas with limited resources.

Since Storer (1969) pointed out the taxonomic complications within Tanagers and called for more research and the reanalysis of this group, much has been done in the arena of natural history and behavior. That long sought after reanalysis, however, is not present in this book, despite a thorough synthesis of life history and distribution data based on the older taxonomy (Storer 1970). Perhaps it is too early to reorganize Tanager taxonomy, but the picture should be coming into focus. This book provides a comprehensive summary of the state of current research, unfortunately future research needs and conservation status are not laid out based on the authors' extensive experience.

Despite (1) an eloquent plea by Parker for students of neotropical birds to broaden their interests to include conservation and (2) the stated objective to ultimately aid in the conservation of this group, the authors do not expressly address Tanager conservation. The distribution maps give an idea of range limitation and suggest the vulnerability of some species but more explicit mention, where possible, of population size, conservation status, and possible threats would have been an important first step toward achieving this objective.

This book is another contribution in a growing series of taxon specific books (usually at the family level) that are a hybrid between field guide and monograph, and as such, should be a welcome and well-used addition to the bookshelf of any serious neotropical birder or ornithologist.

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Tom Dietsch

News from Zoos

Puerto Rican Crested Toad Tadpoles Released Into the Wild

Thousands of Puerto Rican crested toad tadpoles raised in U.S. zoos were recently released in Guanaco State Forest, Puerto Rico. The Buffalo, Sedgwick County, Toledo, and Toronto zoos successfully reproduced the toads with aid of an injected hormone (luteinizing hormone, or LH). The breedings were synchronized among the institutions so the tadpoles would all be approximately the same age. It was critical for the toads to be released while still tadpoles so that they could imprint on their "natal" pond and return to breed as adults.

Once thought to be extinct in the wild, the Puerto Rican crested toad (*Peltophryne lemur*), was rediscovered in 1967. Its decline is a result of human encroachment, commercial development, and introduction of exotic species such as marine toads and mongooses. No more than 300 animals have been located in the wild in recent years. Approximately 200 are now maintained in AZA-accredited zoos throughout North America.

Two "Zoo Schools" Win National Awards

In October, the Lincoln Public Schools' "Zoo School" at the Folsom Children's Zoo, Lincoln, Nebraska, gained national recognition when the school's team of four teachers was selected for USA Today's 1999 All-USA Academic Teacher Team. The Zoo School—officially known as the LPS Science Focus Program—is an alternative high school program located at the Folsom Children's Zoo and is attended by approximately 65 students from all four Lincoln public high schools.

Also in October, the School of Environmental Studies (SES) at the Minnesota Zoo was selected as a New American High School by the U.S Department of Education and the National Association of Secondary School Principals. The New American High Schools initiative showcases schools that are on the leading edge of reform, combining high expectations and a commitment to rigorous academics with innovative instructional techniques, integrated technology, tailored professional development, community service and work-based learning experiences, and community-based partnerships to increase student achievement and performance.

Bushmeat Crisis Task Force Hires Coordinator

The Bushmeat Crisis Task Force (BCTF) hired Heather Eves as the BCTF coordinator. Ms. Eves studied the bushmeat issue in Africa for her doctoral work at Yale, and is one of the originators of the Sangha River Network—a professional research network for the Sangha River region of Central African Republic, Cameroon, and Republic of Congo.

The BCTF was created after a meeting of 34 experts from 28 organizations and agencies was held in February at the American Zoo and Aquarium Association in Silver Spring, MD. The meeting participants represented zoological parks, major conservation organizations, animal protection groups, and the bio-medical research community. The bushmeat trade is described as the illegal commercial sale of threatened and endangered species for human consumption. Gorillas, chimpanzees and other species of primates, as well as elephants and antelopes, are among the animals killed and sold for their meat in the markets of equatorial Africa.

Poll Finds That Public Underestimates Their Damage to Oceans

A recent poll commissioned by the Ocean Project finds that the American public is largely unaware of their impact on the health of the oceans. The Ocean Project, a consortium of AZA aquariums and zoos, and natural history museums, commissioned the poll to measure the public's knowledge and attitudes about the ocean. While 92% of those surveyed considered the oceans essential to human survival, only 14% recognized that individuals, rather than industries, posed the biggest threat to ocean survival. The majority of ocean pollution is caused by contaminated runoff from yards, parking lots, and roads, and an estimated 15 times more oil than the Exxon Valdez spill finds its way into the sea annually from street runoff and individual dumping into municipal storm drains.

Nearly 50 institutions participate in The Ocean Project, whose mission is to build public awareness of the importance, value, and sensitivity of the oceans. As a first step, the project has launched a web site (www.theoceanproject.org) to connect people with a wide range of ocean information. Other plans are for development of programs and exhibits at aquariums, zoos, and museums, educational films and materials for teachers, and more.

Information for News from Zoos *is provided by the American Zoo and Aquarium Association.*

News & Events

Annual Meeting of the Society for Conservation Biology

The annual meeting of the Society for Conservation Biology will be held June 9-12, 2000, at the University of Montana (Missoula). The meeting's theme is "Large-Scale Conservation: Genes, Landscapes, and People." The keynote addresses will be given by Dan Simberloff and Michael Soulé. In addition to activities on the campus, field trips will be offered through the Montana Natural History Center, an educational nonprofit organization based at the university. For more information, please contact Fred Allendorf (darwin@selway.umt.edu) or Dan Pletscher (pletsch@forestry.umt.edu), or visit the event's website at http://www.umt.edu/scb2000.

Redwood Conservation Account

Save-the-Redwood League's master plan for old-growth redwood conservation recently was supplemented by a new book released by Island Press. Reed Noss's *The Redwood Forest: History, Ecology, and the Conservation of the Coast Redwoods* bring's together a comprehensive account of the redwood ecosystem. Leading experts authored articles on topics from aquatic ecosystems to landscape-scale conservation planning. For more information, contact Robbie Kaplan (tel.: 202/232-7933, email: rkaplan@islandpress.org) or www.islandpress.org.

Baltimore Zoo Breeds Endangered Tortoise, Again

This past summer, the Baltimore Zoo became the first zoo in the world to breed Egyptian tortoises (*Testudo kleinmanni*) more than once. Seven tortoises were hatched in 1999, bringing the total number of tortoises hatched since 1994 to 35. For more information, please contact Andrea Keller at the Baltimore Zoo (tel.: 410.396/6620).

Overview of Invasive Species Phenomenon Published

Often described as an ecological assault, numerous alien species threaten native fauna and flora. George Cox's *Alien Species in North America and Hawaii* represents the first assessment and synthesis of this phenomenon in North American and Hawaiian ecosystems. Issues of exotic species dispersal, invasion patterns, and public policy are discussed. For more information, contact Benjamin Churchill (tel.: 202/232-7933, email bchurchill@islandpress.org).

Announcements for the Bulletin Board are welcomed.

Endangered Species UPDATE

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