Endangered Species UPDATE

May/June 2001
Vol. 18 No. 3
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School of Natural Resources and Environment
THE UNIVERSITY OF MICHIGAN

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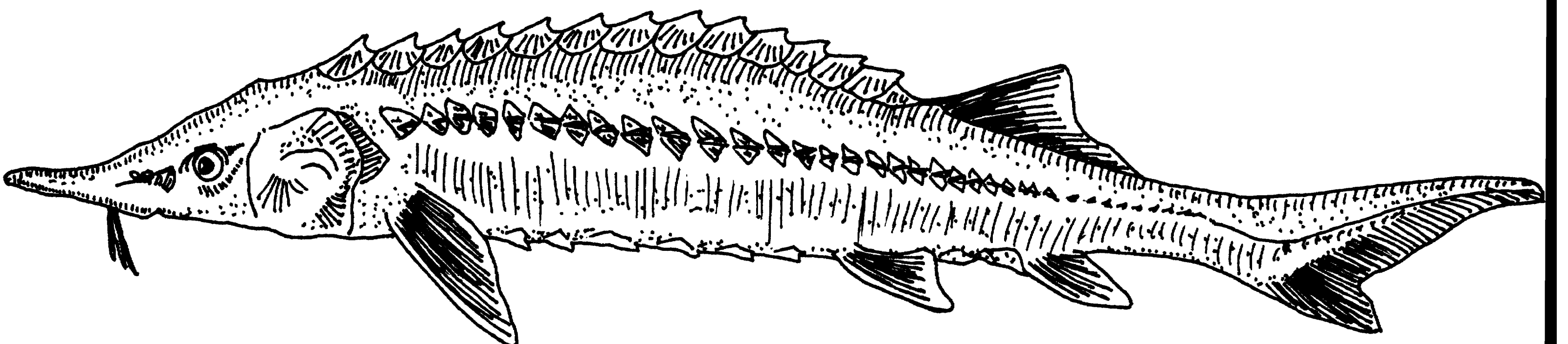


Insert: May/June 2000 U.S. Fish and Wildlife
Service Endangered Species Bulletin

Letter to the Editor

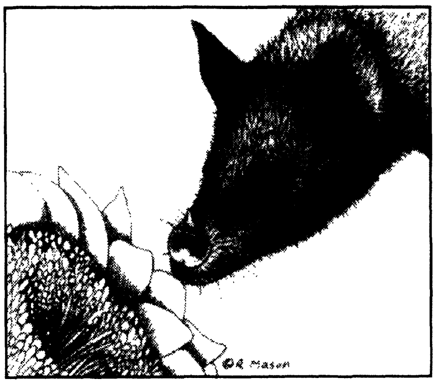
I'm encouraged that the student from Brazil was interested in the *Endangered Species UPDATE*, but I'm extremely upset by part of your response to his letter about felids in the recent issue (Vol. 18, No.1 2001). You stated that felids control pests such as "various rodents and bats." I am disappointed that you would foster widespread misconceptions about bats being pests, especially to a country where human fear and subsequent elimination of important bat species is a serious problem. Bats are essential pollinators and seed distributors of many plant species, commercial and otherwise, especially in biologically diverse areas such as the Amazon Basin. Bats also help to control "pests" such as many insect species that spread disease. True, there are vampire bat species, but most of these feed on native animals or livestock, and rarely pose a threat to people. Additionally, rabies is also rare in bats, being found more often in terrestrial mammals such as canids and rodents! I hope that you inform your readers of the benefits of bats, and encourage articles about the many endangered bat species in the U.S. and around the world. Please refer to the Bat Conservation International website www.batcon.org for more information.

Sincerely,
J Thayer
University of California, Davis; Point Reyes Bird Observatory

Editor's response

Thank you for your comment—I agree completely! Responses to such questions are researched and written by undergraduate students through a program with the University of Michigan. Unfortunately, the editors did not catch that slip. Thank you for pointing it out.

FOCUS ON NATURE™ *by Rochelle Mason*



The **LESSER LONG-NOSED BAT** (*Leptonycteris curasoae*) is a leaf-nosed, medium-sized "microbat" measuring 2.75 to 3 inches in length. Roosting in caves and mines during the day, this valuable pollinator sips nectar at night mainly from agave and saguaro cactus flowers while hovering like a hummingbird. Pollen groomed from its face and body is ingested and converted into amino acids thus providing protein in the bat's diet. It forages in desert regions of southern Arizona and extreme southwestern New Mexico during the warmer months and spends the rest of the year in Mexico. This endangered bat and its feeding and roosting habitats can be better protected by a donation of your time or money to an international nature conservation organization. © *1999-2000 by endangered species artist Rochelle Mason. www.rmasonfinearts.com (808) 985-7311*

Endangered Species UPDATE

A forum for information exchange on endangered species issues
May/June 2001 Vol. 18 No. 3

Instructions for Authors: The *Endangered Species UPDATE* welcomes articles, editorial comments, and announcements related to species protection. For further information contact the editor.

Subscription Information: The *Endangered Species UPDATE* is published six times per year by the School of Natural Resources and Environment at The University of Michigan. Annual rates are $28 for regular subscriptions, and $23 for students and senior citizens (add $5 for postage outside the US). Send check or money order (payable to The University of Michigan) to:

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Cover: Line drawing of Kootenai White River sturgeon (*Acipenser transmontanus*) by Meggan Laxalt, U.S. Fish and Wildlife Service

The *Endangered Species UPDATE* was made possible in part by the David and Lucile Packard Foundation, Turner Foundation, Boone and Crockett Club, Chevron Corporation, and the U.S. FWS Division of Endangered Species Region 3.

printed on recycled paper

Forgotten Elements: Including Structure and Process in Recovery Efforts

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Abstract
Survival of endangered species requires both the best science can offer and *the best human collaboration possible. The focus is often on the former while the latter may be neglected. The authors interviewed coordinators of U.S. endangered species recovery programs involving captive breeding concerning the human dimensions of their programs. The findings show some weaknesses in the use of organizational structures, group processes, leadership and teamwork skills, recognition, and intra and inter-organizational mechanisms to support these programs. The paper presents data from the interviews and discusses these behavioral science concepts. The respondents value the collaborative programs and want more, not less, interaction in the future. They, however, also need help in improving their skills in these 'soft' areas.*

Introduction

Many species faced with extinction depend on conservation collaborations in which *in situ* and *ex situ* efforts are linked. This means that people from different organizations and very different educational and cultural backgrounds are involved, assisting in a complex effort. For example, the US Fish and Wildlife Service (FWS) and the American Zoo and Aquarium Association (AZA) have a collaborative partnership, which includes 11 North American and Pacific Rim programs with a Species Survival Plan (SSP). Typically, the zoo community has a coordinator who concentrates on organizing and overseeing the captive breeding of the endangered species while the FWS has a coordinator with overall responsibility for the effort, but with a focus on reintroduction and preservation and expansion of critical habitat.

In theory, the perfect species recovery program should set clear objectives, based on the best available scientific information, develop and implement an Action Plan that is feasible, and reach its goals in a timely cost-effective manner. In practice the "human dimension" (Jacobson and McDuff 1998) creeps into all our activities and often has a negative impact on our ability to define and achieve our conservation goals. Thus, recovery programs for endangered species and habitats may have the best scientific input available, but be unable to effect the change necessary to save the species or the habitat.

The human dimension includes many levels. First is individual behavior, e.g., the leadership skills of a designated coordinator, or the personal agendas and style of particular individuals, that may result in blocked action. Second, a lack of interpersonal skills such as listening and communicating may have a profound impact on progress in a program. At the group level, teamwork—or the lack of it—may facilitate or impede activities related to creating or implementing a recovery plan. This level not only includes interpersonal interactions, but also group decision-making, conflict management, and commitment to the team process. Further, there is an inter-group phenomenon both within and outside a group involved in a species recovery, since many different organizations and stakeholder interests will be represented (Ritvo et al. 1995). The organizational cultures (values, mandates, operating procedures and underlying assumptions) from which team members originate will certainly differ, thus complicating the design and execution of joint activities (Schein 1985). In practice, all of these become the "forgotten elements."

We can, however, reduce the negative impact of the "human dimension" by paying more attention to how recovery programs are structured and the processes used as stakeholders carry out their various activities. We can view the structure as if it were an architectural plan or blueprint—the design of the effort. In this sense structure includes the design of the organization, peoples' roles/functions, including the leadership roles, and the interactions required between and among these roles. Committees and their meeting schedules are part of the structure. Guidelines for how minutes will be kept and distributed are part of the structure. Structure has acquired a somewhat negative reputation in our recognition of the importance of participation, but this can be like the old "throwing the baby out with the bath-water."

"True 'freedom' is not the absence of structure—letting the employees go off and do whatever they want—but rather a clear structure which enables people to work within established boundaries in an autonomous and creative way. From the beginning, the ground rules and boundary conditions under which the people are working should be established: what can they decide, what can't they decide? Without structure, groups often flounder unproductively, and the members then conclude they are merely wasting their time" (Kanter 1983).

Structure provides the framework within which we act and the guidance for how to proceed. It sets boundaries for individual and group behavior and limits the degree to which a single personality or agency can control the process or outcome of the group effort. It is like an envelope that contains our actions, and helps to maintain us on a steady course. For a case study of a successful organizational intervention focused on building structures see Moosbruker (1983).

Structure includes agreements and other written documents defining how the various agencies and organizations will interact, e.g. a Memorandum of Understanding (MOU), Cooperative Agreement, and guidelines for the Recovery Teams, including clear definitions of the individual and institutional roles. Another element of the structure *could* be written criteria for evaluating short-term and long-term progress and for measuring success, that are transparent, consistent and communicated to all stakeholders.

Process summarizes *how* the group does its work, how individual members interact, how participants communicate, how decisions are made, as distinct from the content or *what* of the interactions (Schein 1988). The process to be used, for example, in decision-making, can be specified, but how it is carried out is as much art as science. Groups composed of participants from diverse organizational cultures may be especially complex because the interests of the varied agencies may be dissimilar. The leadership style of the group's head is especially critical to its functioning, because, generally, groups go through stages of development from the time of their formation, behave differently at different developmental stages, and usually need help to reach high performance. A leader needs to be sensitive to and adjust his/her behavior during these different stages (Moosbruker 1988).

Method

Using a standardized format, the two authors interviewed 22 FWS and AZA SSP coordinators and other key personnel, e.g., team leaders from the field, by phone. First we calibrated our styles by listening to each other interview and discussing any discrepancies.

We conducted the interviews by telephone because the respondents are scattered throughout North America and the Pacific Rim, making face-to-face contact much too costly. We promised confidentiality to enhance the openness and completeness of the responses. Each interview took between one and two hours, depending on how much the respondent wanted to elaborate. We did not cut people off, but tried to redirect to the questions in our standardized format.

Topics covered in the interviews included:

- structure of the over-all recovery effort;
- processes in use at the small group level;
- role of the leaders and important leadership qualities;
- where the interviewees felt they could use process help/knowledge;
- extent of evaluation and recognition of their work;
- perceived role of each organization in the recovery effort;
- difficulties each group encounters in carrying out their roles;
- degree to which coordinators believe that they are making significant progress towards recovery goals;
- what changes in activities or interactions would enhance success;
- perceived barriers to further and more collaboration, e.g., perceived differences in organizational culture between AZA and FWS.

The topics were chosen to reflect the theory presented above and based on information from the study sponsors in AZA and FWS.

Results

Structure

More use could be made of structure in these collaborative partnerships. For example, only three programs have a functional MOU or agreement that covers the FWS and SSP interactions. Only two of 11 programs have a Recovery Team of which the SSP is formally an integral part. In

Table 1. Self-ratings of overall success and program structure; ratings on a five-point scale. The Ns differ because programs with "lapsed" recovery teams, non-integrated SSPs, and pending MOUs were not included. The differentiation was "clear use of this structure" versus "clearly not using this structure." Due to small Ns, statistical analysis was not attempted.

MOU	Captive breeding	Reintroduction	Wild population	N
Yes	4.2	3.7	3.9	3
No	3.3	3.0	2.8	6

Recovery teams	Captive breeding	Reintroduction	Wild populations	N
Yes	4.5	4.0	4.0	2
No	4.0	2.8	2.0	5

some cases, Recovery Teams had lapsed or were not being used, in part because coordinators believed that the Recovery Team's major function was to write the Recovery Plan.

Just over 50% of interviewees thought that their recovery program had clear objectives; most of the remainder thought that the goals and objectives needed updating. Similarly, only 42% of respondents thought that there was a clear strategy to reach recovery goals.

The roles of the AZA SSP and FWS coordinators in the recovery effort were clear to almost all of the interviewees, with the FWS Coordinator overseeing the entire program, but emphasizing the reintroduction, habitat and field monitoring, while the AZA Coordinator focused on the captive breeding effort. The FWS Coordinator also interfaced with the FWS hierarchy, helped with regulatory issues like obtaining permits, saw that FWS implemented what is specified in the Recovery Plan, acquired land and secured funding for the program. Nearly everyone agreed that FWS is the lead agency in these programs.

Despite the fact that the Coordinators were clear about their own roles, there were only three of 11 programs in which Coordinators felt that the roles of all the different actors were clear. A typical quote from an interviewee: "It is not clear who should be told what because the structure is so confusing."

There are limited objective criteria of success or progress in these programs, except the ultimate de-listing of the species. We compared self-ratings of the teams' over-all success on a five point scale for three major activities: captive breeding, reintroduction and managing the wild population. The programs clearly using the structure of an MOU rated their success on all three dimensions higher than those not using the structure (the sample sizes are small, but the averages were consistently higher for structured programs). The same was true for programs currently utilizing a Recovery Team with an integrated SSP (Table 1).

Process

At the small group level the decision-making processes within the program were clear for about 45% of the respondents. The remainder either thought that decision-making processes were not clear, needed improvement or they did not know. About half the respondents felt that information was shared in a timely fashion. Similarly, half of the respondents thought that people were open with each other at meetings, i.e., being able to talk about it if things were not going well.

Leadership and Training

We asked the interviewees what they thought the three most important qualities of a leader were in this type of recovery program. We consolidated the responses into categories

Table 2. Perceptions of the team leader's role: What do you think are the three most important qualities of a leader in this type of recovery programs?

Quality	No. of respondents	Comments
Interpersonal skills	22	Communication, being open, honest, and listening, deals well with people
Leadership skills	15	Includes vision, initiative, seeing the big picture, strategy, clear goals, prioritize/make hard decisions, conduct meetings well, delegation
Team player	14	Inclusiveness, bring people together, facilitative skills/achieving consensus, give credit to others, build trust, demonstrate confidence in others
Commitment/ motivation	13	Agency commitment: doing the work
Scientific/technical expertise	8	
Organizational and managerial skills	6	Understanding policy, evaluating information objectively
Personal qualities	4	Humility, patience, energy

and show the data in Table 2. Only eight of 27 individuals interviewed included scientific and technical expertise in their list of the top three qualities. Working on life or death (for the species) problems brought interpersonal and team skills to the forefront.

When asked whether they could use help, i.e. training, in skills related to coordinating a recovery effort, the majority indicated that they could use help. Except for delegating tasks, 50% or more of respondents said they needed help with each of the following skills: running effective meetings, communicating all relevant information in a timely manner, having a good sense of what needs to be done when, motivating the team members to get work done, and facilitating discussions on major issues. Over 75% of respondents indicated that they could use help resolving conflicts, developing the team vs. working one-on-one, and dealing with people when they don't follow through.

This suggests that access to persons with expertise in the applied behavioral sciences, either as a facilitator or as a trainer, would be helpful to recovery efforts. The following quote reflects the feelings: "We are not given people skills as much as we could be."

Recognition and Evaluation

About 50% of interviewees felt that neither they nor their partners received sufficient recognition for their work in the recovery effort. Sixty-two percent of interviewees indicated that the recovery effort had not been evaluated, even though they personally may have received evaluations in their job. Only four interviewees indicated that their recovery effort had been recently and fully evaluated. "Nobody gets enough recognition for conservation work," was a common feeling.

In terms of progress toward recovery, on average, both FWS and AZA respondents indicated that the captive breeding programs were achieving greater success than reintroduction or field monitoring and research programs.

Organizational Differences

Most respondents believed that the zoo participants (who derived from multiple zoos) were much freer and more flexible in their ability to act. Many respondents perceived the FWS as engaging in micro-management despite a shortage of staff and funding. Also, FWS was perceived as more political than the zoos, with some species receiving more than a fair share of the funding and suffering from too many "chiefs" and politically motivated top-down decision making. Two quotes from the interviewees: "They were happy with what we achieved, but I wanted to move further forward with all parts of the program" and "FWS needs to respect their own people, to delegate authority and let people make decisions."

Overall however, respondents were very positive about the partnership and wanted to see more joint programs between the zoo community and FWS, as shown by this response: "It's been a joy to come together with this group of diverse people and work well."

Implications

Many individuals felt clearer guidelines for the interaction would help, for example, providing a master MOU template that programs could adopt and a better definition of roles and responsibilities. Also, the development and continued involvement of Recovery Teams to obtain best possible advice would benefit the recovery efforts.

Many mentioned the need for improved funding, both the amount and its distribution. A number of respondents from both organizations wanted to see more decentralization within FWS, so coordinators would have more autonomy in making the decisions within their realm of expertise. A number of respondents wanted more support and less administrative work from AZA. One respondent said: "I think the States and AZA should be given more money and responsibility in the ESA law. Or, even as it's written, FWS could provide a more active role for other organizations."

Suggestions included joint *in situ* recovery programs, job sharing, personnel exchange, joint training courses, and workshops where coordinators could share with each other what works, teach each other about how their own institutions operate, and brainstorm new ideas for improving the interaction. This "cross-cultural" knowledge could help both sides collaborate more effectively.

Respondents recommended development of procedures for ongoing internal and external review, evaluation, and strategic planning and for replacement of coordinators. In the latter case, neither partner currently had a say in the replacement of a departing coordinator, despite the fact that coordinators need to work together closely. A quote: "If they pick the wrong person for FWS Coordinator it could be a disaster. I doubt they'll ask me for advice."

Strategic questions and possible directions

Why do endangered species programs not make better use of structure and process? One possible answer is that the knowledge of just how to do this may not exist in the conservation community. Johnston's recent article (2000) suggests this may indeed be the case. The requisite knowledge is out there, but in a different field and one to which the coordinators were insufficiently exposed (Gray 1989). This seems to be true despite a valiant attempt at education through the written word (Clark and Reading 1994). The fact that reading alone is insufficient would not surprise many behavioral scientists. The use of this kind of knowledge is an art form requiring skill and practice, much like playing a sport well (Senge 1990). Experiential learning is the recommended approach, which would include presentation of concepts, discussion of the new behavior suggested by the concepts, practice of new behavior, and then getting feedback on relative success in use of the new behavior. At least the latter two components need to occur in a psychologically safe setting at first, and certainly not on stage in a multi-party arena until well practiced.

Experiential learning requires time. In a resource poor environment time is as precious as money. Although most of the coordinators said they needed help in many social science areas, the training will probably have to be taken to the people rather than attempting to bring the people to the training. Perhaps an *in situ* behavioral science intervention would be most appropriate.

Also, previous introductions of ideas about the utilization of structure and process knowledge into conservation efforts were possibly unduly critical, saying more about what was done wrong than about how to do it right (Reading and Miller 1994). Or it may have been heavily prescriptive with insufficient understanding of the practice art (Clark and Cragun 1991). If either of these situations exists, they may have created an up-hill course for the conservation community to look favorably on social science intervention. Acknowledgement can help dispel negativity, combined with a kinder, gentler approach. To quote a respondent: "Endangered species management gets very emotional. There are very dedicated people and we get a lot of bad news."

One possible direction pointed to by this study is the revision of the FWS Guidance for Recovery Programs, last revised in 1990. Perhaps awareness of the opinions of the coordinators will speed up this activity, which has been in the planning stages for several years. Support for this idea comes from interviewees: "FWS has no guidelines about the number of species any one person can manage. I have too many!" and "We could lose this species!" and "There are three people in the office and 70 endangered species to deal with."

Another action suggested by the data would be to develop criteria for success or progress on the way to delisting a species. The criteria must be valid for most or all programs and be readily acceptable to the zoo and FWS communities. Perhaps a representative group could be formed and trained in teamwork and team decision-making at the same time they develop the needed criteria. They would then form a mobile "Advisory" group or helping team available to any program that needed them. Their intervention could include both a supportive evaluation and an introduction to and support of teamwork concepts and practices. Apparently, there are too few conservation programs that have developed criteria for short-term (or long-term) evaluation of their progress and have a regular review of process and product as a measure of success (Kleiman et al. 2000)

Acknowledgements

We are very grateful for the help and sponsorship of Michael Hutchins of AZA and David Harrelson, USFWS. We are also appreciative of the time and straight talk from the 22 Coordinators and other key personnel we interviewed.

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Declining Sage Grouse in the American West: Can the Threat of Listing this Species Help Transform the Bureau of Land Management?

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Abstract
The sage grouse is a widely ranged, sparsely distributed species that lives in the vast "Sagebrush Sea" in the western US and Canada. Two sage grouse species have experienced significant declines over the past 50 to 150 years. Conservationists have identified the sage grouse as an important indicator, umbrella, and flagship species for sagebrush ecosystems, and have developed a conservation strategy centered on the bird, including the preparation of petitions to list sage grouse under the Endangered Species Act. The Bureau of Land Management manages most sage grouse habitat. Resource users fear the potential impacts of listing sage grouse—the "spotted owl of the desert"—on activities Bureau of Land Management permits on federal public lands. For the same reason, conservationists look forward to the changes listing the sage grouse might bring to agency policy and land management. There is already evidence that the threat of listing sage grouse may be contributing to an evolving conservation ethic within the agency, which may lead to improved management of public lands.

Introduction
As the national environmental conscience has grown, federal land management agencies have been forced to recognize—and even prioritize—watershed, wildlife, and recreational values over traditional resource extraction on federal public lands. For agencies that historically served commercial interests, redirecting their bureaucracy and policy to promote environmental protection and restoration is often a contentious and painful process. Usually, pressure must be applied from both outside, and to a lesser degree, inside a federal agency to impel it toward conservation goals.

The most fundamental changes in federal land management to date have been driven by species listings and resultant requirements under the Endangered Species Act (ESA) (although the Clean Water Act and the Indian Trust Doctrine also promise to be effective means to land protection). The best example may be the sweeping changes that the northern spotted owl precipitated in forest management, timber cutting, and wildlife conservation in Pacific Northwest forests managed by the US Forest Service and the Bureau of Land Management (BLM). Listing the spotted owl helped transform the Forest Service and BLM forest management branch into more conscientious managers of public lands and watersheds by requiring improved habitat planning under the National Environmental Protection Act and the National Forest Management Act. (The agencies' behavior under the second Bush Administration remains to be seen.)

Sage grouse (*Centrocercus spp.*) are poised to bring similar changes to more divisions within the BLM that manage mostly tree-free grasslands and deserts. Sage grouse live on vast stretches of BLM land in what is generally known as the "Sagebrush Sea." The mere threat of listing sage grouse under the ESA has already yielded positive results for the grouse and its habitat. More importantly, the increased attention on sage grouse conservation may be contributing to important changes within BLM as a whole, and specifically in their management priorities.

Sage grouse declines
Settlement of the West exacted a heavy toll on sagebrush habitat, and in turn, sage grouse populations that declined in the face of human development. Over the past 200 years sagebrush habitat has been fragmented, damaged, and destroyed by a plethora of human activities. These activities include livestock grazing; agricultural and urban conversion (including suburbanization and "ex-urbanization," or the establishment of new communities far outside of existing urban areas); invasive species (especially cheatgrass); herbicides and pesticide application; altered fire regimes; oil and gas development; off-road vehicle use; and the place-

ment and construction of utility corridors, roads, and fences. The BLM estimates that 220 million acres of sagebrush country have been reduced to 150 million acres of mostly degraded habitat across the west (BLM 2000).

As early as 1916 observers were concerned about sage grouse becoming extinct. Before the effects of habitat degradation were well known, William Hornaday (1916) blamed sage grouse population declines on liberal hunting seasons and automobiles that sped hunters along high desert roads into the heart of sage grouse country. At this time, the species began to disappear from the periphery of its range. In the early twentieth century, Ober (1920) noted, "The sage hen is one of our grandest game birds, a bird that should be carefully guarded to prevent extinction...about twenty years ago when the sage hens made their homes in Long Valley, which is in the south end of Mono County and just northwest of Inyo County's north boundary line. At that time it was considered mere play for the cowboys to dash with their horses into a large flock of sage hens, one thousand or more, and strike down two or three with their quirts or cow whips before the birds could possibly get out of the way...Of the thousands which a few years ago inhabited our plateaus, now only a few scattered hundreds remain."

Western states attempted to reverse the population decline by banning sage grouse hunting, often for many years at a time. Yet, except for a short time in the 1950s (not coincidently the golden years for federal predator control programs), sage grouse populations have continued to decline. Since 1980 the sage grouse population has been reduced by an estimated 35 to 80% (Braun 1999). Sage grouse no longer occur in Arizona, British Columbia, Kansas, Nebraska, New Mexico, and Oklahoma (Braun 1999). The present size of the breeding population is estimated at 140,000 individuals scattered in two Canadian provinces and eleven western states (Braun 1999).

Sage grouse as focal species

Conservationists recognize that focal species—indicator, umbrella, flagship, and keystone species—are more likely than others to drive ecosystem protection by forcing agencies to practice better habitat management (Miller et al. 1999). Sage grouse meet the definition of three of the four types of focal species. Due to their dependence on healthy sagebrush habitat, sage grouse are one of few definitive *indicator species* for the sagebrush steppe ecosystem. Because they require vast areas of habitat to survive, sage grouse are also *umbrella species*; conserving and restoring sage grouse habitat will benefit other sagebrush obligate species such as the sagebrush vole (*Lagurus curtatus*), sage sparrow (*Amphispiza belli*), sagebrush lizard (*Sceloporus graciosus*), and the pygmy rabbit (*Brachylagus idahoensis*). The charismatic sage grouse—also known as sage hen, sage cock, spine-tail grouse, "cock of the plains"—are also appreciated and respected by the public, conservationists, wildlife managers, and resource users, making them *flagship species* for the little-known, little-loved Sagebrush Sea. Finally, although sage grouse are not considered true keystone species, they continue to be important prey for predators and there are reports that large numbers of sage grouse might act as control agents for grasshopper outbreaks. The sage grouse's status as a focal species explains why federal and state agencies, resource users, and conservationists are involved in protracted discussions about sage grouse conservation, and why the news media has followed this species so closely.

Current conservation efforts

In 1998 conservationists attending the Desert Conference hosted by the Oregon Natural Desert Association expressed their concern about declining sage grouse populations throughout the western United States and

Greater sage grouse (*Centrocercus urophasianus*). Photo courtesy of Idaho Department of Fish and Game.

Canada. Discussion of the conservation community's role in sage grouse conservation was hindered, however, by our lack of understanding of the sage grouse and its habitat requirements. In January 1999 the American Lands Alliance and fifteen cosponsors hosted the Sage Grouse Status Conference in Boise, Idaho, to learn more about sage grouse ecology. Originally intended to be a small, informal discussion between conservationists and upland bird experts, the conference swelled to 90 participants representing local, regional, and national conservation groups; state and federal wildlife and land management agencies; university wildlife programs; and the livestock grazing and hunting communities. Conference presenters confirmed that sage grouse are in trouble (American Lands 1999). Not surprisingly, the conference also exposed disagreement among conservationists, land management agencies, and resource users on the best way to conserve sage grouse, and protect and restore their habitat.

Following the conference, American Lands commissioned a rangewide status review of sage grouse. In January 2000 American Lands and partners filed a petition to list the Gunnison sage grouse (*Centrocercus minimus*), a newly described species of sage grouse that lives in southwestern Colorado and southeastern Utah, as endangered under the ESA. The US Fish and Wildlife Service failed to respond to the petition. As litigation proceeds on the Gunnison sage grouse petition, we are preparing to petition the wider ranged greater northern sage grouse for listing under the under the ESA. American Lands is also coordinating a public education campaign, media, and legal strategies to protect the sage grouse and its habitat.

Sage Grouse Natural History

Sage grouse have inhabited the western United States and southern Canada since the Pleistocene epoch (Wetmore 1951). The sage grouse was discovered by Lewis and Clark in 1806 and was given its scientific name, Centrocercus urophasianus (Latin for "spiny-tailed pheasant"), in 1831 (Patterson 1952). Their original range closely conformed to the distribution of tall and short sagebrush covering what became sixteen western states and three Canadian provinces. Historic accounts reveal that sage grouse were very abundant throughout their range prior to European occupation of the West (Rasmussen and Griner 1938, Grinnell et al. 1918, Burnett 1905, Coues 1893). Flocks of thousands were commonly described (Edminster 1954), and the total population may have numbered two million birds. Sage grouse bones have been discovered in caves used as shelter by aboriginal people in northwestern Nevada for whom "the sage grouse was probably valued as a food species" (Grayson 1988). Prior to the arrival of white settlers, Native Americans also utilized the sage grouse for food, and created dances and costumes to mimic the grouses' strutting behavior (Autenrieth 1981).

"Spotted owl of the desert"

The prospect of listing high profile, widely distributed species like sage grouse has generated an array of responses from agency representatives and other observers, some privately calling sage grouse a savior for the BLM, others publicly describing a doomsday scenario. One BLM biologist stated, "listing the sage grouse would drive [BLM] to its knees" (AP 2000). Another highly placed range administer stated, "a listing would be the single biggest impact on rangelands management in all of history." These statements are great press, but are subject to endless interpretation.

The media has seized upon such statements, dubbing sage grouse "the spotted owl of the desert" and reporting in hundreds of articles on the potential local, regional, and West-wide impacts of listing sage grouse under the ESA. The increased attention on sage grouse has in turn prompted a flurry of meetings among federal, state, and local governments; resource users; and other interest groups to craft dozens of management plans and memoranda of understanding in an attempt to avoid listing. These parties fear that listing will reduce resource use on BLM lands and believe that local planning will best serve the grouse.

Whether these plans result in real protection for sage grouse is yet to be seen. Such planning processes are often bogged down by discord among special interests seeking to maintain the status quo. The BLM's participation in such planning efforts is also conflicted. The agency is torn between multiple publics and bombarded by new science that predicts disastrous consequences from past management practices. Meanwhile, current BLM management schemes (as dictated by Congress) often prioritize resource use over habitat conservation and restoration, forcing the agency to preserve some level of commercial use in sage grouse recovery plans even when it might harm the species.

As the threat of listing sage grouse has grown over the past three years, both the BLM and individual personnel have appeared overwhelmed and confused about how to deal with the species. There are, however, indications from biologists and others involved in sage grouse conservation that attitudes are shifting within BLM. Today there is a growing awareness that the sage grouse cannot be saved under current management paradigms and that changes are in order.

Transforming the BLM

Perhaps recognizing the shortcomings of local conservation planning (and certainly to prepare for the impact of listing sage grouse), the BLM has initiated multiple efforts to conserve sagebrush habitat that have piqued the interest of conservationists. In a brave exercise of self-analysis, the agency has developed a long list of BLM programs and actions that pose a "high risk" to sage grouse. The list includes livestock grazing, fuels and fire management, land development, weed control, mining and other programs. By recognizing these management practices as detrimental to sage grouse habitat and by confronting the commercial interests that profit from them, the agency has begun its reformation into a better land manager.

The BLM is also requesting and spending money to protect sage grouse. Recovering sage grouse habitat is one purpose of the multimillion dollar Great Basin Restoration Initiative developed by the BLM to restore millions of acres charred by wildfires and choked by weeds in Nevada. The BLM national budget for fiscal year 2001 included millions of dollars to inventory sage grouse in the West. The agency is now accounting for sage grouse presence in local grazing management plans and expansive resource management plans and has joined other agencies to map sage grouse leks and hundreds of thousands of acres of sagebrush habitat. In June 2001 the BLM will host a major conference on sage grouse ecology and management.

Greater sage grouse (*Centrocercus urophasianus*). Photo courtesy of Idaho Department of Fish and Game.

The BLM may be seeking to balance natural resource management with other ecosystem services. In presenting its fiscal year 2001 programs to Congress, the agency portrayed itself as a protector of open spaces and watersheds instead of reinforcing its image as a traditional resource manager. In 2000 the agency created the National Landscape Conservation System (NLCS) to manage dozens of national monuments, national conservation areas, Wild and Scenic rivers, wilderness and wilderness study areas. Additionally, an associate director in the BLM was promoted to develop guidance and policy for the NLCS. Although the agency promised to impose no new legal protections or restrictions for NLCS units, the system will be fertile ground to develop progressive BLM leaders and strengthen the conservation ethic within the agency.

The BLM also watched Congress and the Clinton administration promote sage grouse conservation as the species gained notoriety. Sage grouse are mentioned in President Clinton's proclamations enlarging Craters of the Moon (Craters 2000) National Monuments and establishing the Upper Missouri River Breaks National Monument (Missouri Breaks 2000) in Idaho and Montana, respectively. Recent legislation creating the Black Rock Desert-High Rock Canyon Emigrant Trails National Conservation Area in Nevada also mentions sage grouse (Black Rock 2000). Finally, in the House of Representatives' floor debate on the Steens Mountain Cooperative Management and Protection Act, Representative Earl Blumenauer (D-Ore.) used sage grouse to argue in favor of protecting Steens Mountain and surrounding environs in southeastern Oregon. All of these designations were made on BLM land. The Steens Mountain legislation sets a precedent as it designated the country's first livestock-free wilderness area where sage grouse, pronghorn, and redband trout will no longer be harassed by domestic livestock (Salvo and Kerr 2001).

Conservationists advocating, organizing, and litigating against poor management practices are also contributing to the BLM's reformation.

For example, in the past several years the agency has lost important court cases attempting to defend outdated grazing practices even while its solicitors were successful defending former Secretary of Interior Bruce Babbitt's Rangeland Reform regulations that seek to conserve and restore grazing allotments. Currently, some BLM staff are considering the ecological and political benefits of permanent grazing allotment retirement.

Some agency personnel and conservationists are seeking more profound changes to hasten the transformation of the BLM. An organization of 1000 current and former BLM employees requested President Clinton to rename BLM lands as "National Public Lands" last autumn (Milstein 2000) to improve their public image and give them equal status to national forests, national parks, and national wildlife refuges. Conservationists have even proposed that Congress and the Department of Interior change the name and mission of the BLM to manage the new National Public Lands System (Kerr 2000). Changing the BLM's name and purpose would bring new vision and leadership to the agency and help negate its past as a servant to commercial interests.

Conclusion

Regardless of what the media reports, conservationists advocate, or the administration directs, sage grouse will be saved or lost by the BLM as the largest landowner in the species' range. Many actions described above and the transformation of the agency predicted by this article will not occur until both species of sage grouse are listed under the ESA. Like the spotted owl, listing sage grouse will increase funding for habitat restoration, build public support for grouse conservation, and provide legal and political cover for land managers working to change resource use on BLM lands.

While listing species is supposed to be a biological question, the process has become a litigious affair often lasting many years. Politics also affects the decision of whether to list a species. Sage grouse have probably drawn the attention of lawmakers and the Bush administration in Washington, D.C., who would oppose listing to protect commercial use on BLM lands. Also, some individuals within the BLM will always op-

Sage Grouse Ecology

The sage grouse is a beautiful, charismatic bird. Both males and females are a mottled, brownish-gray. With the exception that males weigh twice as much as females (males weigh up to six pounds), there are only subtle differences between the sexes during non-breeding periods. White chest feathers and specialized head feathers distinguish cocks during the spring breeding season. Cocks also sport long black tail feathers with white tips; female tail feathers are mottled black, brown, and white.

The sage grouse mating ritual is fascinating to observe. In the early spring, the more colorful males congregate each dawn at "leks," ancestral strutting grounds that are clear of large sagebrush and tall debris. Leks vary in size from one to forty acres (Scott 1942) and may be located up to 50 miles from sage grouse wintering areas (Pyrah 1954). To attract a hen, cocks strut, fan their tail feathers, and swell their breasts to reveal bright yellow air sacs. The progression of wing movements and inflating and deflating air sacs elicits a rumbling, popping "swish-swish-coo-oo-poink!" Sage grouse often gather at leks again in the evening and cocks will strut throughout the night when the moon is bright. Altogether, the sage grouse mating ritual is among the most stirring and colorful natural history pageants in the West.

The sage grouse is aptly named, deriving not only its name, but food and shelter from the shrub. The grouse uses different habitats throughout the year (always near sagebrush) foraging on grasses, wildflowers, insects, and sagebrush. The species' ideal nesting habitat has two components: a sagebrush overstory and a thick grass/forb understory (Gregg 1992; Wakkinen 1990; Braun et al. 1977). Both the over- and under-story provide food, shelter from the elements, and cover from ground predators and raptors (DeLong et al. 1995; Webb 1993; Gregg 1992). Newly hatched chicks feed on abundant insects found in the grasses and forbs (Johnson and Boyce 1990).

Chicks follow their mother to summer range consisting of an interspersion of sagebrush stands and forb-rich areas, including wet meadows and riparian areas (Connelly 1999). A good winter range provides sage grouse with reliable access to sagebrush under all snow conditions. Such habitat is essential as sagebrush is the only food source available to the grouse in the winter. During the year sage grouse will range between leks, loafing and feeding areas, brood rearing areas, wet meadows and riparian zones, and wintering habitat, sometimes covering over 100 acres of terrain (Hulet et al. 1984). Thus, vast expanses of healthy sagebrush habitat and functioning hydrologic systems are necessary to support sage grouse.

pose changing the agency's management priorities whether the sage grouse is listed or not. For these reasons, conservationists must continue to pressure the BLM, the Bush administration, and Congress to accept that change is inevitable, and for the sage grouse, the sooner the better.

Acknowledgements

The author thanks Andy Kerr for reviewing drafts of this article.

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Recovery Progress Report for the Endangered Kootenai River White Sturgeon, *Acipenser transmontanus*

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Abstract
*The Kootenai River population of white sturgeon (*Acipenser transmontanus*) was listed as endangered in the United States on September 6, 1994 by the U.S. Fish and Wildlife Service. This transboundary population, residing in the Kootenai River of the United States and Kootenay Lake in British Columbia, Canada, was isolated from other white sturgeon in the Columbia River basin approximately 10,000 years ago during the last glacial age. The unique population of white sturgeon has been in general decline since the mid-1960s primarily due to low recruitment from natural reproduction. Human activities have changed the natural flow regime of the Kootenai River, altering the white sturgeon's spawning, egg incubation, nursery, and rearing habitats, and reducing overall biological productivity. A recovery plan, developed in cooperation with several State, Federal, Tribal and Provincial agencies in the United States and Canada, was completed in 1999. This paper provides a progress report on recent recovery efforts, focusing on Kootenai River flow augmentation during the spring reproduction period; a conservation aquaculture program to prevent extirpation; and habitat restoration including fertilization of Kootenay Lake in British Columbia, Canada.*

Introduction
The Kootenai River originates in British Columbia, Canada, flows south into northwest Montana and Idaho, then flows north into Canada where it enters Kootenay Lake and eventually the Columbia River.

Approximately 10,000 years ago during the last glacial age, a natural barrier at Bonnington Falls downstream of Kootenay Lake in Canada isolated white sturgeon (*Acipenser transmontanus*) in the Kootenai River drainage from other white sturgeon in the Columbia River basin (Northcote 1973). This newly landlocked white sturgeon population adapted to the pre-development habitat conditions in the Kootenai River drainage moving freely between Kootenay Lake (in Canada) and the Kootenai River (Idaho and Montana). Reproducing adults migrated into the Kootenai River to spawn during the peak flow period that occurred historically from May through July (Figure 1). Combined flows were often in excess of 1,700 cubic meters/second (m^3/s) (60,000 cubic feet/second (cfs)). Side channels and low-lying deltaic marsh lands were undiked at this time, providing productive, low velocity backwater areas important for early age rearing and feeding habitats for some species of fish.

For more than the last 100 years, human development has modified the natural hydrograph of the Kootenai River through such activities as Libby dam construction and operation, dike construction, and lowered Kootenay Lake levels. These activities have altered white sturgeon spawning, egg incubation, nursery and rearing habitats, and reduced overall biological productivity. Although these factors may have contributed to a general lack of recruitment of this unique population of white sturgeon during the last century, the operation of Libby Dam in 1974 is considered to be a primary reason for the population's continued decline (Apperson and Anders 1991). When Libby Dam began regulating the Kootenai River, average spring peak flows were reduced by more than 50% and winter flows increased by more than 300%. In 1997, there were an estimated 1,468 adult and 17 juvenile wild white sturgeon (Paragamian et al. 1997).

Recovery update
A recovery team composed of two Canadians and eight Americans was formed in January 1995. The team completed a final recovery plan (Plan) for the Kootenai River white

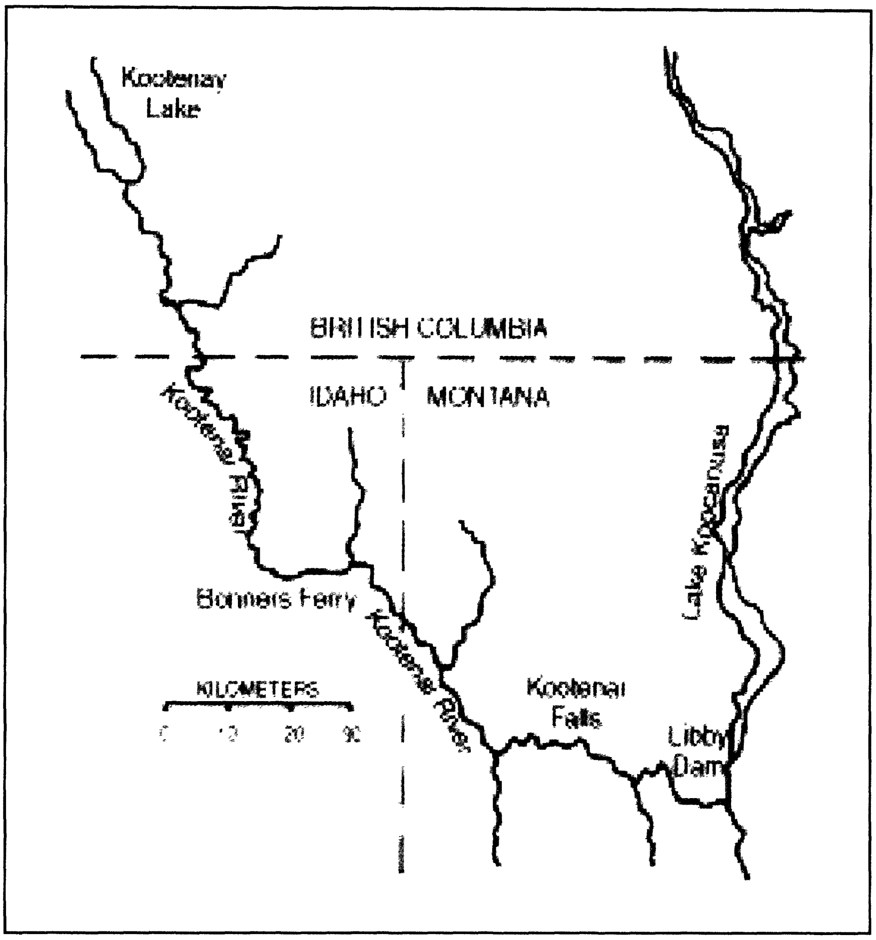


Figure 1. Kootenai River drainage.

sturgeon in 1998 which was subsequently approved by the U.S. Fish and Wildlife Service in late 1999 (Duke et al. 1999). The recovery plan describes a series of 46 specific conservation measures in the United States and Canada that are believed necessary to recover the endangered white sturgeon. Recovery objectives are to reestablish successful reproduction in the wild by increasing Kootenai River flows and producing hatchery-reared juveniles over the next 10 years to prevent extinction. Specific actions currently underway for recovery include Kootenai River flow augmentation during the spring reproduction period; a Kootenai River white sturgeon conservation aquaculture program to prevent extirpation; habitat restoration including fertilization of Kootenay Lake in British Columbia, Canada; and research and monitoring to evaluate recovery progress.

The Plan also identifies 11 additional lower priority research and conservation measures for other native fish, including threatened bull trout (*Salvelinus confluentus*), burbot (*Lota lota*), kokanee salmon (*Oncorhynchus nerka*), and rainbow trout (*O. mykiss spp*) in the Kootenai River Basin.

The Service estimates that at least 25 years will be needed following implementation of the final recovery plan before delisting of the white sturgeon population can be considered. Twenty-five years is the approximate period for juvenile white sturgeon, either reared naturally or in a hatchery, to reach maturity and complete a new spawning cycle.

Kootenai River flow management

Beginning in 1991, the US Army Corps of Engineers and Bonneville Power Administration provided Kootenai River flows from Libby Dam to aid Kootenai River white sturgeon recruitment. These flows, considered experimental from 1991 through 1995, were intended to identify various factors limiting successful reproduction of Kootenai River white sturgeon and help achieve recovery. Beginning in 1995, there was acknowledgment that an adaptive approach was needed because the precise relationship between annual timing, magnitude, temperature, and duration of flows downstream of Libby Dam necessary for successful sturgeon reproduction had not been demonstrated. Since that time, the operation of Libby Dam has included a spring refill period for conservation storage depending upon runoff forecasts in an attempt to better mimic natural flow regime more closely (Duke et al. 1999). As water temperatures rise and as low-elevation runoff downstream of Libby Dam subsides, releases from Libby Dam are typically increased when adult white sturgeon are staging in the suspected spawning reach. Actual releases have been variable, due to runoff forecast and reservoir refill uncertainties. Flows are controlled so as not to exceed flood control limits at Bonners Ferry; however discharges have reached as high as 1500 m^3/s (54,000 cfs).

Annual Kootenai River flow augmentation from Libby Dam to benefit white sturgeon also may result in water spill at other Canadian Kootenai River dams to compensate for loss power generation. The United States and Canada meet annually to evaluate the potential fisheries, power production and flood control impacts associated with regulating flows at other Kootenai River hydroelectric projects to benefit Kootenai River white sturgeon.

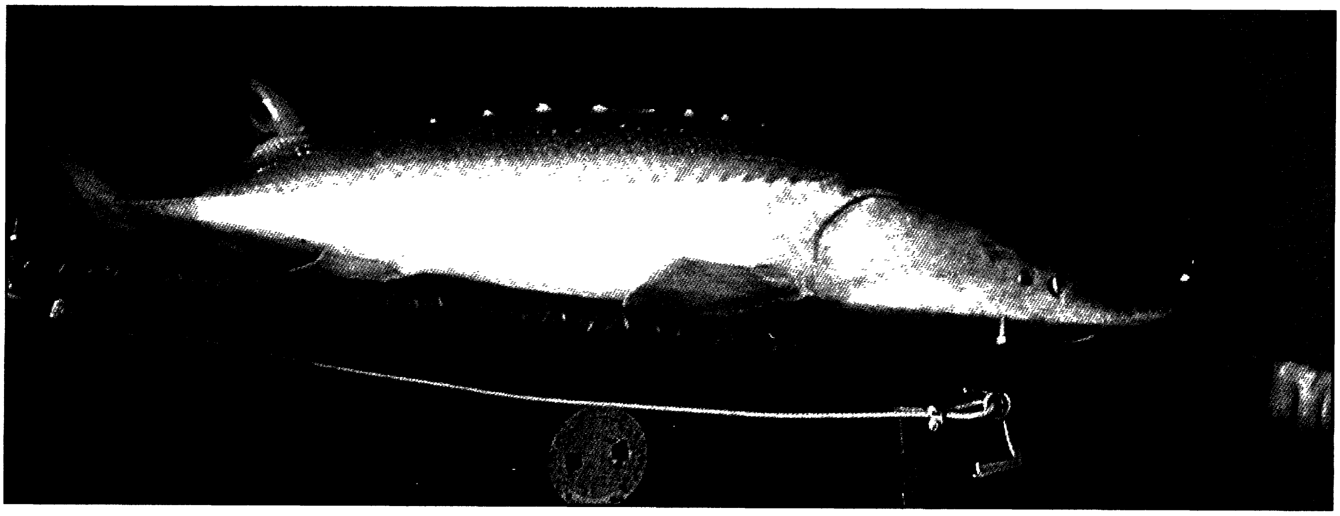
To date, the increased Kootenai

River flows provided through the flow augmentation program has resulted in documented spawning each year but not survival beyond the egg stage. Consequently, significant natural recruitment has not yet been restored. Only a total of 18 wild juvenile white sturgeon have been collected since 1993, with the largest year class appearing to be 1991 with 10 wild recruits.

Kootenai River White Sturgeon Conservation aquaculture program
The Kootenai Tribe of Idaho white sturgeon hatchery began as an experimental program in 1990 in response to questions concerning water quality, white sturgeon gamete viability, and feasibility of aquaculture as a component in recovery. Early efforts led to refinements to culture practices that resulted in improved successful egg fertilization, incubation, egg viability, and rearing. Following these efforts a Kootenai River white sturgeon conservation aquaculture program was initiated to begin rebuilding the wild population, and prevent extinction until efforts to restore natural recruitment and production are realized (Ireland et al. 2000). A breeding plan has been implemented to guide management in the systematic collection and spawning of wild adults before they are lost from the wild breeding population from old age or death. The program attempts to rear four to nine white sturgeon families (one female spawned with one male) per year, and then release adequate numbers of juvenile fish from each family to survive and produce four to 10 adults at age 20. The program also includes a genetic inventory component to ensure that the conservation aquaculture program maintains the inherent genetic diversity of the remaining wild population. In 2000, BC Environment approved the use of the Kootenay Trout Hatchery located near Fort Steele, B.C. as a back-up or fail-safe white sturgeon facility. Fertilized white sturgeon eggs from each family are transported from the Kootenai Tribe Hatchery in Idaho to the Canadian facility to ensure that at least some juvenile sturgeon will survive for later release into the Kootenai River in the event some catastrophe occurs at the hatcheries.

Since 1992, nearly 7,050 juvenile white sturgeon from six year classes have been released into the Kootenai River to augment the wild population (Ireland et al. 2000). Additionally, nearly 129,000 larvae three to 12 days old were released into the Kootenai River during the summer of 2000 to evaluate whether larvae survival is a recruitment "bottleneck." Monitoring to determine the movement and survival of these larval fish is ongoing, although it may be a year or two until fish are large enough in size to be captured with available sampling gears. Prior to release, all fish are also disease tested to minimize the introduction of diseases into the wild population.

Although still in its infancy, the Kootenai River Conservation Aquaculture Program is currently satisfying its objectives of reducing the threat of population extinction by rearing juvenile sturgeon from native broodstock; maintaining the wild population's genetic diversity in its broodstock selection; and minimizing the introduction of disease into the wild population. The conservation aquaculture program , designed to be implemented and evaluated for a minimum period of 10 years from 1999 though 2008, may be extended if other measures to restore natural white sturgeon recruitment and reproduction are not successful. Conversely, if natural restoration measures are successful then the conservation aquaculture program may be adjusted before 2008.



Kootenai River white sturgeon, *Acipenser transmontanus*. Photograph courtesty of Idaho Fish and Game.

Kootenay Lake artificial fertilization
The B.C. Ministry of Environment, Lands and Parks and B.C. Hydro are currently fertilizing the North Arm of Kootenay Lake to increase biological productivity and restore native fish populations (Ashley et al. 1999). This program was initiated in 1992 in response to a long-term decline in the kokanee population, which are thought to have been an important prey item for adult white sturgeon.

The project involves nutrient introductions (phosphorus and nitrogen formulations) into a 16 km zone (10 miles) of the North Arm of Kootenay Lake once per week from late April through early September. From 1992 until 1997, approximately 317 tons of phosphorus and 581 tons of nitrogen formulations were released each year, which is the equivalent of 70% of pre-impoundment (1949) loading levels. The project has resulted in increased kokanee escapement from an all-time low of 270,000 in 1991 to 2.2 million in 1998. Kokanee densities in the fertilized North Arm of the lake have increased from approximately 200 fish per ha in 1992 to an average of 900 per ha for 1993 to 1999 in some areas of the North Arm, in 1998 densities were estimated as high as 3,500 per ha. Since 1997, nutrient introductions have been reduced in 1997 by 80% due to a perceived carry-over of productivity from previous years. An initial analysis of phytoplankton abundance in the last two years has also shown a substantial decrease likely resulting from cutting back too much on the fertilizer loading rate. Fertilizer loading rates were increased substantially during the spring/summer 2000 field season in order to boost productivity levels.

The increasing overall biological productivity in Kootenay Lake since 1992 has benefited kokanee and rainbow trout and should benefit white sturgeon by increasing their prey base.

Conclusion

Twentyfive years or more may pass before we know whether conservation measures designed to fully recover Kootenai River white sturgeon are successful. Upon completion of the recovery plan, regional support for implementing the various recovery actions coalesced and substantial increases in funding to implement the recovery plan became available through the Bonneville Power Administration under the auspices of the Northwest Power Planning Act in the United States and the Columbia Basin Fish and Wildlife Compensation Program in Canada. The United States and Canada continue to cooperate and implement transboundary recovery actions on behalf of the Kootenai River population of white sturgeon. This has led to partial or complete implementation for all but four of the 57 identified recovery tasks in the Plan.

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Marine Matters

Knowledge of Groundwater Responses— A Critical Factor in Saving Florida's Threatened and Endangered Species Part I: Marine Ecological Disturbances

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Abstract
Florida's marine species, including threatened and endangered species, are subjected to adverse environmental conditions due to groundwater alterations because agencies charged with implementing and enforcing the Clean Water Act and Endangered Species Act fail to consider those impacts. Examples of anthropogenic groundwater perturbations that can result in direct, indirect, secondary and cumulative impacts to marine species include: (1) aquifer injection of effluent and other ecologically hazardous wastes; (2) aquifer 'storage' and 'recovery'; (3) groundwater mining; and (4) structural mining of the aquifer system (e.g., limerock, sand, phosphate). Groundwater flow in Florida's regional karst aquifer system varies greatly both spatially and temporally, in response to those anthropogenic alterations. Those perturbations can result in significant physical, chemical and biological changes in the marine ecosystem. Related adverse impacts can include: (1) predisposing organisms to disease (e.g., decreasing host resistance, increasing pathogen vigor), including catalyzation by carbon-loading; (2) introducing new pathogens; (3) promoting rapid, antagonistic evolution of microbes; and (4) introducing hazardous chemicals, including endocrine disrupters. The adverse effects of those alterations may be a significant factor in the major ecological disturbances of Florida's marine environment described in volume 18(1) of Endangered Species UPDATE. *The magnitude of adverse impacts to marine species from those groundwater perturbations is unknown. Currently, the agencies have not fulfilled their fiducal responsibilities by failing to require the necessary studies, proceeding with permitting actions in the absence of that required information, and failing to take enforcement action against existing violations.*

Background
In volume 18(1) of the *Endangered Species UPDATE*, McKay and Mulvaney (2001) provided a well-documented summary and discussion of the apparent increase in marine morbidity and mass mortality events, in addition to the emergence of new diseases spanning taxa, increases in harmful algal blooms, and longterm/ unexplained population declines in marine wildlife. They also discussed various natural and anthropogenic factors that may be contributing to the problems they described. Anthropogenic alterations of groundwater flows and groundwater contamination, however, were not included in the factors they addressed. The major causes of groundwater alterations in Florida are: (1) disposal of effluent and other hazardous liquid wastes by shallow and deep aquifer-injection; (2) aquifer 'storage' and 'recovery' (ASR); (3) groundwater mining; and (4) structural mining of the aquifer system (e.g., limerock, sand, phosphate), as summarized by Bacchus (2002). Those anthropogenic groundwater perturbations can result in significant physical, chemical, and biological changes in the marine ecosystem; concomitant adverse impacts on marine organisms (including threatened and endangered species); and a "taking" of critical habitat. This article is the first in a series addressing implications of anthropogenic groundwater alterations

This paper was excerpted from J.W. Porter and K.G. Porter eds. Everglades, Florida Bay, and Coral Reefs of the Florida Keys: An Ecosystem Sourcebook. *CRC Press LLC, Boca Raton, FL (in press).*

in Florida, and addresses the role of those alterations as potential causal factors in the myriad unexplained disease outbreaks and deaths of marine organisms in Florida since 1980 (see Table 1 in McKay and Mulvaney 2001).

Federal and Florida laws require consideration of all adverse impacts (direct, indirect, secondary and cumulative) of projects that are proposed to be permitted and to take enforcement action against violations. The Scientific Advisory Board (SAB) of the United States Environmental Protection Agency (EPA) recently determined that hydrologic alterations represent a major environmental stressor (SAB 1999). The intimate interconnection between Florida's various aquifer layers and surface water (via fractures, dissolution/collapse features, paleochannels, and other discontinuities) has been established in the scientific literature (summarized by Bacchus 2000a; 2000b; 2002) and case law, and will be addressed in a subsequent article in this series. This intimate interconnection in Florida's karst aquifer system results in both spatial and temporal responses to anthropogenic alterations. Despite these facts, the large-scale, long-term adverse impacts due to groundwater alterations currently are not considered by agencies charged with implementing and enforcing the Clean Water Act and the Endangered Species Act in Florida.

The "First Biennial Report to Congress, 1996" by the EPA is one example of the failure to recognize impacts of groundwater perturbations (EPA 1996). That report addressed restoring historical freshwater flow to Florida Bay and conducting research to understand the effect of water transport from Florida Bay on water quality and resources in the Florida Keys National Marine Sanctuary ('Sanctuary'). No studies have been initiated or proposed to evaluate the effect that diversion of historic, fresh groundwater discharge from these sensitive areas has had on the ecosystems of the 'Sanctuary.' Likewise, the impacts of deep and shallow injected effluent on the sensitive resources of the 'Sanctuary' and newly-created Tortugas Marine Reserve ('Reserve') have not been determined. The only reference to deep-well injection in the EPA's report was that it be "evaluated and implemented" by the City of Key West. Although deep-well injection of effluent in Key West was scheduled to begin in spring 2001 (City of Key West 2000), no Environmental Impact Statement (EIS) or other comprehensive scientific investigation has been conducted to evaluate the potential impacts of that proposed action. Migration of injected effluent has been documented or is suspected to be occurring in 42 of the 81 operational deep-injection sites (National Archives and Records Administration 2000), which are located primarily along south Florida's coast (Figure 1). Therefore, the pending permit by the Florida Department of Environmental Protection (FDEP) authorizing deep-well injection of secondarily-treated sewage effluent in Key West has major implications for both the 'Sanctuary' and newly-created 'Reserve.'

If activated, the Key West deep-well injection facility would be considerably closer to the newly-created 'Reserve' than the Miami/Dade Blackpoint sewage treatment plant, which is located adjacent to Biscayne Bay at the northern extent of the 'Sanctuary.' Recent data from Top et al. (2001) support the conclusion that extensive preferential induced discharge of deep-aquifer water is occurring within the 'Sanctuary' (including in proximity to coral reefs), as a result of effluent-injection at the Miami/Dade facility. Additional support for the induced discharge of deep and shallow injected effluent is provided by the: (1) 1994 documented pulses of fresh water lowering ambient salinity from approximately 35 ppt to 28 ppt in ground water discharging from the base of a deep reef near Carysfort Reef, in Biscayne National Park (R. Curry, unpublished data); (2) previous discovery of low-salinity water seeping from the base of deep coral reefs off Key Largo (Simmons, Jr. 1992); (3) 1983 groundwater discharges from the bases of Carysfort and French Reefs, with salinities as low as 10 ppt (where ambient salinity was 33 ppt), and numerous pesticide peaks and heavy metal (cadmium, chromium, copper, iron, lead, mercury, and zinc) concentrations ranging from 100 to 10,000 times greater than mean sea water values (Simmons Jr. and Love 1987); and (4) initial observation of "white plague" coral disease (now in epidemic proportions) at Carysfort Reef soon after aquifer-injection of effluent was initiated at the Miami/Dade facility (Dustan 1999). Aquifer-injection of 110 million gallons each day of secondarily-treated effluent has been permitted at the Miami/Dade facility since before the time of the marine incidences described in Table 1 of McKay and Mulvaney (2001). Such apparent wide-spread induced discharges of ground water further suggest that the proposed ASR injection of 1.7 billion gallons of surface water in the Everglades Restoration Plan (U. S. Army Corps of Engineers and South Florida Water Management District 1999, and as proposed using contaminated surface water by the Florida Legislature in 2001) ultimately would result in more extensive induced discharge of injected contaminants throughout Florida Bay, the coral reef tracts in the 'Sanctuary,' and the Everglades.

The FDEP currently is proposing to double the volume of minimally-treated effluent at the Miami/Dade facility, despite documented viola-

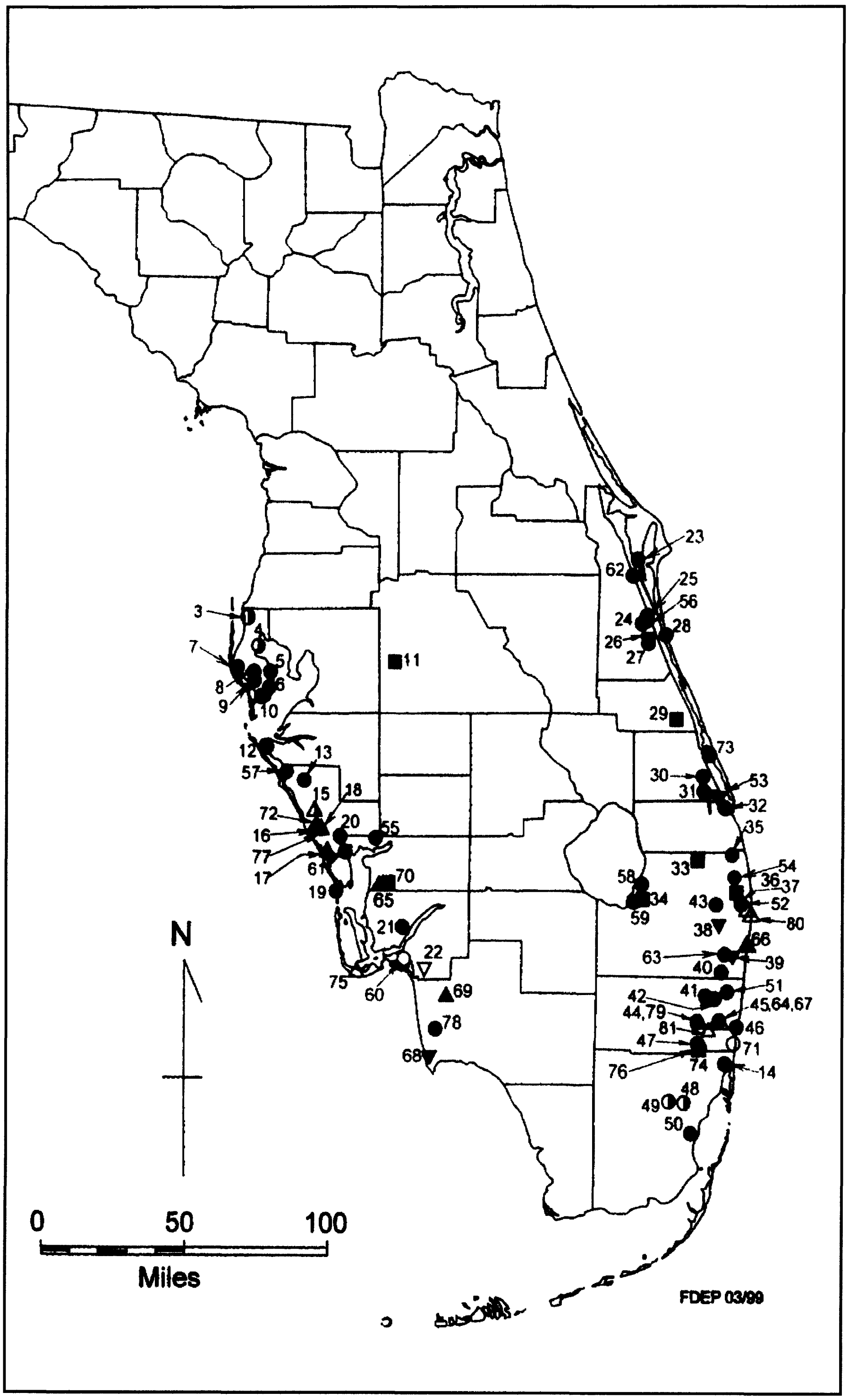

Figure 1. Location of Class I deep-well injection facilities in south Florida, with the Miami/Dade Blackpoint effluent-injection facility (50) shown as the southeasternmost facility, as of 2000 (from Florida Department of Environmental Protection 1999).

tions of the existing permit, including migration of injected effluent (addressed in part by McNeill 2000). The engineering firm responsible for the Miami/Dade aquifer-injection wells also constructed the injection wells proposed for aquifer-injection of minimally-treated municipal effluent in Key West. Rapid induced discharges into the 'Sanctuary' have been documented via shallow injection wells in the Florida Keys (e.g., Corbett et al. 2000; Dillon et al. 2000; Paul et al. 1997). Injection of effluent and other ecologically hazardous wastes into Florida's karst aquifer system, via shallow and deep wells, is conducted under FDEP's Underground Injection Control rule. The title of that rule is grossly misleading because injected contaminants are uncontrollable. Minimally-treated effluent is injected into the shallow aquifer via approximately 1,000 wells throughout the Keys. An FDEP permit is pending for shallow-aquifer injections adjacent to the last remaining sea turtle nesting beach in the Upper Keys (Division of Administrative Hearings 2000). Marine species designated to receive federal protection in south Florida's Keys/Monroe County include the American crocodile (*Crocodylus acutus*) and manatee (*Trichechus manatus*), in addition to the following four species of sea turtles: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and Kemp's ridley (*Lepidochelys kempi*). Numerous other federally-listed species and species recognized by the State of Florida as threatened, endangered or species of special concern also occur within the Florida Keys/Monroe County. The agency actions and inactions referenced above particularly are negligent in light of the fiducial responsibility of the government, our current level of knowledge, and the public admission of violations to the aquifer-injection rules. Environmentally-sound alternatives are available, but are not being implemented.

Although there is extensive evidence that all four major causes of groundwater alterations referenced initially are contributing to the marine disturbances in Florida (see Bacchus 2002), as summarized by McKay and Mulvaney (2001), only the potential 'difusion' of nutrients (nitrogen and phosphorus) from shallow injection wells is being considered (see Lapointe 2000). Agencies authorizing the construction and operation of ASR injection wells and other groundwater alterations have not: (1) identified the preferential flow paths that are known to exist; (2) monitored the frequency, volume, and chemical characteristics of the discharges via these preferential flow paths; or (3) determined the ecological impacts of such discharges. Because of this narrow focus, major federal initiatives such as the "Harmful Algal Blooms and Hypoxia Research and Control Act of 1998" (P. L. 105-383), contributing more than $52 million to address the problem of harmful algal blooms and hypoxia in the Gulf of Mexico, may fail to identify induced discharge of contaminated ground water as a significant fact in coastal eutrophication. Top et al. (2001) described kills of finfish and shellfish that were linked to groundwater-laden nutrients, providing examples of Atlantic coastal areas where ground water accounted for half of the nitrogen loading of the sediments. This article departs from the narrow focus on nitrogen and phosphorus as the sole potential impacts from aquifer injection (effluent, other ecologically hazardous fluids, ASR). Some of the numerous other related adverse impacts, including to federally-listed species, can include: (1) predisposing marine organisms to disease (e.g., decreasing host resistance, increasing pathogen vigor), including catalyzation by carbon-loading; (2) introducing new pathogens to the nearshore marine environment; (3) promoting rapid, antagonistic 'evolution' of microbes; and (4) introducing hazardous chemicals, including endocrine disrupters, to the nearshore marine ecosystem.

Predisposition to disease, and beyond

Groundwater mining and structural mining of the aquifer system result in hydrologic perturbations such as the interception/diversion of pristine, low-salinity, low-nutrient submarine groundwater discharge (SGD) of constant temperature. Aquifer injection of fluids can replace this pristine resource with treated effluent. Those perturbations can induce a state of physiological distress in Florida's marine ecosystems. Physiological distress, in turn, can promote predisposition to disease caused by pathogens present historically, or introduced recently (e.g., via injected effluent or transported African dust). It also could render organisms more susceptible to other stressors (see Bacchus 2002). For example, coral reefs have experienced significant adverse impacts both directly (Bell 1992) and indirectly, via algal proliferation (Lapointe 1999), with the addition of extremely low levels of nitrogen (0.014 mg L^{-1}) and phosphorus (0.06 mg L^{-1}). Levels of those nutrients in effluent that has received advanced wastewater treatment (AWT) and subsequent 'polishing' are approximately two orders of magnitude greater than the levels of nutrients that can cause those adverse impacts (FDEP, unpublished data). Despite the adverse marine impacts that can occur from nutrient loading, no consideration is being given to other components of the injected, secondarily-treated effluent (and other contaminated fluids) that may pose a comparable or greater threat than the nutrients. The following section describes the potential role of introduced carbon, in conjunction with groundwater perturbations, in predisposing marine organisms to diseases and death.

Carbon as an anthropogenic, catalystic environmental stressor

Aspergillus sydowii is a fungus implicated in mass mortalities of sea fans (*Gorgonia*), as discussed by McKay and Mulvaney (2001). This fungus is a common, cosmopolitan, saprobic fungus, however, isolated from many types of terrestrial environments, including soils from Alaska to the tropics. It also has been cultured from subtropical marine waters near the Bahamas and the Straits of Florida, and has been found in eulittoral zones and oceanic zones, including isolations from waters collected as deep as 4,450 m (13,350 ft). This fungal species had not been recognized as the cause of widespread disease in plants or animals prior to the mass mortalities of sea fans. Several species of *Aspergillus* are opportunistic animal pathogens, generally infecting individuals with compromised immune systems. Likewise, the infection of sea fans by *A. sydowii* may be the result of opportunistic pathogenicity due to weakening of the host from stressors, such as water pollution or other environmental factors (Geiser et al. 1998; Nagelkerken et al. 1997; Roth et al. 1964; Smith et al. 1996). Rinaldi (1983) described the role of the compromised host in the invasive fungal disease of humans by species of the genus *Aspergillus*. The significance of host vigor in avoiding infection by this fungus was emphasized.

Other factors that may influence the ability of a pathogen to infect its host include competition between the pathogen and competing antagonists. *Trichoderma*, another fungus commonly found in soils, is regarded as an antagonist of fungal pathogens. *Trichoderma* exhibited reduced competitive ability in laboratory experiments when higher concentrations of carbon (C) were present, relative to available nitrogen (N). That finding suggests a delicately balanced C/N ratio is required for maximum competition (Overmier 1975). During the same experiments, the fungal pathogen *Gliocladium virens* required high levels of C for successful invasion of *Diplodia* colonies. Therefore, the C/N ratio may influence pathogenicity by affecting the competitive ability of antagonists, or by increasing the ability of fungal pathogens to invade their host, independent of any increased susceptibility of the host organism due to other stressors.

Despite the fact that disruption of the C/N ratio can facilitate infection by opportunistic fungi, not all organisms exhibit equal susceptibility to infection. Organisms that are more sensitive to environmental perturbations are considered the 'canaries' that issue early warnings. These hypersensitive indicator organisms (e.g., sea fans, certain species of corals) respond more rapidly and severely to perturbations, often succumbing to infection by fungi, bacteria or viruses.

Mass mortality of seagrasses in Florida Bay is similar to the mass mortality of sea fans. The seagrasses also became victims of a fungus considered to be a nonaggressive (opportunistic) species on seagrasses throughout south Florida (J. Zieman, personal communication). This fungus is a marine slime mold (*Labyrinthula* sp.) identified as endemic to the south Florida area. Therefore, it does not occur in Africa, the origin of the aerially-dispersed dust in the African dust theory (as discussed by McKay and Mulvaney 2001, and challenged by Bacchus 2002). Furthermore, that marine slime mold does not produce the type of resistant structures that would allow long-range aerial distribution (D. Porter, personal communication). Therefore, it is unlikely that the African dust dispersed across the ocean is the source of the pathogen implicated in the mass mortality of the seagrasses in Florida Bay.

Seagrasses, like other organisms, can be weakened by environmental stressors and made more vulnerable to disease (Den Hartog 1987; Muehlstein 1989; Short et al. 1988). The mass die-off of seagrasses in Florida Bay in 1987, reportedly was due to hypersaline conditions in Florida Bay during a period of low rainfall. Our current state of knowledge, however, suggests that the hypersaline event was not due to low rainfall alone (e.g., impacts of groundwater mining) and was not the sole or possibly even the most significant stressor (summarized by Bacchus 2002). The similar die-off of seagrasses in Cockburn Sound, Western Australia (also summarized by Bacchus 2002) suggests that induced discharge of injected waste water played a significant role in predisposing seagrasses in Florida Bay to the opportunistic fungal disease.

Durako and Kuss (1994) suggested that the die-off of turtle-grass (*Thalassia testudinum*) in Florida Bay was density-dependent because it was observed only in areas that previously supported very dense populations of turtle-grass. They also noted that the lower density stands that were less affected by the die-off also were in areas of lower salinity. Possibly, the denser stands of turtle-grass were associated with areas of historic SGD that originally provided more favorable growing conditions for the turtle-grass. In addition, those areas of SGD subsequently could have become areas where saline water from deeper aquifers was surfacing (supported by data from Top et al. 2001) as induced recharge, due to deep-well injected effluent. Point discharges of excessive nutrients and other contaminants could have reduced the vigor of seagrasses and increased the vigor of pathogens (e.g., the undescribed marine slime mold).

Duarte (1995) provided extensive insight into the feedback mechanisms leading to the "domino effect," as coastal eutrophication results in a shift from ecosystems dominated by relatively slow-growing, nutrient-conserving macrophytes such as seagrasses, to systems dominated by rapidly growing phytoplankton and macroalgae. In the latter case, greater amounts of dissolved organic C are released and available for recycling. *Ceramium corniculatum*, the red alga that was reported covering the coral reefs at Cheeca Rocks, is an example of the thin, finely-textured macroalgae described by Duarte that results in the "domino effect", the rapid release and recycling of C. Cheeca Rocks is a shallow coral reef system in close proximity to numerous shallow effluent-injection wells in the Upper Keys.

The sensitivity of corals to increases in C was demonstrated by Mitchell and Chet (1975) with coral heads exposed to low concentrations of various substances, including crude oil (100 ppm) and organic matter (1000 ppm, in the form of dextrose), under controlled laboratory conditions. Many of the coral colonies died after exposure to low concentrations of crude oil for 24 hours. Addition of organic matter (dextrose) resulted in the same level of increased mucus production associated with exposure of coral heads to crude oil. In fact, corals died within 24 hours after dextrose was added to the water. Concomitantly, the bacterial population associated with the coral heads "reached an extraordinarily high peak" of 10^7 cells ml^{-1} within 24 hours after addition of dextrose.

Bacterial isolates from the coral surface in the presence of crude oil indicated that 15 to 25% of bacteria isolated were capable of growing on coral tissue extract as the sole C and N source. That finding suggested those bacteria could co-occur with corals in low numbers under natural, oligotrophic conditions, without external sources of nutrients. Of equal significance, they discovered that approximately 60% of the bacteria identified in those experiments were motile, gram negative rods. They further noted that more than 50% of the motile bacteria displayed chemotaxis (chemical attraction) to the coral mucus. The majority of those bacteria also were capable of growing on coral tissue extract as the sole C and N source.

Corals produce mucus in response to both chemical (e.g., C compounds) and physical (e.g., sand) stressors. Coral mucus is composed of polysaccharides, molecules containing many sugars (which are composed of C atoms). Although dextrose is not considered a toxic substance, it is a source of C, as is the mucus that is produced by the corals when they are under stress. Microbes, such as bacteria and fungi, use C as a food source. In the experiment conducted by Mitchell and Chet (1975), the bacterial population associated with the coral heads increased at the same rate as the production of mucus by the coral. Their experiments with antibiotics (penicillin and streptomycin) illustrated that coral death was due to the bacteria (including two predatory bacteria), rather than the actual stressors. Results were the same, even with an order of magnitude increase in crude oil concentration. Their research was critical in showing that even when concentrations of pollutants were insufficient to kill the corals directly, the increased stimulation of omnipresent microbes and microbial processes was sufficient to cause coral death.

The role of increased C in coral deaths documented by Mitchell and Chet (1975) supports concerns by Dustan regarding the implication of C-loading and coral death (Dustan 1999, personal communication), and by Bacchus (2002) regarding disruption of the C/N ratio. Therefore, injection wells at the Miami/Dade facility and throughout the Keys are implicated in the demise of the coral reefs via C-loading and disruption of the C/N ratio. Likewise, additional C entering the water near the coral reefs, via induced discharge of injected effluent, may be a factor in the assault of corals by *Sphingomonas* (white plague). Initially, white plague was reported from coral reefs near the northern boundary of the 'Sanctuary' at approximately the time that the Miami/Dade facility began injecting effluent adjacent to Biscayne Bay. *Sphingomonas* is representative of the ultramicrobacteria in oligotrophic marine waters (Fegatella and Cavicchioli 2000).

Edwards (2000) reiterates the differences in responses of microorganisms under artificially nutrient-rich conditions and their natural, oligotrophic environments where they are exposed to starvation conditions and grow slowly, or not at all. The presence of organic matter in the water column also has been shown to increase the survival time of bacterial pathogens in the water, such as *Vibrio cholerae*, the human pathogen that causes cholera (Joseph and Bhat 2000). More chilling is the mounting evidence that symbiotic organisms (e.g., bacteria, fungi) can become pathogenic towards their hosts under abnormal conditions (Bacchus, unpublished data; Hentschel et al. 2000).

Another unaddressed aspect of C-loading, via induced discharge of injected effluent, is the potential interaction of this organic material with chemicals added to the effluent during the treatment process. Effluent injected throughout the Keys typically is treated with chlorine, generally without dechlorination. When chlorine comes into contact with organic matter it can form compounds known as trihalomethanes (chloroform, bromoform, dibromochloromethane, and bromodichloromethane). Those compounds have been classified as probable human carcinogens. In addition to the organic matter in the minimally-treated effluent injected at the Miami/Dade facility and throughout the Keys, approximately half of the SGD areas of direct discharge observed during a recent reconnaissance in the Florida Keys had thick layers of organic material associated with them (Bacchus, unpublished data). Previous studies also have documented organic layers within living coral reefs associated with the Florida Keys (summarized in Bacchus 2001). If direct discharge of injected effluent (which also contains organic material and is heavily-chlorinated) is occurring via preferential flow paths, such as those with associated organic layers in the Keys, organisms exposed to this water could experience significant adverse impacts.

No research appears to have been done to determine if exposure of marine animals to wastes discharging in nearshore waters could contribute to conditions such as the recent proliferation of tumors in sea turtles (Figure 2), or other recent increases in unexplained diseases and deaths of marine organisms. A recent study in the Keys by Swart et al. (2000), however, provided additional evidence of nearshore discharge of injected effluent. Of the 50 locations sampled in the study, Anne's Beach exhibited one of the highest concentrations of coprostanol and cholesterol (indicators of human sewage). Anne's Beach is an extensive undeveloped stretch of naturally-vegetated beach lacking septic systems, cess pits, and related sources of sewage that were the focus of that study. The source of those human sewage indicators was not known (P. Swart, personal communication). The sewage, however, may represent a threat to sea turtles at the last remaining sea turtle nesting beach in the Upper Keys, north of Anne's Beach, as well as to humans. Shallow injection wells operate in close proximity to Anne's Beach.

Implications described above, coupled with increasing incidence of unexplained/unidentifiable diseases and mortality in other marine organisms (including federally-listed species) provide sufficient impetus for a total moratorium on the increase in number of injection wells and volume of injected fluids in the Keys vicinity until a comprehensive investigation of the potential impact of injected wastes on coastal ecosystems and associated organisms is completed. Additional potential adverse impacts are described below.

Newly-introduced pathogens and rapid, antagonistic evolution

The preceding discussion addressed the ability of environmental conditions subjected to anthropogenic alterations to increase susceptibility of (predispose) organisms like corals and seagrasses to infection by commonly-occurring, opportunistic pathogens. Also addressed was the potential for altered environmental conditions to increase the virulence of commonly-occurring pathogens. A related scenario is the introduction of pathogens (viruses, fungi and bacteria) into environments foreign to those in which they evolved.

The first relevant example is the injection of large volumes of effluent containing human pathogens into a karst aquifer system, with subsequent induced discharge into the marine environment. The second example is the State of Florida's repeated attempts to initiate large-scale injection of surface water, via ASR, as referenced previously. The ASR injections (1.7 billion gallons per day planned in the vicinity of Lake Okeechobee) are promoted as the critical component in 'restoration' of the Everglades (U. S. Army Corps of Engineers and South Florida Water Management District 1999). This approach, however, appears to be more closely linked to the presumption that ASR would increase the amount of water available to support more extensive development in the Everglades watershed. There is, however, no scientific support for that presumption. Although Governor Bush's (R-FL) attempts were unsuccessful this year to pass legislation allowing large-scale injection of untreated surface water throughout Florida, efforts are underway to begin aquifer-injections of untreated surface waters in south Florida as experiments.

There are at least two significant differences between the dispersal/discharge of microbes in effluent via groundwater flow channels and disposal via ocean outfall pipes. The first is the cooler, more stable temperature of groundwater transport of effluent. The second is the potential for longer periods of incubation in the absence of light. Both conditions can

Figure 2. Necropsy of a green sea turtle (*Chelonia mydas*) from Florida's Upper Keys, where minimally-treated effluent injected into deep and shallow aquifers appears to be discharging into nearshore surface waters. The large white mass is a tumor engulfing both kidneys (photograph courtesy of Sue Schaf, The Turtle Hospital 1999).

extend the period of viability for at least some pathogens (J. Paul, personal communication). Finally, consideration must be given to the possibility that introduction of microbes into a new environment, or exposure of existing organisms to altered environmental conditions, may facilitate evolution of new organisms, as is suggested by recent findings (see Bacchus 2002). This is of equal concern with respect to the contaminated surface water (agricultural and urban runoff) that Florida proposes to inject as ASR. Concerns are mounting that even if organisms in injected surface water did "die-off," as proponents suggest, that toxins, such as those produced by dense concentrations of bluegreen algae, would be unaffected during the 'storage' period, as would other chemical contaminants.

Mounting evidence also suggests that organisms with rapid regeneration times (e.g., microbes) are evolving equally rapidly in the severely disturbed environments we are creating. This is true particularly for sewage-laden, eutrophic coastal waters. For example, Parveen et al. (1997) used multiple-antibiotic-resistance profile homology to determine that *E. coli* isolates from point source sewage discharge were markedly more diverse than isolates from nonpoint sources, such as stormwater runoff. Those findings provide additional evidence that both our natural resistance, and our medical resistance to these organisms are under serious threat.

Responses are similar at the ecosystem level. Burkholder and Glasgow, Jr. (1997), Burkholder et al. (1995), and Glasgow, Jr. et al. (1995) provide disturbing details regarding increasing frequency, magnitude, severity, and range of outbreaks of toxic ambush-predator dinoflagellates in coastal areas of the southern United States. Those organisms were undescribed and unknown to science until recently. The marine slime mold implicated in the mass mortality of seagrasses in Florida Bay may represent another example of microbes evolving rapidly in coastal areas where significant anthropogenic eutrophication and other pollutants are increasing.

As an example of the situation in the 'Sanctuary' administered by the National Oceanic and Atmospheric Administration (NOAA), research conducted at coral reefs throughout the 'Sanctuary' not only documented increases in coral diseases and deaths described previously, but also revealed that no recruitment of reef-building coral species was occurring (Tougas and Porter 2002). Ironically, recruitment of reef-building coral species is occurring at other locations in the Caribbean. The prospects of the reef corals, the interdependent reef species, and other coastal organisms, including federally-listed species, surviving those recent, anthropogenic assaults in Florida do not look optimistic.

Parts per million vs. parts per billion and trillion

In addition to increasing the spatial scale of perceived contributors to the environmental problems in south Florida (e.g., regional groundwater perturbations), we also must decrease the scale of our focus with respect to potential water quality contaminants (e.g., increased sensitivity of detection). For example, no monitoring currently is being conducted to evaluate the introduction/escalation of endocrine disruptors in south Florida's coastal waters. Environmental monitoring focuses on the toxic impacts of pollutants (often in the range of parts per million), rather than impacts of pollutants that disrupt the normal functioning of hormones (usually in the range of parts per billion or parts per trillion). The former can lead to death of the organism exposed to the contaminant, while the latter can result in loss of future generations of exposed organisms.

Colborn compared (1) nonlethal (low) levels of compounds that cause toxic responses to organisms and (2) orders of magnitude lower levels of endocrine disruptive compounds that may be 'lethal' to all future generations, after exposure of the initial generation (see Figure 7 of Bacchus 2002). In some cases, hazardous levels of endocrine disruptors may be below current detection limits of sampling equipment (T. Colborn, personal communication). Harmful compounds also can bioaccumulate. For example, algae can take up and concentrate pollutants (other than nutrients) from minimally-treated sewage, like the effluent injected throughout the Keys. The die-off of the sea urchin (*Diadema antillarum*) population in the Keys may have been due to contaminants in the algae (primary food source of sea urchins) that it consumed, or to compounds (e.g., nonylphenol/ ethoxylates) in discharged ground water associated with the reefs. Recall that adverse impacts of those compounds include disruption of the reproductive process, generally being revealed in subsequent populations. The importance of this possibility is more significant since The Nature Conservancy is devoting the financial and personal resources of its organization to "rearing laboratory urchins for eventual release onto the coral reefs," according to the Florida Chapter's Spring 2001 newsletter.

Synthetic chemicals (e.g., nonylphenol and its breakdown products) are capable of disrupting hormonal function, and are becoming more widespread in the environment. Those compounds are biotransformed to several stable metabolic products, including nonylphenol and its breakdown products. Many of those compounds, including nonylphenol, are lipophilic. Therefore, they are stored in fatty tissue, and are considerably more toxic than the parent compound (Giger et al. 1984; 1987; Granmo et al. 1989; Holt et al. 1992; Li and Schroder 2000; Reinhard et al. 1982).

Those compounds can function as estrogen mimics. Estrogen mimics can cause deformities in penises and testicles, in addition to reducing sperm counts in males exposed to those chemicals. Exposure to very small concentrations of these estrogen mimic compounds also has caused breast cancer cells to proliferate under laboratory conditions (Colborn et al. 1996). Marine mammals bioaccumulate nonylphenol (Ekelund et al. 1990). In addition to being components of household and industrial detergents, those compounds are added to products such as polystyrene and polyvinyl chloride (PVC) as an antioxidant to make the plastics more stable and less brittle, and to pesticides, contraceptive creams, and personal care products. Those chemicals can leach into water. Bacteria in animals' bodies, in the environment, and in sewage treatment plants (STPs) degrade those compounds into nonylphenol and other chemicals that can mimic estrogens (Colborn et al. 1996).

Approximately 40% (molar concentration) of the total nonylphenol in STPs can reach surface waters via secondary effluents (Ahel et al. 1994). During the 1980s, fish in streams exposed to discharge from STPs in England appeared to be sexually confused, containing characteristics of both sexes. Controlled tests were conducted with caged fish exposed to water flowing from the STP. After 3 weeks of exposure, levels of the estrogen "marker" in the fish exposed to the STP water in the stream had increased 1,000 times more than levels in control fish. In the summer of 1988, a nationwide study was conducted at 28 sites in England and Wales. Dramatic increases in the estrogen "marker" were found in all cases where the fish remained alive through the tests. In one case the increase in the marker for the exposed fish was 100,000 times the level in the control (Colborn et al. 1996; Jobling et al. 1998).

The use of alkylphenols, the breakdown product of alkylphenol polyethoxylates contained in detergents, was a strong suspect. Extended research tested fish exposed to alkylphenols to determine if: (1) these compounds caused estrogenic responses in fish similar to responses in breast cancer cells in the laboratory and (2) levels in the environment were high enough to cause the estrogenic responses in the fish. The answer to both questions was yes. The authors noted, however, that a range of chemicals could be contributing to the response observed in the fish exposed to streams with STP discharge (Colborn et al. 1996; Jobling et al. 1998). Toxicity of nonylphenol and its breakdown products to other organisms, including coastal organisms, also have been documented (Granmo et al. 1989).

The use of alkylphenol polyethoxylates has increased since the 1940s. Because of concern expressed during the past decade regarding the persistence and toxicity of these chemicals to aquatic life, several European countries banned use of the most common of these chemicals in household cleaners by the late 1980s. Additionally, 14 European and Scandinavian countries were to phase out use by 2000 (Colborn et al. 1996). In 1995, nonylphenol and its ethoxylates (NPEs) were added to Canada's list of substances that are toxic or are capable of becoming toxic. Partial justification for this concern was the presence of nonylphenol and NPEs in the effluent from municipal STPs and the knowledge that nonylphenol and NPEs have been shown to produce endocrine disrupting effects in fish and other organisms. An environmental risk assessment conducted recently in Canada determined that nonylphenol also should be considered toxic, based on the Canadian Environmental Protection Act (Davidson et al. 2000).

Currently, neither the EPA, nor FDEP have required or initiated monitoring to determine if estrogen mimic compounds (or any other harmful chemicals) are present in the treated effluent that is being injected into the highly permeable aquifers in south Florida. In fact, not only does the EPA not regulate, or require monitoring for nonylphenol and related compounds in drinking water in the United States, nonylphenol has not been placed on that agency's waiting list of compounds of concern, to be investigated in the immediate future (EPA Hot Line/Labat-Anderson, personal communication). Consequently, even effluent reportedly treated to "drinking water standards" can contain hazardous and toxic levels of nonylphenol and its breakdown products. Therefore, claims by the EPA that treatment of injected effluent will be upgraded to "drinking water standards" is of little value, even from a water quality standpoint.

Summary

Effluent injected into shallow wells in the Florida Keys has been shown to discharge rapidly into surface waters, including near sensitive coral reef ecosystems in the NOAA 'Sanctuary.' Studies similar to those conducted for shallow injection wells have not been conducted for deep injection wells, like those injecting minimally-treated effluent at the Miami/Dade facility and similar injections pending in Key West. Most recent results, however, suggest that induced discharge related to deep-well injection from that facility is occurring throughout the NOAA 'Sanctuary.' No information is available regarding the degree to which the treated effluent (even at "drinking water standards") injected into deep wells may be transporting ecologically hazardous and toxic substances, such as endocrine disruptors, to sensitive coastal ecosystems (e.g., the NOAA 'Sanctuary').

Nutrients have been the sole focus of the effluent-related studies in the Keys, in part because the rapidly increasing eutrophication is obvious even to the casual observer, due to planktonic and macro-algal blooms. Even if there was reliable scientific evidence to support the belief that significant amounts of excess nutrients in injected effluent were being adsorbed/taken up by the carbonate aquifers (and there is not), that information would not suggest that other pollutants (e.g., excess C, endocrine disruptors, viruses) were being adsorbed/diluted similarly, prior to discharging into environmentally sensitive areas like the 'Sanctuary.'

Likewise, even if contaminants such as endocrine disruptors were subjected to the same theoretical dilution processes as N and P, the environmental damage from endocrine disruptors occurs at concentrations orders of magnitudes lower than for nutrient pollutants. Therefore, even at highly diluted concentrations those compounds could present a significant environmental hazard to organisms in Florida Bay, as well as associated coral reefs in the NOAA 'Sanctuary' and newly-created 'Reserve.' The current state of knowledge regarding adverse impacts associated with aquifer-injection in south Florida provides support for a moratorium on any increase in the number of injection wells and the volume of injected fluids in south Florida until extensive investigations are conducted to determine the full extent of the damage that has occurred.

Conclusions

The regional karst aquifer system underlying south Florida is not a static system, but changes spatially and temporally, particularly in response to anthropogenic perturbations. The historic submarine groundwater discharge in south Florida occurred from the margin of the submerged carbonate platform, outcrops in terraces, and areas of discontinuities (e.g., karst dissolution/subsidence features, paleo channels). Data suggest that the historic discharge of pristine, low-salinity, low-nutrient ground water of constant temperature into Florida's coastal areas was significant in maintaining the associated ecosystems. The quantity and quality of that historic SGD has been and will be altered by: (1) aquifer injection of effluent and other ecologically hazardous wastes, (2) aquifer 'storage' and 'recovery,' (3) groundwater mining, and (4) structural mining of the aquifer system (e.g., limerock, sand, phosphate).

The same subsurface flow paths that supplied historic pristine ground water to coastal areas now may be points of preferential induced discharge for fluid wastes injected into wells along south Florida's coast. The 110 million gallons a day of minimally-treated sewage permitted for injection at the Miami/Dade facility, and smaller volumes injected in approximately 1,000 shallow wells throughout the Florida Keys, in addition to the 1.7 billion gallons of surface water proposed for ASR injection in south Florida are examples. Minimal dilution, dispersion, and adsorption should be expected for injected contaminants due, in part, to rapid travel times in the aquifer, prior to induced discharge into nearshore surface waters.

Current literature suggests that induced discharges containing aquifer-injected contaminants are occurring in the Gulf of Mexico, Straits of Florida, Gulf Stream, and Atlantic Ocean, and may be a factor in harmful algal blooms and hypoxia. Government agencies charged with implementing and enforcing the Clean Water Act and the Endangered Species Act have failed to consider the direct, indirect, secondary, and cumulative impacts of those groundwater alterations to Florida's marine species, including threatened and endangered species. By proceeding with permitting actions, in the absence of the required information, the agencies are negligent and therefore liable.

Acknowledgments

This article was excerpted from a copyrighted publication by CRC Press LLC, with permission from the publisher. Comments on the full manuscript were contributed by Barrett Brooks, Bill Burnett, Jaye Cable, Don and Karen DeMaria, Randall Denker, Jack Kindinger, Frank Manheim, June Oberdorfer, Jim Porter, Chris Reich, Don Rosenberry, Eugene Shinn, Ian Thomas, Zafer Top, and Patrick Yananton. Additional contributions to the full manuscript were made by the members and activities of the SCOR/LOICZ Working Group on SGD. Discussions with Phillip Dustan prompted more extensive consideration of the role of carbon in decline and death of coral species. Kerry Britton provided insight into aspects of biocontrol of fungal pathogens. Gray Curtis and the editor provided constructive criticism on the excerpts of the full manuscript that comprised this paper. Support was provided by Ellen Hemmert, Maurice Spitz, and Greg and Jim Thompson. Gratitude also is expressed to Pat Mixson for her assistance in gaining access to numerous USGS publications, to the UGA Reference Librarians for assistance in securing copies of various documents with limited availability, and to Thelma Richardson for graphics assistance. George Brook, Todd Rasmussen and Mark Stewart provided the ability to visualize the subsurface world of karst aquifers, and the

UGA Institute of Ecology provided exposure to a myriad ecological concepts, problems and solutions.

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Book Review

Oceanographic Processes of Coral Reefs: Physical and Biological Links in the Great Barrier Reef
by Eric Wolanski

Oceanographic processes are crucial to the understanding of coral reefs yet are often downplayed in attempts to explain how these intricate ecosystems function. Volumes that integrate the biological, physical, and chemical aspects of this subject are also rare. Eric Wolanski, however, has produced a very useful book and CDROM that will give readers an introduction to the biological and physical oceanographic processes of coral reefs. He has done this by focusing the book's subject matter on the key processes that underpin the world's largest continuous reef system, the Great Barrier Reef. Despite its Australian focus, this book will be highly useful for coral reef researchers everywhere. Chapters in the excellent text span the broad-scale regional processes, local oceanography, biological communities, and anthropogenic influences on coral reefs. An overriding theme of the book is the important role that linkages play within this ecosystem, whether these are between land and reef, or between individual reef components. The book also provides an excellent text for university courses that want an up-to-date and modern synthesis of the important oceanographic processes that define coral reefs.

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News from Zoos

Project Golden Frog takes a leap forward

The Baltimore Zoo recently received approval from the US Fish and Wildlife Service to import 20.20 adult Panamanian golden frogs (*Atelopus zeteki*), and 100 end-stage tadpoles to develop a captive population of threatened golden frogs. Researchers left for Panama on 27 December 2000 to search for and gather pairs of frogs in amplexus or tadpoles completing their metamorphosis stage. There are two main threats to the golden frogs—deforestation and a fungus that affects both adult frogs and tadpoles. The fungus is moving at a rate of 42 kilometers per year and will destroy the golden frog's habitat in two years or less.

The project, which initially received more than $30,000 from the AZA Conservation Endowment Fund, has also received grants from the Columbus Zoo, Oklahoma City Zoo, Cincinnati Zoo and Botanical Garden, Miami Metrozoo, and Cleveland Metroparks Zoo. The funding from these institutions will provide both US participants and collaborating Panamanian scientists with four-wheel drive vehicles and support for field research activities.

International Snow Leopard Trust

Since the creation of the Snow Leopard Species Survival Plan (SSP) and the International Snow Leopard Trust (ISLT), Woodland Park Zoological Gardens in Seattle has been integral to the snow leopard's survival. To further their commitment to this endangered species, The Woodland Park Zoological Society recently announced two challenge grants to be given to the Trust.

These grants could not have arrived at a better time. ISLT is already involved in starting and supporting conservation and research projects in 12 countries in the snow leopard's natural habitat—central Asia. With the current economic and political instability in this region, increased hunting is occurring for the animal's pelts and for traditional medicine. This places even more stress on the wild population.

There are an estimated 4,500 to 7,000 snow leopards remaining in the wild. The snow leopard is a keystone species in its native mountain habitat and to conserve this secretive cat, ISLT must deal with the ecosystem as a whole, especially the humans in the region.

Over the past 20 years, the SSP has managed a captive population of 244 and is proud of the genetically diverse population now found in zoos. A major achievement for the SSP was the birth of three snow leopards at Woodland Park in May 2000. ISLT provides a vital link between displaying snow leopards in zoos and conserving them in the wild.

New Avian Propagation Building at North Carolina Zoological Park

After two years of planning and one and a half years of construction, the RJ Reynolds Forestry Aviary at the North Carolina Zoo has been overhauled. The major problem with the renovation was what do with the their collection in the interim.

With no suitable back-up facility onsite and not wanting to give away their collection, an off-site Avian Propagation Building was constructed to hold their 70-bird, 26-species collection during the renovation. The new propagations building will help promote sustainable captive populations and drastically reduce the need to use wild-caught birds for zoo collections. One of the unique aspects of the project was including the zoo's aviary staff in the design and building process.

The building was designed with a central keeper area and a north and south wing. The north wing contains 22 flight areas and the south wing contains 18. Thirteen species showed various breeding, nesting or nest building behaviors during their stay at the new building. [Adopted from an article by Jeff Claffy, The AFA Watchbird.]

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

Carnivores 2002: From the Mountains to the Sea

Defenders of Wildlife announces its fourth national conference, *Carnivores 2002: From the Mountains to the Sea*. This conference will be held in Monterey, California November 17 to 20, 2002. It will focus on the biology and conservation of a full range of marine and terrestrial predators. For more information, contact Yvonne Borresen at 202-789-2844 x315, email carnivores2002@defenders.org, or visit www.defenders.org/carnivores 2002.

Chicago Botanic Garden hosts plant conservation conference

Ecology and Management of Oak Woodlands, the 2001 Midwestern Plan Conservation Conference, will be hosted by the Chicago Botanic Garden and held September 13 and 14, 2001. This conference is intended to provide a forum for exchanging research results on Midwestern conservation issues, for setting regional plant conservation priorities, and for developing and implementing collaborative conservation projects. For more information, Ed Lyon at 847-835-8278 or elyon@chicagobotanic.org.

Michigan conservation

Ruin and Recovery: Michigan's Rise as a Conservation Leader by Dave Dempsey is now available from the University of Michigan Press. Against the backdrop of national trends, *Ruin and Recovery* traces the evolution of the public movement to conserve Michigan's forests, fish and wildlife in the late nineteenth and early twentieth centuries. For more information, visit www.press.umich.edu.

Canadian wildlife

Environment Canada's Canadian Wildlife Service provides an informative site on species at risk in Canada <http://www.speciesatrisk.gc.ca/Species/English/Default.cfm>. The searchable site offers basic information on each species, including conservation status as assigned by the Committee on the Status of Endangered Wildlife in Canada and proposed recovery. The site may be searched by species or geographic distribution.

Announcements for the Bulletin Board are welcomed. Some items have been proivded by the Smithsonian Institution's Biological Conservation Newsletter.

Endangered Species UPDATE

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