

**Testimony on the
Status of Current Research on Coral Reef Ecosystems
and Factors Affecting Them**

**Presented to the
Subcommittee on the Environment,
Committee on Science, Space, and Technology
and the
Subcommittee on Oceanography, Great Lakes, and the Outer
Continental Shelf,
Committee on Merchant Marine and Fisheries
U.S. House of Representatives**

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I would like to thank Congressmen Scheuer, Lewis, Fascell, Hertel, and Brown for the opportunity to speak today at this Congressional Hearing on a subject of great interest and concern to the citizens of Florida, the United States, and the world: the current status of and research needs for coral reefs. My testimony will focus on the present status of Floridian coral reefs and offer a general list of research priorities.

Many coral reefs in Florida are declining at truly alarming rates. We have been monitoring coral reefs in Florida since 1984. The six monitored areas include two photostations in the Looe Key National Marine Sanctuary, two photostations in the Key Largo National Marine Sanctuary, and two photostations in the Biscayne National Park. Monitoring began in 1984 for photostations in the two National Marine Sanctuaries, and in 1989 in the Biscayne National Park. Each photostation consists of a plot of coral reef 10-15 m² in area, photographed at a high resolution with both black and white and color film. These six stations have in common that they are all inside protected areas.

All six regions lost coral species between the initial survey year and the most recent survey in 1991 (see Figure 1). Survey areas lost between one and four species; these losses constitute between 13% and 29% of their biodiversity. Unfortunately no reef was exempt. These extinctions are not species extinctions, that is these species still exist elsewhere in Florida and the Caribbean, they are local extinctions from the areas examined.

The amount of living coral on the reef is also declining (see Figure 1). Five of six stations showed a reduction in the percent cover of living corals.

One reef lost almost half of its coral between 1984 and 1991 (see Figure 2). Both branching corals (the elkhorn coral, *Acropora palmata*) and boulder corals (the greater and lesser star corals, *Montastrea annularis* and *M. cavernosa*) show declines. Normally these massive corals build the reef. For these common species, our data over the last seven years reveal that there is usually (1) a reduction in the total amount of live coral cover, (2) a reduction in the total number of individuals, and (3) a reduction in the number of the large, reproductively mature colonies in favor of much smaller individuals.

Few areas seem exempt. Coral loss is occurring in shallow water and in deep water. Coral loss is occurring in the Upper Keys and in the Lower Keys. In the one station that apparently grew, the increase in canopy branches of coral was offset by a loss of the understory branches from the same individuals for no net gain of coral.

Our data suggest that coral loss is accelerating. Losses between 1986 and 1991 were more than double the losses between 1984 and 1986. The highest rates of loss exceed 10% per year. Obviously, no reef can withstand this rate of loss for long and remain a coral reef.

Unfortunately, while we see coral dying, we do not see juvenile corals of the massive species recruiting to take their place. We have not seen recruitment of the massive coral species to any of the study sites.

The photographs reveal, in only a rudimentary fashion, the causes for decline on these reefs. Mortality of this magnitude is usually caused by hurricanes. South Florida usually receives hurricane damage every 6-7 years on average. Inexplicably, Florida has been without a direct hit from a major hurricane for the last 28 years.

"Bleaching" is an important source of coral mortality at our study sites. Coral bleaching is caused by abnormally high sea temperatures. High sea temperatures result in the loss of the beneficial symbiotic algae living within coral tissue. These algae normally provide coral with their food and oxygen, and the loss of these algae causes the coral to lose weight and eventually, under conditions of prolonged ocean warming, to starve to death. While recovery from bleaching is sometimes possible, bleached corals do not reproduce during the year they bleach. Bleached corals are also sterile for at least one year after that.

We do not know if the present trend towards higher tropical sea temperatures is caused by global warming. We can say, however, and with a high degree of certainty, that since corals already exist at or near their upper lethal temperature, any further ocean warming caused by global climate change will have an immediate and adverse effect on the survival of coral reefs. It is fully conceivable, but not proven, that we are already seeing this in current coral bleaching events. These events are global in scale, not confined to Florida or the Caribbean. The *Workshop on Coral Bleaching, Coral Reef Ecosystems and Global Climate Change* sponsored by the National Science Foundation, the Environmental Protection Agency, and the National Oceanic and Atmospheric Administration (1991) concluded that the possible use of coral bleaching as an early warning indicator of global warming "was seen as strong reinforcement of the need for systematic monitoring" of coral reefs.

Coral diseases also contribute to reef decline in the Florida Keys. Whereas no examples of white band or black band disease were present in any of our initial surveys, by 1991 all stations exhibited coral disease. White band is of unknown pathogenic origin; black band appears to be caused by an infection of the blue-green alga, *Formidium*. Unfortunately, we know little about the epidemiology nor anything about the physical or biological factors that promote infection and confer lethality to these diseases.

Many species of bluegreen algae are pollution indicators, and there is speculation that elevated nutrients from improper waste disposal practices in the Florida Keys may promote the growth of black-band disease. This constitutes a reasonable speculation, and one which is worthy of investigation, but at this time, we do not have proof whether observed increases in the frequency of this disease relate to human activity in the Florida Keys.

There is a developing body of evidence to prove that many nearshore environments, those areas within a 1000 meters of shore, are being seriously impacted by a variety of human activities. Unfortunately, we do not have the same kind of certainty to explain coral degradation on reefs some three to five kilometers offshore. The replacement of coral-dominated areas by algal-dominated areas is suggestive of nutrient loading in these normally low-nutrient reef waters, but we do not have adequate information to prove or disprove this contention. We can not say with certainty whether these changes are due to mother nature or human nature.

The *Workshop on Coral Bleaching, Coral Reef Ecosystems and Global Climate Change* (1991) reached a similar conclusion about coral reefs world-wide: "On a global average basis, coral reefs are being lost or degraded at an alarming rate,...but at present we lack the data needed to confirm, quantify, or explain this trend on a scientific basis." As with our own study described above, this workshop also concluded that "anthropogenic environmental alterations on global, regional, and local levels are reason for serious concern about the health and local survival of coral reef ecosystems." The group therefore strongly recommended "prompt development of a research-oriented coral reef monitoring program of global scale, a coordinated program of research at laboratory, microcosm, and field scales." Furthermore, they recommended "the development and expansion of a scientifically based, internationally coordinated long-range monitoring program oriented toward reef environments and biology." Finally, these experts emphasized in the strongest terms that "such a program would yield immediate important results in terms of major theoretical and applied scientific questions related to spatial variations, in addition to providing the longer-term data base needed for other studies." (see Appendix A for further references)

While the situation I have described is alarming, unfortunately I can neither provide you with proof as to the cause for these disturbing trends, nor offer you a specific management plan to counteract these declines. HR Bill 4537, the "Coral Reef Environmental Research Act" currently pending before Congress, would go a long way to meet the research needs that are so obviously called for by these results. The bill is a clear and forceful proposal to acquire the information needed to institute wise management practices. I personally wish to congratulate the Bill's authors, Congressmen Scheuer, Lewis, Fascell, Hertel, and Brown, and their respective Subcommittees, for this insightful and much-needed piece of legislation.

I wish to make an unequivocal statement on the absolute need for research in relationship to environmental management and environmental legislation. Principle 15 of the recently signed United Nations *Conference on Environment and Development* states the following:

In order to protect the environment, the precautionary approach shall be widely applied to states according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

While this Principle initially sounds laudable, the way the statement is worded, it is not clear if this Principle recommends drastic remedial action before it is known what to do. For instance, in response to the Crown-of-Thorns starfish plague in the Indo-Pacific, divers were sent out to "save the reef" by cutting up the coral-eating starfish. They found out only later that, like the sorcerer's apprentice, each dismembered starfish arm grew into a whole starfish! From uninformed, but good intentions, they had actually multiplied the problem twenty fold, one time for each starfish arm. Good science in the service of management will avoid such disasters; House Bill 4537 will fund this science.

Effective environmental management requires an understanding of the dynamics of the ecosystem. Environmental management is analogous to bank management: not only do you need to know the assets in the bank at any one time, you also need to know the rate of deposits and withdrawals. Likewise, the environmental manager needs to know the condition, or inventory of the "biotic reserve," and also the natural rate of recruitment and loss. Information on change requires long-term monitoring, and I am especially pleased that the Bill highlights the need for this kind of information. As impressive as the studies that I have shown today may seem, we need longer studies, on larger spatial scales, to really understand this amazingly diverse and extraordinarily complex environment.

There is a need, either in future legislation or as an amendment to HR Bill 4537, to include the National Park Service as a full partner in the legislation. The reasons for this are quite simple and quite compelling: National Park Service holdings already include 25% of Florida's coral reefs. These are among the most highly developed coral reef habitats in the Florida Keys (the Biscayne National Park, the Everglades National Park, and the Dry Tortugas National Monument). Our system of National Parks also includes some of the best reef habitat anywhere in the Caribbean (the Virgin Islands National Park and the Buck Island National Monument). NPS has on its staff world-renowned coral reef scientists dedicated full time to the study and management of coral reef ecosystems. They have been doing this for more than a quarter century. The legislation which created NOAA's marine sanctuaries is identical to that which created NPS's: "to protect and preserve these environments in perpetuity for future generations." The National Park Service needs these research funds as much as any other government agency, and although not officially represented here today, is in an excellent position to contribute to the scientific research proposed by this Bill.

There is also a need to be sure that the funds proposed for research are distributed on the basis of competitive grants. Peer review is to science what freedom of speech is to democracy: it is the *sine quo non* of the process. It is the means by which the taxpayer will get the best results for his tax dollar. The National Park Service, the National Oceanic and Atmospheric Administration, the National Science Foundation, the Environmental Protection Agency, and the U.S. Geological Survey all have such programs, and these programs should be encouraged.

Focusing on corals, studies in the following areas should have priority because results in these categories will produce immediate benefits to both environmental management and

basic science:

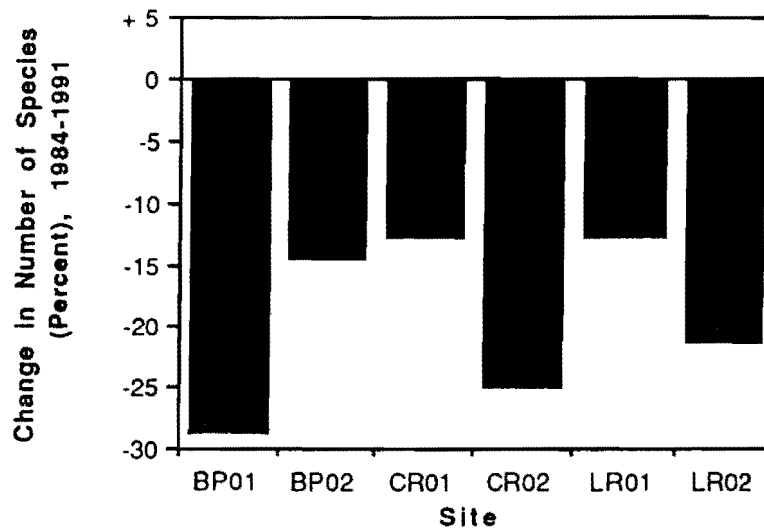
1. Continuation and expansion of long term monitoring studies
2. Initiation of recruitment studies
3. Initiation of studies on the impact of visitors on the reef
4. Investigations on the affects of nutrients on the growth and survival of
 - a. Corals
 - b. Algae
5. Investigations of the distribution and origin of nutrients on the reef tract
6. Investigations on the consequences of current waste water disposal practices in the Keys to both:
 - a. Nearshore mangrove, seagrass, and patch reef ecosystems
 - b. Offshore coral reef ecosystems
7. Analysis of coral disease, including the
 - a. Influence of nutrients on black-band disease
 - b. Nature and extent of white band disease
8. Improvement of our understanding the physical oceanography of Florida Bay, the Florida Keys, and the outer continental margin to understand:
 - a. Mechanisms of water transport between the land and the reefs
 - b. Origins of water coming into the Florida marine seascape
9. The relationship between coral bleaching and global climate change

In conclusion, and as a general observation, it must be made clear to all here assembled, that controlling the growth of human populations and reducing the amount of pollution that humans produce to foul the earth's atmosphere and oceans will do more to insure the survival and continuance of coral reefs than any other specific recommendation that we might make.

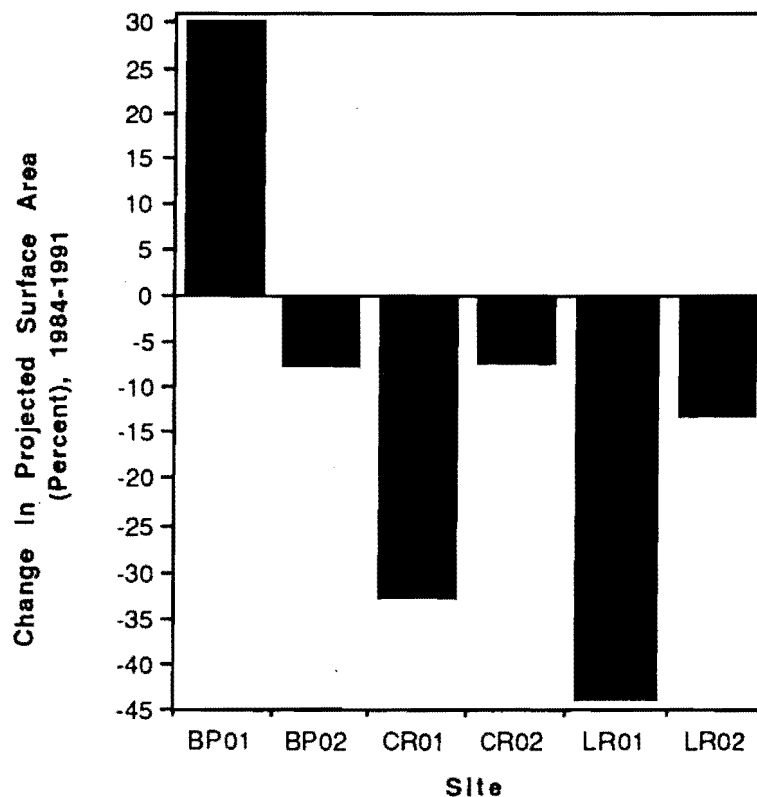
Appendix A. Previous Workshop Reports

- D'Elia, C.F., R.W. Buddemeier, and S.V. Smith. 1991. *Workshop on Coral Bleaching, Coral Reef Ecosystems and Global Change: Report of Proceedings*. Maryland Sea Grant College, University of Maryland; College Park, MD. 49 pp.
- Harwell, C. (Ed.) 1991. *Report on the Research Planning Workshop for the Florida Keys National Marine Sanctuary, Miami Florida*. Sanctuaries and Reserves Division NOAA/NOS/OCRM. Washington, DC. 63 pp.
- Kleppel, G.S., and W. Seaman, Jr. (Eds.) 1989. *Fishery Recruitment in Florida Waters. Toward a Predictive Capability*. Florida Sea Grant Tech. Paper 57.
- Miller, J.W. (Ed.) 1988. *Results of a Workshop on Coral Reef Research and Management in the Florida Keys: A Blueprint for Action*. National Undersea Research Program, Research Report NURP-88-5. NOAA, Washington, DC.
- Olson, C. 1991. *The Florida Keys Environmental Summit Report*. Florida Keys Land & Sea Trust, Key West, Fl.
- Simmons, G.M. et. al. 1991. *Undersea Research Needs in the Florida Keys*. National Undersea Research Program Research Report, University of North Carolina, Wilmington, NC.

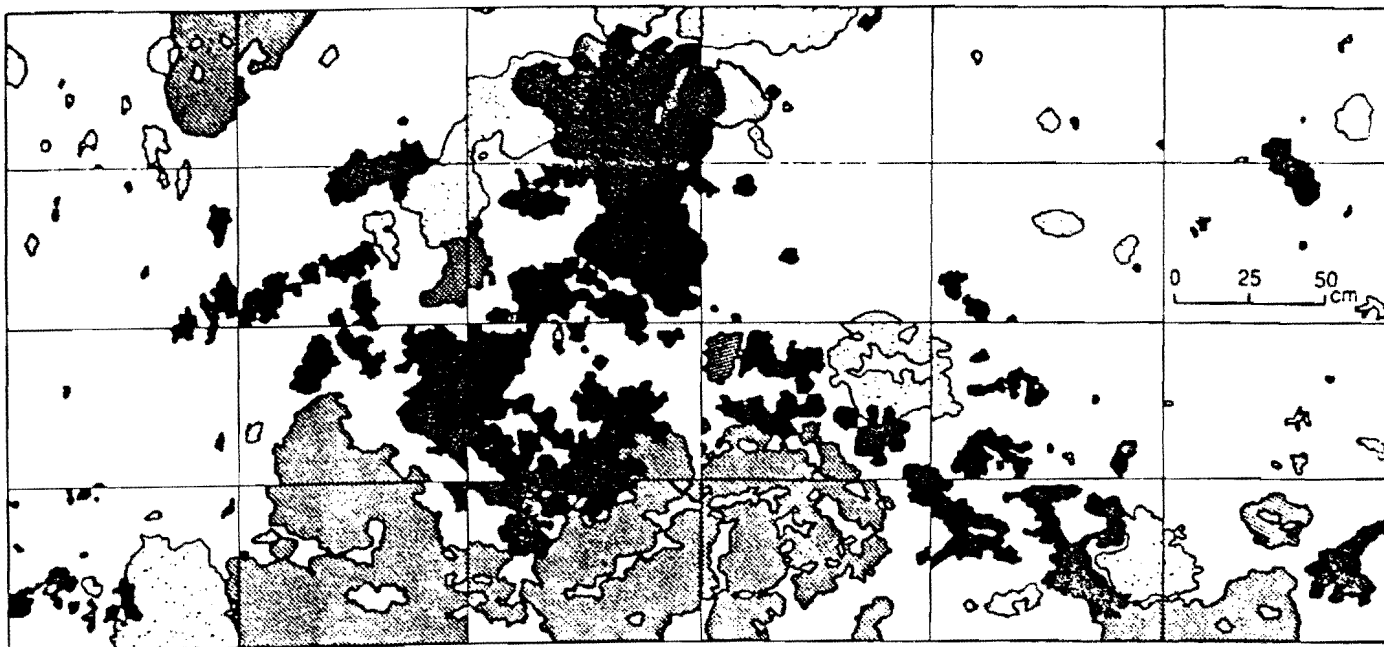
Loss of Coral Species



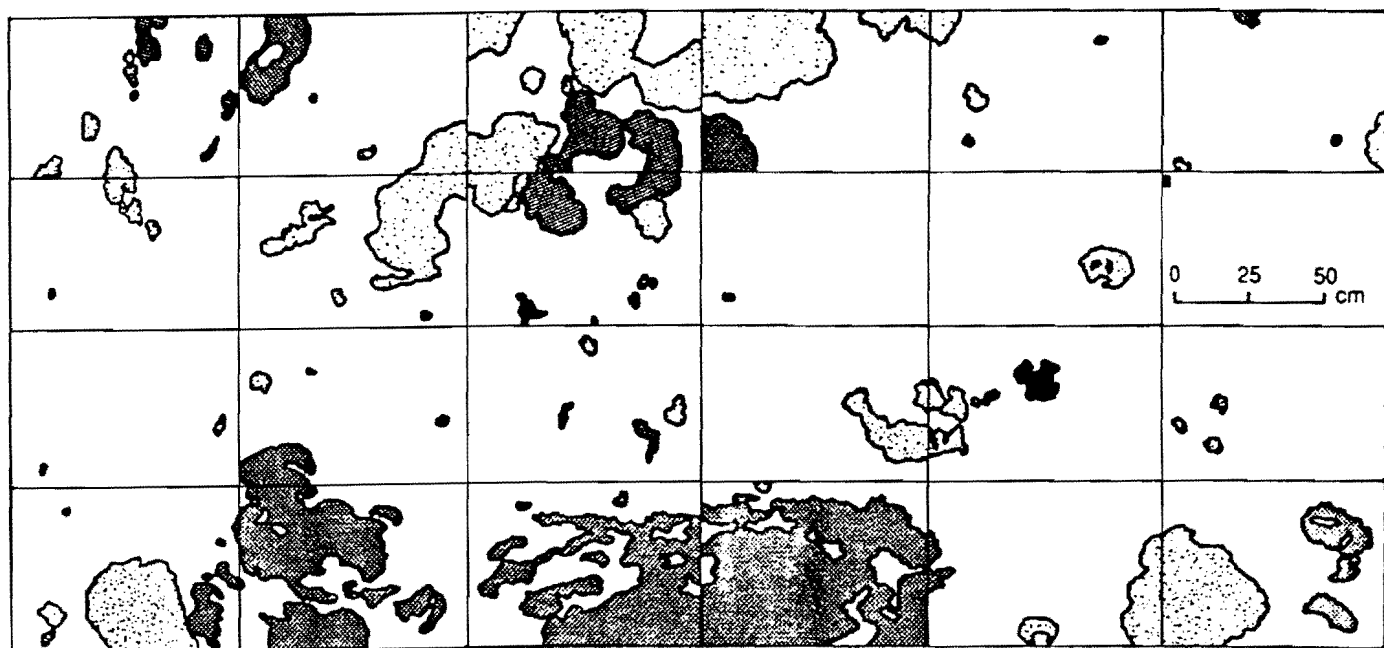
Loss of Coral Cover



Note: Changes at sites BP01 and BP02 are for 1989-1991.



1984



1991



Acropora palmata



Montastraea annularis



All other coral species

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IMPROVING DECISION MAKING IN CORAL REEF RESTORATION

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Coral reefs from the Caribbean and western Atlantic are under siege. The most appropriate course of immediate action is to replace damaged and disturbed reefs with fully functional, restored ecosystems at a rate resulting in no-net loss of ecosystem value (i.e. rate of reef destruction offset by rate of reef repair).

Restoration is an attempt to overcome - through manipulation - the factors that restrict natural recovery. In performing reef restoration, scientists are given a powerful opportunity to test our understanding of reef structure, development, and function. The underlying logic to successful restoration must be rooted in an integrated, multidisciplinary approach that includes engineering, geologic, and biologic factors. Reef restoration, therefore, provides a unique, fundamental challenge to our understanding of reef ecosystems. It allows scientists to test and evaluate individual aspects of reef development and ecosystem function precisely. It tells us what we know, what we don't, and what will work in practice. The implications are to see whether, in light of our present knowledge, we can recreate a reef that functions - and functions properly.

Although the science of reef restoration is in its infancy, we must glean as much as we can from the projects completed to date. As well, we must borrow from the vast knowledge gained in performing wetland, and coastal restoration programs. Certainly, we will learn more from our failures, because failure will reveal inadequacies in these projects. Success in future efforts will be based on our ability and political will to implement multidisciplinary, scientifically-based restoration efforts with ecologically definable and testable goals.

To date, the restoration of many ship-damaged reef ecosystems have been driven by financial and legal constraints and not science. These projects fail to restore the impacted resource to a level that is functionally equivalent to a pre-disturbance baseline. "Successful" reef restoration requires that a scientifically-based success criteria be established. These goals mandate the implementation of an injury assessment and restoration protocol that sets a foundation upon which all aspects of the restoration planning is based.

After a vessel runs aground injuring a coral reef, an assessment should be prepared to quantify and qualify the resultant injury. Because many of the damage actions may result in litigation between the trustee and the responsible party, the assessment must also substantiate or refute the description of events that caused the grounding. The site should initially be treated much like that of a crime scene and accordingly, physical evidence from the site needs to be documented, collected and quantified.

Coral reef triage efforts should be implemented in concert with the initial injury assessment for salvaging the living resource. Following these tasks, a detailed damage assessment and restoration plan (DARP) should be performed. The DARP should quantify the injury to both the living and non-living resource. This includes mapping and calculating both the area and volume of impacted reef. Calculations detailing changes in the cover of benthic organisms are also critical. To this end, detailed ecological surveys of adjacent undamaged reefs will be necessary to formulate a pre-injury working baseline.

Once the injury assessment portion of the DARP is completed, a variety of restoration alternatives should be outlined. This includes all options from "no-action alternatives" to "complete restoration" where there is a return of the ecosystem to an approximation of its condition prior to disturbance. In calculating monetary damages requires an assessment of not only the injury and its restoration, but a determination of the length of time for the injured area to functionally return to pre-impact levels. These damages are based on scaling of the restoration over time to compensate for interim ecosystem losses.

To properly undertake the injury and damage assessment strategy as outlined above requires a multidisciplinary team of individuals dedicated toward a common goal. This approach to impact assessment and restoration will provide an ecologically defensible basis upon which to document the injury, set restoration goals, implement the appropriate restoration program, and gauge overall project success.

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