WATERSHED MANAGEMENT FOR ENDANGERED AQUATIC AND RIPARIAN SPECIES: FACTS AND FALLACIES

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ABSTRACT: River basin management is becoming increasingly complex in the United States since watershed managers are required to take into consideration the threatened and endangered (T&E) species that inhabit aquatic and riparian ecosystems. Unfortunately, too many fallacies and political agendas have crept into the picture. Suppositions and hypotheses fly everywhere in the political-legal environment under the guise of making "conservative" decisions for preservation of T&E species, but few are rigorously tested. Some of the fallacies are: single species management works, extrinsic factors cause the problems, simple solutions are available, fluvial systems are stable, we understand the natural range of variability, and ecosystems can be restored, etc. Watershed management decisions in the 21st century related to T&E species must be founded on the basis of solid science.

KEYWORDS: Threatened and endangered species, riparian, cumulative effects

INTRODUCTION

River basin management is becoming increasingly complex in the United States since watershed managers are required to take into consideration the threatened and endangered (T&E) species that inhabit aquatic and riparian ecosystems. The presence of conflicting environmental legislation and the tendency to settle basically scientific disputes with litigation has made watershed management even more complicated. This situation warrants the application of as many facts as we can command in order to arrive at sound river basin management decisions. Unfortunately, too many fallacies and political agendas have crept into the picture, mudding the waters of our decision-making processes. Suppositions and hypotheses fly everywhere in the political-legal environment under the guise of making "conservative" decisions for preservation of T&E species, but few are rigorously tested. Some of the fallacies are: single species management works, extrinsic factors cause the problems, simple solutions are available, fluvial systems are stable, we understand the natural range of variability, and ecosystems can be restored, etc. In reality, a more factual understanding of aquatic and riparian systems is needed. These ecosystems are highly complex, dynamic, variable in their characteristics, and very resilient. Watershed management decisions in the 21st century related to T&E species must be founded on the basis of solid science. This paper examines some of the untested assumptions regarding T&E species in the context of watershed management.

RIPARIAN AND FLUVIAL SYSTEM DYNAMICS

Any analysis of riparian ecosystems must take into account the stark fact that riparian areas are complex, diverse, and constantly changing because of the highly dynamic fluvial systems in which they occur (Svejcar 1997). Riparian ecosystems are simply not static. Understanding and management of riparian ecological systems requires a recognition of the role of disturbance and the evolutionary experience of riparian organism within the context of regional ecosystems. Like streamflow regimes and hydroclimate, riparian ecosystems have distinct local and regional distinctions (Lins 1997). Land managers must be able understand and assess the following dimensions of disturbance: 1) type (abiotic, biotic, or interactions), (2) regime (intensity, frequency, spatial scale, temporal scales relative to annual or life cycles), (3) ecological/physical system (hydrologic regime, geomorphic type, landscapes, populations, taxa, etc.), and (4) regional/local context (within, adjacent to, or encompassing riparian zones).

Short-term disturbances in riparian ecosystems are easier to comprehend and observe. The short-term view of things can result in bias by the observer as to the real dynamic state of a riparian ecosystem. The 100-year flood that comes along and "surprises" humans is nothing more than another creative disturbance in the long evolution of a riparian zone. Long-term disturbances, particularly those out of the current observational and historical range of humans, may confuse our interpretation of the dynamic state of riparian ecosystems and the real magnitude of disturbance we observe. For example, streams and riparian zones in the Great Basin region of the western United States are still adjusting to the drying up of late Pleistocene lakes, and consequent lowering of base-levels (Masters et al. 1991). Streams and their riparian zones in the Southwest have had to respond to the disturbances of four major sequences of aggradation and degradation at intervals of 150 to 400 years over the past 2,100 years (Grissino-Mayer 1996).

The dynamic nature of riparian ecosystems and the disturbances, which create and shape them pose major challenges to land managers. The goal of riparian and watershed management should be to maintain the natural array of disturbances which sustain the unique biota living in or dependent upon riparian ecosystems, and to control the anthropogenic disturbances which could exceed the resistance and resilience characteristics of these ecosystems.

A fundamental concept handed down by many hydrologists and geomorphologists over time is that riparian ecosystems are very dynamic and that stability is relative to the time scale (Heede 1981, 1992). Logic would then require that change is the required norm for riparian ecosystems, and rating riparian conditions on a selected stream over a period of time is also relative, with perhaps no one period being 'better' (or pristine as some would suggest). Another fundamental concept is that ecosystems adjust to current day conditions, some like rangelands more slowly than riparian. Man continuously provides inputs to these ecosystems that inevitably cause changes, some irreversible. When T&E species are involved, the challenge is to understand the system's processes that can potentially be changed (maybe only temporarily) to provide the species an opportunity to adapt. In the context of watershed management, the number of components that may need to be examined, much less changed, is often beyond the scope of many resource management agencies. In addition, a remedial action for one species may conflict with the needs of another. Additionally, there is little understanding for the degradation and aggradation processes by which riparian ecosystems exist. Thus a pre-stated condition, e.g. pre-settlement, pristine, etc., is likely unachievable in practical terms and probably should not be a criterion defining watershed management actions. Scientific evidence exists about various resource qualities (e.g. soil, water) that permit us to prescribe reasonable management actions couched within existing environmental conditions to mitigate adverse effects on T&E species, and where it is lacking we should endeavor to discover and understand the processes of species-habitat interaction. However, this is not to imply that the such actions are economically practical or long lasting. The capability of any site remains a fundamental constraint reducing the desired effect of any management action. In some instances, the cumulative effects of natural and 'man-induced' influences produce unique perhaps nonreproducible habitat conditions within our lifetime.

Range of Natural Variability

Forests and rangeland watersheds play important roles in the hydrological cycles and the functioning of riparian and aquatic ecosystems. Properly functioning soils, watersheds, and riparian areas are very important for retaining and supplying the moisture that supports ecosystem sustainability (Medina et al. 1996). It is simplistic to assume that the hydrology of watersheds will always stay within the range of variability observed in the past two centuries. The longer we observe, the greater the likelihood that hydrologic responses will exceed the measured range of variability. Abrupt or significant fluctuations in stormflow magnitudes and baseflows can be indicators of anthropogenic disturbances which might be deleterious to T&E species and ecosystem sustainability, but are also quite normal as the length of record increases or when the climate changes.

Some ecosystems have natural, long-term oscillations in their climates and hydrology which transcend the measured "historic range of variation" (Grissino-Mayer 1996). Unless these oscillations are understood, it is difficult to determine and interpret what is truly a significant deviation from the historic range of variability, and what the consequences of that deviation are for what humans define as sustainability. Annual water yields, seasonal peakflows and low flows, flood frequencies, and timing or duration of peakflows and low flows are only useful indicators of sustainability if they are related to changes in land management or natural disturbances that could negatively impact ecosystems. The historic range of variation depends on the length of record, and will be altered continuously as the length of hydrologic records increases or as climate changes occur. Temporal and spatial variations in climate make this indicator difficult to interpret and apply. The real questions that need to be addressed are: 1) Has the hydrologic regime been disturbed from a natural dynamic state to a permanently disturbed state or a temporarily disturbed state (Kauffman et al. 1997), and 2) Is there any linkage between a deviation from the historic range of variation and the sustainability of T&E species? If there is no linkage and the disturbance is only temporary, then deviation from the historic range of variability is not useful for analyzing impacts on T&E species.

ECOSYSTEM RESTORATION AND VEGETATION - UNGULATE DYNAMICS

A common goal of some restorationists is to 'restore' riparian habitats to a pre-existing condition, most often defined as 'pre- European'. This view of presettlement conditions being the 'best' and/or used as reference benchmarks for restoration may be untenable. First, evidence of preexisting conditions is rare and difficult to obtain because many events, e.g. climatic changes, volcanism, floods, droughts, debris flows, wildfires, etc, have cumulatively influenced riverine corridors and altered in many cases evidence of vegetation and channel geomorphology. Thus, much of what we think we know remains qualitative. Second, man has always been part of the ecosystem processes that have affected riparian environments. This is still the case today. Third, herbivores (i.e. ungulates, rodents, and insects) have also been a major historic factor affecting the vegetation attributes of riparian environments (Pieper 1994).

Another challenge of watershed managers requires considering the chemical, biological and physical processes that cumulatively may have adverse effects on T&E species. Herbivory is an example of a biological action that is presently viewed as impairing ecosystem functions for T&E species. However, direct evidence is generally lacking about cause and effects. More important there exists a limited understanding of the cumulative interactive effects of many factors with herbivory (Augustine and McNaughton 1998, Crawley 1993, Schinski and Whitham 1989). Some managers would opt to eliminate livestock as an ungulate influence, while ignoring other wildlife ungulates as a contributing factor (Medina and Rinne 1999). The latter option may be viewed as the 'natural' approach to reaching pre-settlement conditions. What changed? Perhaps nothing since the ecosystem will continue to function under some influence of herbivory. Furthermore, many plants have adapted mechanisms to deal with herbivory, and these mechanisms include a variety of complex intrinsic physiological functions in response to extrinsic influences such herbivory. Hence, answers to T&E species management are not as simple as eliminating one variable. Such actions could result in greater environmental consequences that may directly or indirectly adversely affect the target T&E species. Consider the case of livestock grazing on riparian habitats where exotic plants such as tamarix (Tamarix spp.) are in the process of being established. Removal of the biological agent (ungulate) may be the release impetus for the plant becoming established and dominant in the system. Which biological factor will have the greatest cumulative effect on the ecosystem, much less T&E species.

RECOVERY, SINGLE OR MULTIPLE SPECIES APPROACH

Southwestern native fishes are low in diversity, often disjunct and unconnected in distributions, and mostly federally threatened and endangered species (Rinne and Minckley 1991). Following enactment of the 1973 Endangered Species Act (ESA), there was extensive listing of many species including fishes in the Southwest (USA). The listing process was the initial step and provided legal protection under the Act. However, as Johnson and Rinne (1982) pointed out, listing and protection *per se* under the law will not sustain rare and declining species. Rather, it is recovery actions, on the ground, that ultimately have the potential to restore species in range and numbers.

The Act provided for recovery teams and plans to be formed to address listed species. In part, because of the extensive listing of species after institution of the Act, recovery plans were developed on a species by species basis to urgently manage the ever-increasing list of threatened and endangered (T&E) species. Accordingly, single species management became the primary *modus operandi* for attempting to recover species (Rinne and Stefferud 1999). The question becomes, "Is this the best approach to recover and sustain rare and declining fishes in aquatic habitats of the southwestern United States?"

T&E species, largely by default became the focus around which much of the management of land use activities revolved. In a sense they were "indicators" of the state of the environment. Indicator species is not a new term, being introduced in the late 1970s into the USDA Forest Service's terminology (Rinne 1984). However, in contrast the concept of managing National Forest lands to maintain diversity of species across the landscape was penned in the 1976 National Forest Management Act. Therefore, within a few years after the ESA, the concepts of single or indicator species and diversity of species management were in place. Nevertheless, with fishes the approach, until the mid-to-late 1980s, has been a single species approach. To date, no species of southwestern T&E fish has been either de- or down-listed. Again, the question has to be asked, "Can we recover species on an individual, or single species, as opposed to a multiple species, ecosystem, or watershed approach?" Similarly, "Can we recover and sustain native fishes without using a more holistic, watershed/river basin, multiple species approach?" Some examples of efforts to date may assist us in answering this question.

Native southwestern trouts

There are three trouts native to Arizona and New Mexico; one endangered, one threatened, and one sensitive and in process of being considered for federal listing status (Rinne 1988). The two listed species, the Gila trout (*Oncorhynchus gilae;* endangered) and Apache trout (*O. apache)* have sustained extensive efforts on a single species approach toward their recovery over the past almost 3 decades. However, neither has been down or de-listed. Rinne (1988) first suggested it and later by Propst and Stefferud (1992) that a basin or watershed, larger landscape approach should be taken in recovery efforts for these species. In one case, this approach has been taken for the Apache trout (Rinne and Janisch 1995). The Gila trout was purported to be near down listing status in the late 1980s when a wildfire occurred on the watersheds of the largest population and type locality stream and abruptly and dramatically removed this recovery option. It also pointed out the importance and perhaps necessity of recovery species in a watershed context. Further, superimposed on a watershed approach could be a multi-species management strategy.

Native cypriniform species

Most of the native fish fauna in the Southwest is comprised of cypriniform species, or small-sized (< 100 mm) minnows and suckers. Two of these species, listed as threatened, are the spikedace (*Meda fulgida)* and loach minnow (*Rhinichthys osculus)*. Both are short-lived, habitat specific species that are markedly reduced in range and numbers (Rinne 1988, 1992). Another component of the ESA is to designate critical habitat for listed species. A recent intent to sue the listing agency, the U.S Fish and Wildlife Service, for not properly addressing the habitat of these two species has resulted in a rash, "shotgun approach" of listing streams, both occupied or suitable for these species, in an attempt to "recover" or sustain both species. Although the law may dictate this process, in reality, critical habitat recovers nothing. It as mentioned above, is only a protection action that says keep off to any and all activities within these designated reaches of stream. In contrast, what is needed is understanding how these two species, which yet co-occur in some streams along with several other, unlisted native fishes, function in a multiple species, community context (Rinne et al 1998, Rinne et al. 1999). Information is needed on fish community dynamics relative to natural (i.e. cycles of flood and drought and flow regimes, geomorphic influence, wildfire) and human-induced (i.e. grazing, recreation, roads, mining, diversions and pumping). In summary, a watershed, ecosystem, multiple species approach should be the direction for effective conservation and management of T&E species in the future

COMPLEXITY AND SIMPLICITY

The first and most simple step is agreeing that a multiple-species and watershed or landscape approach is prerequisite for recovering T&E fishes. The next and much more complex step, is how to approach such a paradigm. As it has been stated, ecosystems are more complex than we think, and more so, they are more complex than we know how to think. Further, it requires considerable resources to approach management of any resource, T&E fishes or otherwise. Nevertheless, to continue to manage in a context of simplicity, whether it is based on a single species, relative to a single land use, or a single stream or reach of stream will lead to resource bankruptcy.

An example of a simple approach to a complex problem can be illustrated with the spikedace in the upper Verde River. In a period of 6 years, the species has gone from being common to abundant in the upper reaches of the Verde to completely absent from most sampling effort. Natural and management or human-induced influences during this time period included flooding, lack of flooding, change in grazing management, aquatic habitat change, and changes in fish community structure (Rinne and Stefferud 1997, Rinne et al. 1998).

Following significant flooding in 1993 and subsequently in 1995 spikedace were most abundant, and native fishes predominated the fish community (Rinne and Stefferud 1997). From 1996 to present, a generally drought or low flow hydrologic regime has persisted. Commencing in 1997 domestic livestock were removed from the river corridor; there has been no grazing on the upper river corridor since 1998. Riparian vegetation has responded dramatically (Medina and Rinne 1999), spikedace have become very rare, and exotic fish species now dominate the fish community. Obviously, the question becomes: "What are the relationships and interactions of these factors?" To make simple statements relative to this question would be naive at best. One cannot simplify explanation of such a mosaic of multiple, interactive factors without a high probability of failure in adequately providing the proper course of action for land managers, primarily the US Forest Service, on this reach of river.

On the other hand, it does not preclude one from commencing to dissect out the various factors in well-designed, controlled, scientifically sound studies. For example, several questions to ask and research in this context are: 1) Does the change in habitat (i.e. dramatic increase in stream bank and in-stream vegetation as a result of grazing removal) favor native or nonnative fishes; 2) More specifically has the change in habitat (physical and biological--or increase in predator species) been detrimental to the threatened spikedace; 3) Has the lack of flooding in presence of grazing management changes interactively influenced fish community composition or more specifically, spikedace; and 4) What are the relative roles of other, extrinsic or watershed influences in effecting the changes seen in habitat and fish community structure in the upper Verde River?

In simple form, the first question could be addressed by removing vegetation of selected reaches of stream to determine how fish community structure responds. Questions one and two could be addressed simultaneously by removal of nonnative species and vegetation mechanically or by controlled grazing design. In other words, to address the multiple factor, cumulative intrinsic (nonnative fishes, habitat change) and extrinsic (watershed, landscape) one needs to "treat" a single factor and determine the response of one or more related variables. Based on results, additional factors can be interactively treated to determine resource response.

CONCLUSIONS

In summary, one cannot be naive and approach management of a complex system such as watersheds in a simple approach. However, it behooves researchers and land managers to cooperatively dissect, examine singular factors in a cause and effect approach to begin to understand and manage the complexity of the system.

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