Native aquatic plants and ecological condition of southwestern wetlands and riparian areas

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Abstract.-The determination of the ecological condition of wetland and riparian habitats has been the focus of research by many scientists, because of the importance to understand the processes and related functions of these systems. Research on montane wetland and riparian systems has shown the relative importance of native aquatic plants in maintaining these systems in a functional condition. The presence or absence of key species is used as an indicator of the ecological condition, and desired ecological condition of wetlands and riparian habitats can be expressed in terms of the species composition and abundance of native aquatic plants. This type of information is needed by resource managers in defining the endpoint of their management actions. Information is presented on the functional role of these species in sustaining the biological and physical integrity of these habitats.

INTRODUCTION

Wetland and riparian habitats of the Southwest are extremely valuable natural resources. These areas are very productive owing to their capacity to produce:

- High volumes of forage for herbivores,
- Good water quality, and
- A diverse flora and fauna.

Unfortunately, most of these habitats are in a degraded condition as a result of natural events (e.g. floods, fires), man-induced activities (e.g. roads, recreation), and animal-induced activities (e.g. grazing, trampling). Many restoration tactics have been tried over the past 75 years, including reseeding, structural stream improvements, modified livestock grazing systems, and exclusion from grazing. Unfortunately these efforts produced limited results because the symptoms were treated, rather than the causes. In most cases the primary cause of degradation of riparian and wetland areas is loss of the native aquatic flora.

Despite the extensive distribution of Carex and *Juncus* species in riparian meadows and wetlands of the Southwestern United States, there is a great lack of information and understanding of the role these plants play in maintaining healthy, functional ecosystems. Carex wetlands in parts of the Old World, such as Iceland have been managed for forages for at least 1,000 years (Ingvason 1969). Herein I discuss the value and function of a selected group of native aquatic species of Southwestern riparian and wetland habitats, namely species of the genera Carex, and *Juncus,* and how such species contribute to the enhancement and sustainability of a desirable functional condition. A list of species found on fully functional (near pristine) habitats is presented and used as a basis for assessing the ecological condition of other habitats. In addition, key species for use in restoration are suggested. Results presented are taken from riparian research being conducted on the Apache-Sitgreaves National Forest (A/S NF) and Coconino National Forest.

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FUNCTIONAL CONDITIONS

For purposes of clarity 'desirable functional conditions' are defined as being a set of habitat conditions that are exhibited on an ecosystem, such as a riparian or wetland site. The goal is not to define the ecological status, e.g. succession, or channel type, but rather the condition of the habitat, since riparian and wetland ecosystems are capable of being functional at any ecological status. A comprehensive description of desirable functional processes is provided in Medina et al. (this issue).

CHARACTERISTICS OF A FUNCTIONAL RIPARIAN ECOSYSTEM

1. **Stable streambanks** - As defined by their capacity to withstand repeated hydrologic events without significant loss of bank material, owing to their inherent geological character and the presence of vegetation. Alluvial systems characterized by cobble, gravels and sands, are by nature unstable even with the presence of vegetation, whereas streambanks whose soils are high in organic matter, silts and clays are generally more stable, provided they support the right kind of vegetation.
2. **Good water quality** - As defined by the acceptable limits to sustain desirable habitat conditions for flora and fauna.
3. **High water table** - As defined by the distance from the top of streambank to the base level of the water table, and the presence of native aquic or mesic type plants on the streambank and floodplain.
4. **High biomass production** - As defined by the potential of the site to permit plants to grow at or near their full potential. The native aquatic graminoids nearly always produce greater biomass than other graminoids.
5. **Assimilation of organic matter into the soil** - As defined by the percent organic fraction present in diagnostic soil horizons. Organic matter acts as a binding agent for the cohesion of soil particles.
6. **Perennial vegetation** - As defined by species composition. Perennial plants) especially native aquatic graminoids, have extensive, strongly fibrous root systems that protect the soil surfaces and matrix from the erosive forces of water, trampling, etc.
7. **Native vegetation** - As defined by the class of species that are endemic to the area.
8. **Sustained aquatic fauna** - As defined by the continued presence and relative abundance of organisms.
9. **Soil matrix** - Longterm storage and retention of soil moisture to promote perennial flows.

VALUE OF NATIVE AQUATIC PLANTS

Various scientists and resource managers have expounded on the multiple benefits that can be derived from wetland and riparian habitats (Daniel et al. 1979, Rodiek 1980, Johnson and Carothers 1982, USEPA 1988, Fry et al. 1994, Richardson 1994, Zube and Sheehan 1994), including hydrologic concerns (Carter 1986), economics (Crandall 1992), recreation (Johnson and Carothers 1982), and grazing (Behnke 1978). Considerable information has also been provided through symposia (Johnson and McCormick 1978, Johnson et al. 1985, Mutz Lee 1987, Tellman et al. 1993). However, there is very little specific information on such aspects as productivity and functional values of specific plants.

Native aquatic plants are of primary importance in sustaining desirable functional processes (Medina et al., this issue), particularly those that affect channel stability. Most bank instability problems result from the cumulative and interactive effects of loss of streambank vegetation, hydrologic phenomena, and continued ungulate use. Hence, a single most important function of a riparian or wetland plant is to maintain the functional stability (Medina et al. this issue) of the stream channel or shore, such that degradation is limited. Many scientists have reviewed the literature and reported on these factors (Skovlin 1984, Platts and Raleigh 1984, Kauffman and Krueger 1984, Platts 1990).

In a survey of similar channel types of 12 streams in Arizona conducted between 1992 and 1995, it was found that streams with little to no plant cover of native Carex species were in a highly degraded condition (or dysfunctional), while streams that exhibited a high degree of bank stability, herbage production, and functionality (Medina et al. this issue) had streambanks dominated with a variety of native *Carex* species (Table 1). Ord Creek exhibited all the traits of a fully functional riparian/wetland habitat despite its high runoff, elk grazing, and granitic substrates. The most obvious factors that explain this ecological condition are the type and amount of native *Carex* species. Streams which had Kentucky bluegrass (*Poa pratensis*), orchardgrass (*Dactylis glomerata*), wheatgrasses (*Agropyron* spp.), bromes (*Bromus* spp.), and other seeded graminoids as the dominant species occupying the streambanks exhibited signs of degradation, such as sloughing, downcutting or entrenchment, channel widening, and lowering of the water table. Costello (1944) reported that Kentucky bluegrass had effectively replaced native plant species and was an indicator of moderately heavy grazing in wet meadows. This observation holds true today on most Southwestern riparian meadows. Streams with lowered water tables tend towards more mesic conditions in adjacent meadows, which in turn favor exotic grasses (Kauffman et al. 1983).

Another important value of native aquatic plants is their high herbage production. Results of herbage production studies on 2 similar riparian areas on the Colorado Plateau for 3 consecutive years show that the production potential of riparian habitats ranges from about 2,830 kg ha-’ for sites rested from ungulate grazing for one season (Wildcat Creek on A/S NF), to an average of 4,315 kg ha-’ (Buck Springs on Coconino NF) on sites rested for 4 years (Medina, unpublished data). Roath (1979) reported herbage production on some Oregon riparian meadows between 2,268 to 2,675 kg ha^{-1}. Reece et al. (1994) reported average yields from 3,870 kg ha^{-1} in June to 6,090 kg ha^{-1} in August for a Nebraska Sandhills wet meadow. Gorham and Somers (1973) estimate yields from sedge meadows to be between 2,000 kg ha^{-1} in sub-arctic, and montane sites to almost 15,000 kg ha-’ in a lowland mid-latitude site. In contrast, yields of Kentucky bluegrass of 1,000 kg ha-’ have been reported for dense swales by Wiegert and Evans (1964). Bernard (1974) compared peak yields of Kentucky bluegrass and *Carex rostrata* to be 1 ,140 kg ha-’ and 8,520 kg ha-‘, respectively. Manning et al. (1989) demonstrated that root biomass of kentucky bluegrass was 7 times less than *Carex nebraskensis* in the upper O-10 cm soil depth and more than 300 times less in the 10-20 cm depth. The production of large quantities of herbage translates to greater forage availability for livestock and wildlife, plus the added advantage of having greater above ground biomass available during bank-full flow events to improve water infiltration, retention, and storage, and to capture and retain greater amounts of suspended sediments and nutrients.

Table 1. Comparison of streambank stability by streams as a function of the percent of exotic plant cover for a 3000 m reach.

Stream	% Exotic vegetation	% Stable banks
Boggy Creek, A/S NF	64	31
Buck Springs, Coconino NF	71	29
Centerfire Creek, A/S NF	82	11
E. Clear Creek, Coconino NF	69	34
Houston Draw, Coconino NF	67	22
Fern Mountain, Coconino NF	83	16
McKnight Creek, Gila NF	88	7
Merritt Creek, Coconino NF	32	78
Ord Creek, White Mtns, AZ	3	98
Reservation Creek, White Mtns, AZ	17	85
W. Fork Black River, A/S NF	81	27
Wildcat Creek, A/S NF	29	84

DYNAMICS OF CAREX AND OTHER AQUATIC PLANTS

The following discussion is based on current research of the interactions among aquatic vegetation, ungulates, channel hydrology, and geomorphic processes in montane riparian ecosystems. Given the lack of information about processes that govern such interactions, I submit for consideration this (yet) theoretical description of streamside dynamics based on practical field experiences and published research.

Determination of the ecological condition of selected riparian habitats is difficult when the sites in question are degraded or dysfunctional. Consider the case of a typical Southwestern stream reach whose meadows have been exposed to impacts from grazing, logging, roads and recreation. This stream reach could exhibit such characteristics as having a channel type of C, F, or possibly even a G (as per Rosgen 1994), with Kentucky bluegrass/wheatgrasses as the dominant vegetation, and a low or decreasing water table. In all likelihood, the ecological potential of this reach is an E-type channel (for gradients <2%), with streambanks dominated with species of *Carex*, *Juncus*, *Eleocharis*, *Scirpus*, *Glyceria*, and a high water table that sustains sedges, rushes, and other aquatic vegetation. How did such a system changed from the latter to the former? How can this system be restored to a functional state that would approximate the latter conditions?

Through the combined effects of man and animal induced activities the reach became degraded, unproductive and subject to erosion. Early (1920's-1950's) efforts promoted the restoration of these habitats by reseeding, most often with highly adaptable exotic species such as Kentucky bluegrass. In more recent times (1950's-1980's) other species such as orchard grass, assorted wheatgrasses and bromes were reseeded. These reseeded species fare well when the system is in a declining condition. They are highly suited to the mesic conditions brought about by the decreasing water table, which in turn is a product of channel erosional processes resulting in downward and lateral channel migration with each major storm event (Heede 1981, 1992). Sedges became scarce owing to grazing and associated channel dynamics. Reseeded species and other ruderal species replaced sedges and rushes on streambanks. These mesic species generally have a shallow and fine root system in contrast to the long, thick and fibrous roots of sedges (Bernard and Gorham 1978, Manning et al. 1989). Plants native to wetlands and streambanks are mostly water-loving species capable of withstanding prolonged periods of alternating wet and dry conditions (Rumburg and Sawyer 1965), an advantageous life strategy that most mesic graminoids lack. Continued ungulate trampling and general overuse of the habitat also leads to compaction problems, since large masses of surface roots of sedges, in contrast to minuscule quantities of mesic species roots (Manning et al. 1989), function to keep bulk densities low (Moore and Rhoades 1966).

The hydrologic interactions with the streambank vegetation is complex but close examination over time reveals the deficiencies of reseeded and exotic species to stabilize streambanks (Smith 1976, Heede 1985). Hence, at some point in time the stream reach can be described as follows:

1. F channel type characterized by impoverished vegetation and near vertical streambanks,
2. Low water table (perhaps at bedrock),
3. Poor water quality owing to high suspended sediments,
4. Reduced herbage production resulting from lower water table and disturbance adapted vegetation,
5. Low fishery quality (loss of habitat and fauna),
6. Carcasses of woody plants, and
7. In a general state of hydraulic disequilibrium (Heede 1992).

Despite these negative conditions, there can most often be found a microsite at the water's edge where sedges and rushes have prevailed and are working to restore the site to a functional state accordingly. This natural restoration process begins through the continued expansion of the sedges and rushes interacting with flow events which erode and deposit sediments about the new floodplain being developed. Expansion is generally slow owing to the clonal nature of the genera (Carlsson and Callaghan 1990, Wikberg et al. 1994). Sediment deposits about the sedges provide a source of nutrients for growth (Aerts and Caluwe 1994). This physical depositional process interacts with the (biological) plants collectively to produce a geomorphologically distinct micro-landscape form which most often is recognized as point bars, which generally mark the onset of the restoration of the physical parameters of the system to a higher functional state. The continued interactions between physical processes of degradation and aggradation, and the biological component (i.e. vegetation) eventually may result in a C-type channel (Rosgen 1994) if the system if protected from further disturbance. Geomorphological development generally takes place within the confines of channel carve out while still in a F-type, such that the C-type eventually reaches the original E-type, but maybe within an entirely different confinement.

It is hypothesized that the rate of recovery is a function of the rate of re-establishment of the sedges and rushes, sediment deposition, and flow conditions. Sediments and bank-full flows are essential for building streambanks, but the vegetation is most essential for the geomorphological development of channel types (Heede 1985). Many other inter- and intra- component interactions between physical, biological, and chemical factors occur, and which vet remain to be described. One such interaction involves plant competition dynamics in which the native aquatic species displace the exotic mesic species, especially under protection from grazing (Kauffman et al. 1983).

IMPORTANT NATIVE AQUATIC PLANTS

There are several species that have been observed to be essential in the restoration of streambanks of montane riparian or wetland habitats of the Southwest and are also representative of habitats in excellent ecological condition. The distribution of any given species on a riparian or wetland is certainly not uniform since many species are clonal and may be specific to wetter or drier microsite conditions. Some scientists suggest that nutrient limitations may be important in the distribution of sedge meadows (Auclair 1982, Bernard an Fiala 1986). Many other species are known to occur (Reed 1988) but have not been observed in our plant studies or are not considered key species for restoration. The list is preliminary, and a more comprehensive list of flora found on habitats with excellent ecological condition is forthcoming.

The principal sedge species are water sedge (*Carex aquatilis*), slender-beak (C. *athrostachya*), wooly (C. *lanuginosa*), C. *lenticularis*, Nebraska (C. *nebraskensis*), pointed broom (*C. scoparia*), and stalk-grain (C. *Stipata*). Rushes also are a major component of the flora and include Baltic rush (*Juncus balticus*), soft rush (*J. effusus*), long-style (*J. longistylis*), Rocky Mountain (*J. saximontanus*), slender (*J. tenuis*), iris-leaf (*J. xiphioides*). Baltic rush is the common species on wetlands and riparian meadows reaches with standing water yearlong. Small-fruit bulrush (*Scirpus microcarpus*) is another species that is common on sites where streambank building is occurring. Many grasses are also found in varying proportions, but spreading bentgrass (*Agrostis stolonifera*) is the most common associate with sedges and rushes.

Plants that are frequently associated with the re-establishment of a new streambank, particularly in a F-type channel, are wooly and stalk-grain sedges. These tall growing (40-60 cm) plants produce large amounts of biomass which aids in the trapping of bank sloughed materials and suspended sediments. It is not uncommon to find creeping spikerush (*Eleocharis palustris*) as the pioneer species and associated with these sedges.

Nebraska sedge is another key species that pervades riparian meadows and streambanks where the water table is high. This plant has a high root length density nearly 12 times greater than Kentucky bluegrass (Manning et al 1989), can withstand high degrees of defoliation with little apparent damage (Ratliff 1983, Ratliff and Westfall 1987) and produce high quantities (>2500 kg ha^{-1}) of forage, and is one the few species identified that colonize within riffles and stabilize streambanks (Medina, unpublished data).

DESIRED FUTURE CONDITION AND SEDGES

Sedges are a vital biological component of any riparian or wetland ecosystem. Their role in sustaining the dynamic equilibrium of the stream system has only recently be recognized by scientists and resource managers. The proper functioning of a riparian or wetland system is highly dependent on the composition, abundance and health of these types of plants. Collectively, these plants produce an effect over time on the stream channel through the interactions of soil, water and vegetation dynamics that results in stable streambanks. Streambank stability is vital to the sustainability of the stream ecosystem. An aquatic system that is functioning at or near its potential will also have such conditions as desirable habitat for fish and other aquatic fauna and flora, high biomass productivity, and high water table. Sedges, or native aquatic graminoids collectively, are a very important biological component that interact with its environment to produce a desirable functional condition. The presence or absence of key species is used as an indicator of the ecological condition, and desired ecological condition of wetlands and riparian habitats can be expressed in terms of the species composition and abundance of native aquatic plants.

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