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Disturbances on Riparian Vegetation: A Comprehensive Review

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ABSTRACT

Riparian vegetation is considered an integration of all plant communities along the riparian zone. It provides a wide variety of ecosystem services including provisioning, regulating, supporting, and cultural services. Disturbances are discrete events that can disrupt the ecosystem. Based on the intensity, frequency, and duration of disturbances, it can affect riparian vegetation in various ways. Disturbances can be natural or anthropogenic in origin. Major natural disturbances that can influence riparian vegetation include flooding, landslides, wildfire, windthrow, plant diseases, and insect outbreaks. While anthropogenic disturbances are grazing, dams, deforestation, mining, agricultural, recreational, and developmental activities. Usually, natural disturbances play a crucial role in the maintenance of ecosystem structure and processes especially events like floods and landslides. Anthropogenic disturbances affect the composition, diversity and function of riparian vegetation. Soil characteristics of riparian systems are altered by anthropogenic perturbation. Population growth enhances the influences of anthropogenic disturbance on riparian plants. Infrastructure, dams, and agricultural activities have been increasing to meet the demand of inhabitants in that area. This paper reviews various aspects of natural and anthropogenic disturbances on riparian vegetation.

Keywords: riparian vegetation, ecosystem services, disturbances, natural disturbances, anthropogenic disturbances

INTRODUCTION

The riparian systems are transitional zones of both aquatic and surrounding elevated landscapes of terrestrial components. Riparian areas are the zones adjacent to surface freshwater bodies such as rivers, streams, lakes, and ponds. They also act as a habitat for aquatic and terrestrial biota, capturing sediment, retaining, and moderating the extreme temperatures by providing shade. The riparian zones are essential for ecological attributes such as water quality and wildlife. It can influence stream water chemistry through diverse processes including direct chemical uptake and indirect influences such as by supply of organic matter to soils and channels, modification of water movement, and stabilization of soil. The riparian vegetation of fluvial systems are all vegetation units along the river network that are functionally associated with other components of fluvial systems and adjacent areas.[1-3]

Riparian vegetation provides a wide variety of ecosystem services such as water supply, food production, raw materials, genetic resources, biological control, erosion control, sediment retention, nutrient retention, disturbance regulation, climate regulation, gas regulation, water regulation, pollination, waste treatment, carbon stock or sequestration, nutrient cycling, soil

formation, nursery, refugia, aesthetic and recreational services.[4-6] Urban development and exploitation of natural resources are the critical problems influencing riparian areas.[7] Disturbance is a key component of ecological systems, affecting terrestrial, aquatic, and marine ecosystems across a wide range of scales.[8] Any kind of disturbance may affect the establishment, growth, reproduction, dispersal, and mortality of individual vegetation.[9] Multiple physical processes such as flow regime alteration, sediment supply changes, and morphology changes may indirectly affect the vegetation dynamics.[10] The occurrence of anthropogenic disturbances at different levels, frequencies, and intensities can reduce species diversity and lead to riparian degradation.[11,12]

Disturbances to riparian vegetation

A disturbance is defined as "any relatively discrete event in time that disrupts an ecosystem, community or population structure and changes resources, substrate availability or the physical environment".[13] A disturbance regime, as opposed to a disturbance event, refers to the temporal and spatial dynamics over an extended period. The components of a disturbance regime include spatial distribution of disturbances; frequency, return interval, and rotation period; disturbance size, intensity, and severity.[8] Both biotic and abiotic components of a watershed are altered by the disturbances. Some human disturbances such as urban-rural developmental activities may modify the habitat structure. Disturbances can alter the flora and fauna populations and result in significant ecological impacts.[14] Long-term modification and reduction in natural biodiversity are major implications of disturbance on the natural riparian riverine systems.[15] Based on the cause of disturbances, it can be classified into natural and anthropogenic disturbances (Figure 1).

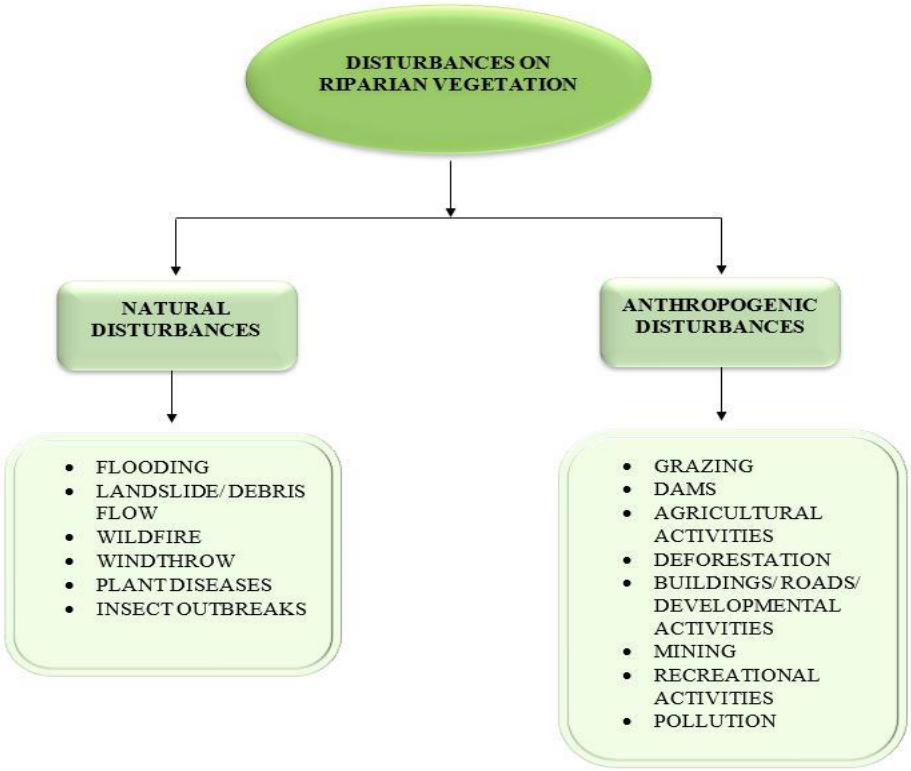

Figure 1: Showing natural and anthropogenic disturbances on Riparian vegetation

Natural disturbances

All ecosystems have a "natural" disturbance regime that they have evolutionarily adapted to and, in some cases, can maintain ecosystem integrity despite severe large-scale disturbance events. Natural disturbances play a key role in maintaining ecosystem structure and processes (e.g., nutrient recycling and initiating succession). For example, some northern forests would convert to bogs without windthrow disturbances that expose mineral soil seedbeds. Numerous other forest types are maintained by periodic fire disturbances.[16] Natural disturbances such as floods and landslides have an extensive role in the maintenance and regeneration of mountainous riparian forests. Tree species in mountainous riparian areas must have adaptive characteristics throughout their life cycle.[17] Generally, naturally occurring abiotic disturbances have a tremendous effect on riparian systems. These disturbances help to the formation of complex habitats of the system.[18] Natural disturbances may leave a very long-lasting footprint that shapes ecosystem structure and function long into the future.[8] Many research works show that natural disturbances have a crucial role in riparian forest regeneration.[19,20] Disturbance agent, spatial extent, pattern, frequency, and intensity of disturbance influences natural disturbance regimes of forest ecosystems. These characteristics may alter according to climate, topography, vegetation, and their interactions.[21]

Flooding

Flooding is a major natural event that can destroy riparian vegetation. It has both positive and negative impacts on the potential damages of flooding. Woody debris floating down the channel can be lodged against standing trees which serves as a tool to aggravate the disturbance of riparian plants. However, the plant rooting in the bank and gravel-bar material impedes fluvial disturbance.[18] Flood events can physically disturb the communities of aquatic organisms also.[22] Floating sediment and large woods may reach to main stream during the flood event. The mobilization of large wood can increase disturbances to the channel.[23] Floods are mostly significant in the downstream reaches of larger catchments.[21] Saplings may be destroyed by large flooding and when the water level reaches the channel bar, seedlings are washed away by flooding.[17] Anaerobic effects during the flood event result in the death of vegetation.[24] Floodplains have been recognized as one of the fertile sites for plants.[8]

Landslide and debris flow

The geomorphic processes such as streamside landslides and lateral channel shifts can transport sediment across landscapes and influence the riparian system. It can be considered as a class of disturbance to the ecosystem. In-stream channels, some small-scale, shallow, rapid sliding at the toe of the large landslides and streamside landslides may occur. These processes do have persistent effects on channels, such as the accumulation of boulders from the landslide. The size of the boulder depends on the debris associated with the landslide. The stream channel is pushed against bedrock on the opposite valley wall due to large landslides. These areas have very restricted riparian habitat and poor recreational values. The stability of riparian zones is influenced by different types of landslides. One class of landslide is large, periodically moving slides. The river's course is deflected and it pinches against the opposite valley wall by this lateral encroachment of this slide type. Another category of landslide is large landslides at the heads of channels. Which is the major source of debris flow that moves down and affects riparian areas. Small streamside slides are common in the landslide area and they cause periodic outbursts of boulder and woody, debris-laden flood surges. These surges can damage riparian zones downstream.[18] On the steep slope, the risks of landslides

increase due to intense rain or snowmelt events.[25]

Wildfire

Wildfire often leads to the decay of tree roots and loss of soil cohesion. On steep slopes, it can increase the risk of landslides during intense rain or snowmelt phenomenon.[25] In the first few years after the wildfire, the primary productivity of the stream ecosystem is intensified due to an increase in nutrient export.[26,27] After the wildfire, standing dead trees can only serve as a partial retention buffer. It enhances stream temperature due to the lack of shading properties.[28,29] Some riparian plant species have ecological adaptations to promote their persistence and recovery following the fire. For example, Epicormic Sprouting adaptation of Cottonwoods (Populus spp.), Oregon ash (Fraxinus latifolia), oaks (Quercus spp.), hawthorn (Crataegus spp.) for the regrowth from dormant buds on branches and stems protected by bark.[30] Fire destroys life and property although, to enhance the production of forage and improve habitat native Americans use fire. Fire suppressor can be considered as the best example to control fire by the society.[31,32,8] Intense fire leads to the formation of a hydrophobic layer within soil through the loss of soil organic matter.[33] It impedes infiltration of rainfall and causes more intense peak flows due to water running over the soil surface. Then it triggers surface erosion leading to a dramatic increase in suspended sediment loads.[34,35] While postfire charcoal in the soil may enhance nitrogen availability for decades.[36]

Others

Some other disturbances in upland areas include wind, plant disease, insect outbreaks, etc.[20] The synergistic effect of various natural disturbances destroys riparian ecosystems. For example, drought conditions can amplify fire intensity, and damages due to insects increase windstorm susceptibility.[13] Severe windthrow and fire results in a rapid shift of dominant tree species in the southern boreal forest of North America.[37]

Anthropogenic disturbances

Riparian Ecosystems are one of the most productive and species-rich systems. However, it is also considered a potentially threatened ecosystem because of its higher sensitivity to human influences.[38] Anthropogenic disturbances are considered exogenous, exotic to an ecosystem (climate change) or endogenous (clear-cutting or strip-mining). System integrity is disrupted by exotic disturbances and the system shifts into another operating state. Natural disturbance regimes are affected by human-induced disturbances by rescaling and making disturbances smaller or larger, more or less frequent or intense.[39] The impacts of Anthropogenic disturbances on ecological communities are a decline in standing biomass, simplification of community structure with reduced perennial species, an overall loss of native species, and an increase in several non-native species. Anthropogenic disturbances lead to an extension of bare and impacted soils, which reduces succession rates of ecosystems by diminishing the number of residuals or individual organisms or their propagules that survive a disturbance event.[40] Indian floodplain habitats are under threat due to various anthropogenic pressures such as overgrazing, deforestation, and land reclamation.[41] Intensification of total nitrogen and phosphorous load in running water from various industrial, residential, and agricultural disturbance sources adversely affects the ecology of a riverine system.[42] Different levels, frequencies, and intensities of anthropogenic disturbances affect species diversity, composition and plant community structure, regardless of the function and biodiversity of riparian vegetation.[11,12,43]

Grazing

Domestic livestock grazing in riparian areas involves the periodic removal of native

streamside plant communities, mainly including herbaceous plants, shrubs or young trees. It is a common disturbance along many streams and rivers to remove certain plants over time for various land use conversion practices such as the creation of hay fields, livestock pastures or the production of cropland. Grazing may occur over days, weeks, months or seasons and is typically repeated on an annual basis.[44] The destabilization of river banks, erosion, and degradation of salmonid habitats are the effects of livestock grazing practices.[45] Channel destabilization is another impact of removal or suppression of riparian vegetation through grazing over a long period by a reduction in root biomass along the channel bank and resistance overbank flow. The areas that have been experiencing seasonal or annual or intensive grazing practices lead to some common effects such as channel widening and gullying.[46-48]

Dams

The biophysical variability of the river such as temperature, materials transport and in-flow characteristics are declined by dams, and it leads to a reduction in the biodiversity of both riparian and instream flora and fauna.[49] Dam limits the transport of nutrients and sediments, which causes aggradation upstream and accordingly deficit downstream of the catchment. Similarly, vegetation cover at lower elevations is negatively affected due to increased water levels in the upstream inundated zone of the dam. The surplus sediment accumulated in the upstream area results in an increase in bed elevation, bank narrowing, and bed fining. Floodplains are significantly affected by trapped sediments. Dam construction leads to river fragmentation and it decreases species richness in associated ecosystems.[10,50,51] Surface flow rates are altered dams and water diversions. It modifies flood periodicity and sediment-nutrient transport, often detrimental to riparian plants.[52,53] While, during post-dam periods with lower flood frequency, riparian forest vegetation is expanded significantly even under increased harvesting activities. The channel morphology and vegetation are highly correlated components. However, most of the dam-induced morphological studies did not consider the effect on higher trophic levels such as vegetation. [54,10]

Deforestation

Deforestation is the result of any kind of developmental activities such as river valley projects and mining in the upper catchment areas. Soil loss and erosion is the major impact of deforestation or clearing the plant cover and it consequently reduces biodiversity and promotes sedimentation in the river. The misuse of riparian systems is accelerating globally.[55-57]

Agricultural expansion

Land use change is one of the potential threats to the riparian ecosystem. Considering land use, agriculture occupies the largest area of land whereas urban land use is a much smaller portion. Urban land use exerts a large influence on river ecosystems with a low percentage of land.[58] The extinction of various plant communities occurred due to agriculture and aquaculture.[59] The input of agrochemicals from agricultural land use increases non-point pollutants into the river and it impacts natural riparian habitat.[57] In agricultural areas, direct destruction of local vegetation takes place via the removal of the vegetation by land cultivation or grazing. The use of pesticides and fertilizers can have a long-term impact on hydrology and also severely affect local and regional riparian plants.[60-62]

Others

Land use changes such as built areas, road construction, mining, agriculture, aquaculture, infrastructure, and urbanization are major drivers of the degradation of riparian ecosystems worldwide and these will continue with population growth.[2,63,57] Recreational activities are another anthropogenic perturbation that enhances

the degradation of riparian ecosystems. The primary effects of recreational activity in riparian vegetation include soil compaction, erosion, vegetation change, and waste.[64] Increase in infrastructure and exurban activities, such as recreation by the area's inhabitants and tourists also increases with human inhabitation in an area. Pollution may result from intensively used infrastructure in riparian zones.[62] Structural approaches to streambank stabilization such as rip-rap, concrete, dikes, fences, asphalt, gabions, matting, and bulkheads can have deleterious effects on riparian areas.[65,66] Disturbance regimes such as flooding can make riparian communities more vulnerable to invasion by non-native plant species.[67] Alteration in frequency and intensity of certain extreme events such as hurricanes and most likely to influence riparian communities. Global climate change can affect the structure and functioning of riparian zones.[68]

The natural processes can act as primary agents of recovery while removing human disturbances in that degraded riparian system. Biota of these systems has evolved to reproduce and survive in an environment of frequent natural disturbances; hence many riparian areas are capable of recovery following a curtailment of human perturbations.[69] The dynamic equilibrium of the ecosystem can be modified into a new system state via more severe anthropogenic perturbations, such as overgrazing, clear-cutting, and dams. The characteristics of this new equilibrium can be different structure (e.g., loss of woody component), different composition (e.g., dominance of non-native species), change in productivity (e.g., shifts in biomass), and a change in ecosystem functions (e.g., water quality).[70]

CONCLUSION

Riparian buffer zones constitute water, soil, and plants along the river margins. Riparian vegetation consists of all plant communities such as herbs, shrubs, and tree species that exist in this zone. Riparian corridors can act as habitat for many animal species and breeding site for many migratory birds. Any disturbance agent can modify the structure and composition of plant communities. Disturbances on riparian plants can be natural anthropogenic in origin. Natural disturbances are flooding, landslides, wildfires, plant diseases, and insect outbreaks. Most of the plant species in the riparian zone can adapt and survive in natural disturbances such as flooding. Natural disturbances are common and sometimes they lead to the succession of plant communities. Anthropogenic disturbances on riparian vegetation include agriculture, dams, infrastructure, developmental activities, pollution, dams, and grazing. Unlike natural disturbances, it can limit plant growth and normal functioning. Continuing disturbances on already disturbed sites can cause degradation of riparian zones and disruption of the entire ecosystem. Growing population and urbanization are exerting more pressure on riparian plants. Government authorities should give attention and immediate measures for proper monitoring and implementation of laws to conserve riparian vegetation.

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