Chapter 5

Protection of Riparian Habitats to Conserve Keystone Species with Reference to *Terminalia arjuna* – A Case Study from South India

B.C. Nagaraja, C. Sunil and R.K. Somashekar

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/58355

1. Introduction

Riparian forests (RF) growing along streams, rivers and lakes have special functions in the landscape as the interface between the terrestrial and the aquatic ecosystem (Malanson 1993). They are distinctly different from the surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by free or unbound water in the soil. Riparian zones are usually a diverse mosaic of landforms, communities and environments within landscapes and they serve as a framework for understanding the dynamics of communities associated with fluvial ecosystems (Gregory *et al*., 1991; Naiman *et al*., 1993; Naiman *et al*., 2005). Being a transition zone between aquatic and terrestrial area where structural and functional properties change with space and time, discontinuously. Typical examples of riparian zones would include flood plains, stream banks and lake shores. The interfaces in riparian zones possess physical and chemical attributes, biotic processes, material flow processes, but they are unique in their interactions with adjacent ecological systems.. Riparian zones are habitats of critical conservation concern worldwide, as they are known to filter agricultural contaminants, buffer landscapes against erosion, and provide habitat for high numbers of species (John *et al*., 2005). The Riparian forests are habitats for a large number of forest species including many of the rare species that depend on water and as such serve as important areas for biodiversity (Gundersen et al., 2010; Darveau et al. 1995; Hylander 2006).

Riparian lands can also include intermittent streams gullies and dips which sometimes run with water. The vegetation ranges from emergent aquatic and semi-aquatic plants through to terrestrial understorey and canopy species (Parsons 1991). Further, the zone can be seen as an interface between terrestrial and aquatic systems and is described as a series of ecotones

between these systems (Risser 1990). Riparian vegetation plays an important role in the maintenance of stream and foreshore stability. Streams and rivers are essentially dynamic systems, their path and flow constantly changes with the time (Warner 1983). The presence of vegetation in riparian areas acts to reduce the rate of change and therefore maintain a level of stability.

Figure 1. Overview of Riparian forest in the banks of river Cauvery

2. Ecology and biodiversity in riparian forest

Plant communities in large river flood plains are amongst the most productive and diverse in the world and frequently support higher number of plant species arranged in vegetation associations of greater complexity than surrounding landscaping units (Menges and Waller, 1983; Tockner and Stanford, 2002). Water level patterns are critical for the successful establishment of new plants (both exotic and native species) following dispersal of seeds or other propagules by water, wind, animal vectors or other dispersal agents. Flow has been determined as primary factors for determining plant community composition and structure along the riparian zone (Blom *et al.*, 1990; Ferreira, 1997). Many plant species depended particularly on the flow for dispersal of their propagules a process referred to as 'hydrochory' (Nilsson *et*

http://dx.doi.org/10.5772/58355

al., 1991). Types of propagules include sexually derived seeds as well as vegetative fragments (mechanically sheared or physiologically abscised branch or root segments) that can re-sprout to result in asexual propagation. Propagative dispersal typically occurs in a downstream direction along streams but may be wind-aided along lakes or reservoirs. Thus, hydrochory may occur in multiple directions along relatively stationary water bodies. Propagative dispersal by water is an effective adaptation of native plants but also provides a major mechanism for invasion by exotic weeds, of which noxious species can have severe ecological and economic impacts (Braatne *et al*., 2002).

Riparian vegetation changes continuously from the beginning of a river in the mountains up to the river mouth with the changing environmental parameters like altitude, humidity, soil conditions and also in the conditions of water like quantum and flow, temperature, pH, salinity. In a tropical countries, the riparian vegetation in a first order stream in the mountain may be ferns and other associated herbaceous plants in the rock crevices. When coming down, evergreen forest samples can be observed in the riparian zone as a quantum and the lateral influence of the water increases. Further going down the bed conditions of the river changes from rocky to sandy especially in the floodplains. Here the soil becomes looser, sedimentation rate will be high, and a good amount of alluvium can be found. In these areas the water influence on the vegetation may be more. Herbaceous, grass and hydrophytic plant communities will be abundant in these zones (Amitha, 2003).

Ripairan areas acts as a migratory corridor and routes for many wildlife as it has been used for regular daily movements and seasonal migration. Riparian zones offers an three critical resources for wildlife: cover, food and water in one space. The undisturbed stands of age old woody species provide habitat for nesting birds resided in the forests. Riparian zones are utilized by wildlife as a sort of "natural highway". They are important to mammals and birds as they journey up and down the river during daily movements besides seasonal migrations. Much wildlife is found to be associated on floodplains than in any other landscape unit in most regions of the world (Klement and Stanford, 2002). In the Pacific coastal ecoregion (USA), for example, approximately 29% of wildlife species found in riparian forests are riparian obligates (Kelsey & West 1998). It provides habitat for more species of breeding birds than any other vegetation association. For example, of all bird species breeding in northern Colorado, 82% occur in riparian vegetation, and about half of south-western species depend upon riparian vegetation (Knopf & Samson 1994). Riparian areas in semiarid zones are critical in providing stopover areas for *en route* migrants (acting as 'dispersal filters'), and therefore affect the breeding success of northern bird populations (Skagen *et al.* 1998). In Europe, 30% of threatened bird species are inland wetland-dependent species and 69% of the important breeding areas for birds contain wetland habitats, primarily flood plains (Tiker & Evans 1997). In Switzerland, 10% of the entire fauna is restricted in its occurrence to riverine flood plains, although flood plains only cover 0.26% of the country's surface. Among 10%, 28% of the fauna frequently uses flood plains and about 44% is occasionally found in flood plains. A high proportion of the riparian obligates (47%) is listed as endangered, compared to 28% for the entire fauna (Walter *et al*. 1998).

3. Ecosystem services of riparian vegetation

Riparian forests performs an array of functions in its buffer are which are beneficial to regional ecosystem to meet the some of their essential needs for their survival in the ecosystem. Some specific species stand unique in portraying their services in the particular ecosystem due to its morphological and phenological nature where their life cycle influences to protect stability of several flora and fauna in the ecosystem. Besides these functions, several species of riparian vegetation render services to the humans, as they provide several direct and indirect economic supports to run their livelihoods.

4. Ecological significance

The riparian plant species improves the microclimatic condition thereby allowing the other associated species to to grow in the community. The forks of old trees in the riparian zone provide wantage points to epiphytes.

Figure 2. Epiphyte *Acampe praemorsa* growing on forks of tree species *Terminalia arjuna* and Orchids laden on tree branches of *Madhuca latifolia*.

Riparian species develops typical root modifications to withstand during the flood events. Such typical modifications of plant root systems are called as buttressed root systems. The buttressed root systems provide the strength to the tree species and to facilitates a suitable site to other riparian species to grow. Rivers combined with such root systems in conjunction with other herbaceous vegetation dissipate stream energy, resulting in less erosion and a reduction in flood damage. A 5 cm deep root system resists erosion up to 20,000 times better than bare soil stream banks. A woody root mat is the "re-bat' of stream banks. The riparian canopy provides organic matter via litter fall; surfaces of submerged leaves are sites of primary and secondary production by micro algae and bacteria, which can rival that of phytoplankton and bactereophils in water column. The Logs of riparian vegetation play an important role in the dynamics of stream morphology and serve as substrates for biological activity by microbial and invertebrate organisms. On land the riparian stream ecosystem is the single most pro-

http://dx.doi.org/10.5772/58355

ductive type of wildlife habitat. The Riparian areas act as a corridor for big game migratory animals between summer and winter range.

5. Social significance

Past civilizations came up on river banks, the followed generations used rivers as a source of water and food. The flood plains of the Indus, the Nile delta, and the fertile crescent of the Tigris and Euphrates rivers provided man with all his basic necessities. They can be considered the pillars of human civilization as they have formed the nuclei for human settlements from the very origins of mankind. Fishing is a major means of livelihood for the people who resided in and around the riparian zones. Many of the tribal's depend upon the river for fishing. The riparian vegetation decrease soil erosion and support silt thereby avoiding the pollutant input to the river. The shade, fruits and flowers offered by the riparian vegetations promotes the fish abundance in the aquatic ecosystems. The riparian vegetation provides Non Wood Forest Products for the dependent communities especially tribals who use the riparian forest to make their huts (Mainly *Bamboo* and *Ochlandra*), honey collections, timber, manure for farming and medicinal plants etc.

6. General overview of Cauvery riverine ecosystem

The Cauvery river originates at Talakaveri (12° 25' N, 75° 34' E) in the Western Ghats at an altitude of 1341m. It is the 8th largest river in the subcontinent and ranks as a medium river on a global scale. The Cauvery River basin is estimated to occupy 81155 km^2 area occuping nearly 2.5% of the total geographical area of the country. The Cauvery river basin areas have a large floristic wealth enough to constitute as a separate phyto-geographic unit. The vegetation of the entire peninsular India excluding Western Ghats is adequately represented in this tract alone (Jayaram, 2000). The known flora of the basin comprises 2037 species from 990 genera belonging to 180 families. The Cauvery river system harbors 1050 species belonging 128 families. 504 herbs (48%), 270 shrubs (25.7%), 170 trees (16.2%) other plant forms like climber, twinners etc constitutes 10%. The river basin is in human use since the beginning of the human civilization. As increase in the population growth intensified demands keep putting pressure on these riparian areas for agricultural development, recreational uses, commercial development, housing development and others.

The Cauvery river basin from headwater reaches to outlet exhibits remarkable habitat heterogeneity. The river is reserved by guilds of fish species. Headwater support more endangered fish which is confined to rock stream types having high gradients and predominantly bedrock substrates (Smakhtin *et al*., 2006; Lakra *et al*., 2010). The riparian zone in the sacred landscape provides habitat for wildlife such as Asian elephants (*Elephas maximus*), Otter species (*Amblonyx cinereus*) (near threatened) (Shenoy, 2005), Endangered Nilgiri languar (*Trachypithecus johnii*) (Sunderraj and Johnsingh 2001), Indian civet (*Viverricula indica*), Lion-

tailed Macaque (*Macaca silenus*) and so on. The forest landscapes here act as corridors for wildlife, as they are in contiguous with large protected areas such as Nagarahole National Park, Talacauvery, Brahmagiri and Pushpagiri Wildlife Sanctuaries.

The river bordering the Cauvery Wildlife Sanctuary in lower reaches of the river has a population of otters, crocodiles and many varieties of fishes along with the famous Masheer. This area is the breeding ground for a number of reptilian species like crocodiles, turtles, python, cobra, russell's viper, banded krait and masheer fish besides wild boar, barking deer, four-horned antelope, green-billed malkoha, white-browed bulbul, pigmy woodpecker. Around 1000 elephants (*Elepha maximus*) graze through these riparian areas, as it also provides connectivity to Biligiri Rangan Hills Temple (BRT) wildlife Sanctuary and Mudumalai Tiger Reserve, which are in conjunction with Mysore – Nilgiri corridor (largest population of Asian elephants is found here).

7. *Terminalia arjuna* as a keystone species in Cauvery riverine ecosystem

Distributed throughout moist deciduous places of southern India, frequenting the banks of the water courses. Identified by thick grey smooth bark, exfoliating in large thin irregular sheets and buttressed trunk. It thrives best on loose moist, fertile alluvial loams and light deep sandy soils, often overlying more or less imprevious rock. The soil should have ample water supplies but should normally be well-drained. The soil under this tree becomes rich in calcium as the leaves are rich in this element. *Terminalia arjuna* species is deciduous, dominant canopy species and a representative riparian elements in riparian forests in lower reaches of Cauvery river. It can live grows to approximately 30m-45 in height, with a diameter at breast height (DBH) ranging from 300 cm – 600 cm. The *Terminalia arjuna* species is well adapted in the riparian zone by developing the buttressed type of root system to withstand the flood events.

Terminalia arjuna scattered along the lower of stretch of riparian forest is identified as a Keystone species. These scattered trees will acts as keystone structures as it supports wide array of species groups (e.g. arthropods, birds or mammals) for food resource and as shelter or nesting site (Munzbergova and Ward 2002; Plieninger *et al*., 2003; Tews *et al*., 2004).

8. Ecological significance of *Terminalia arjuna* in Cauvery river

8.1. Ecosystem engineers

Terminalia arjuna in the Cauvery riverine ecosystem can be referred as 'Ecosystem Emgineers" as it modifies the physical environment by releasing resources to be used by other species. The activities of many organisms provide habitat that would not otherwise be available, often by means of disturbance to the physical habitat. Because of structural alterations they support many organisms and are often referred to as ecosystem engineers (Jones *et al*., 1994). *Terminalia arjuna* stabilizes river banks, trap sediments, increases nutrient availability in the top soil so

http://dx.doi.org/10.5772/58355

Figure 3. Species *Terminalia arjuna* growing along the banks of River Cauvery

as to provide a competitive advantage for adventitive forbs and grasses with higher nutrient requirements than their native counter parts.

Figure 4. Species *T. arjuna* with its interlocking root system

The interlocking root system of this tree reduces the efficiency of rivers to withstand flood events and the butresses roots of this species are effective soil binders. Thus play a significant role in modifying the physical environment in ways that release resources for other species. Flood is a regular event in the downstream of River Cauvery, *Terminalia arjuna* act as barrier against erosion and stabilizes river bank in the riparian forest. It is the lone species along the riparian corridor acting as an emergent layer with good amount of canopy contributing to maintenance of micro climatic conditions viz., soil moisture and nutrirents. It is also necessary for the survival of the other evergreen species such as *Olea dioca*, *Syzygium sp*, *Madhuca neriifolia*, *Madhuca latifolia* etc during the seedling and sapling stage in the lower riparian stretch. The laden and gravels retained between the roots of *T.arjuna* retains soil moisture required for vegetation establishment and also provides a new substrates for the colonization of riparian plants. This species with good canopy cover limits the establishment or invasive from the adjacent scrub and dry land harboring *Canthium sp*, *Alangium salviforum*, *Acacia catechu* etc., as potential dominants. Thereby competition with semi-evergreen species is avoided. Hence absence of this species along the riparian corridor might cause a major change in the riparian vegetation structure and composition.

9. Resource providers

Terminalia arjuna acts as resource provider, as the leaves and flowers of this species falling into the water form diet for a number of fishes. The tree-lined river bank also provides shelter and shade to fish. Shade also keeps the growth of water weeds in balance, and regulates the temperature of water. The smooth coated otter (*Lutra perspicillata*) categorized as 'vulnerable' by 2004 IUCN Red List in the Cauvery Wildlife Sanctuary (CWS), needs a healthy aquatic ecosystem with plenty of fish. The shade provided by trees along the water's edge help to promote fish abundance with obvious benefits for the otter. Besides, gaint trees of *Terminalia arjuna* in the riparian zone act as a good potential nesting sites for bees and numerous bats which roost during day time. The bats play an important role as pollinators and seed dispersal agents. The riparian vegetation in the middle reaches of the Cauvery river is fragmented by various types of anthropogenic pressures resulted in shrinkage of several endemic species in riparian zone (Sunil et al., 2010). As the larger forks and branches of *Terminalia arjuna* provides a habitat for natural pollinators like honey bees, bats etc., influences the chance of recovery of native species in the fragmented patches of the riparian buffer in the middle reaches of the river. The huge canopy offered by *T.arjuna* species forms a thick patches in the riparian zone serving as important buffers in the semi-arid ecosystem, enable to provide a vital links to sensitive wildlife species such as *Ratufa macroura* (grizzled giant squirrel), an IUCN Red listed –near threatened species (Baskaran et al., 2011) which demands thick canopy cover along the riparian zones for breeding and feeding purpose (Joshua and Johnsingh, 1994).

http://dx.doi.org/10.5772/58355

Figure 5. *T. arjuna* acting as the roosting sites for the bats during the day time

10. Control of Invasive species in riparian zones

Riparian habitats are more susceptible to exotic species invasion due to the nutrient rich laden sediments and periodic flooding followed by hydrochory (Pyse and Prach 1994; Gregory and Naiman 2000). Invasion of non-native species in the riparian zone constitutes most serious threats to the biodiversity through the displacement of native plants (Shigenari and Izumi 2004). The Cauvery river in the lower reaches is is surrounded by dry deciduous to scrub type forests, and moist deciduous to semi-evergreen type trees along the river bank. Since the riparian zone stands distinctly here by harboring moist deciduous to semi-evergreen type vegetation, during dry season they assumes a very significant place for wildlife (Natta et al. 2003) particularly to the otters and wide elephant herds found in the sanctuary. But, the riparian vegetation here stands in high risk areas, as there is a chance of invasion of several pioneer species resided in the adjoining dry deciduous and scrub type vegetation into the riparian areas (Manjunath, 2001). Some of the fragmented corridors in riparian forest has already witnessed the invasion of scrub type species by lessening the native riparian species (Sunil et al., 2011).

Riparian species demands shade and moisture in soil in the early stages of their germinations. Huge canopy offered by *Terminalia arjuna* provide sufficient shade and holds soil moisture

during the germination stage of riparian tree species. Some native species which supports avifaunal abundance such as *Ixora bracheata, Syzygium cumini, Syzygium jambose, Diospyros melanoxylon* and *Madhuca latifolia* resembles healthy association to the keystone species *Terminalia arjuna*. Also, it checks the growth of pioneer species in the riparian zone, thereby competition with riparian and semi-evergreen species harbored in riparian zone is avoided. Decline in native species such as *Syzygium cumini, Syzygium jambose, Madhuca sp* along the river bank might lead to the decline of natural source of leaves, twigs, fruit and insects that underpins the aquatic food web (Lovett *et al*., 2007). Hence, canopy species like *T.arjuna* is much inevitable in this region where their absence might cause a major change in the riparian vegetation structure and composition which inturn affects the aquatic ecosystem in the region.

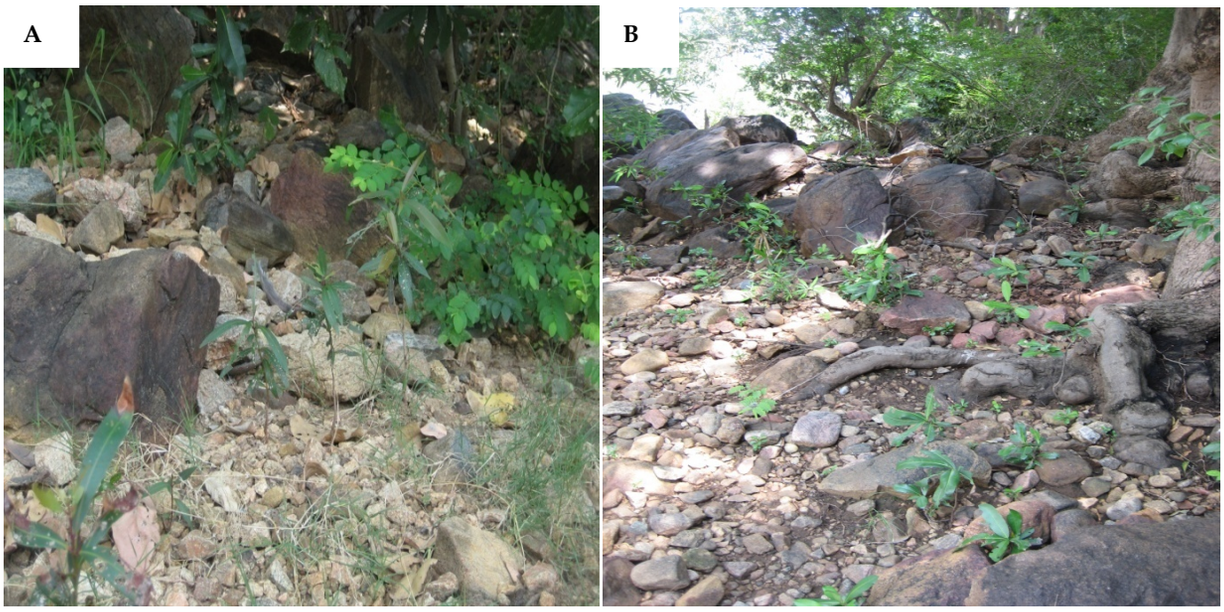

Figure 6. A and B. Seedlings of *Syzygium cumini*, *Ixora bracheata*, *Madhuca latifolia* and *Dalbergia latifolia* growing in area under canopy of *Terminalia arjuna* species.

11. Social significance of *Terminalia arjuna* in Cauvery riverine ecosystem

The primary uses of Cauvery river are providing water for irrigation, household consumption, industries and the generation of electricity (Varunprasath and Daniel, 2010). Over 90% of the river water is abstracted for irrigation. Population density in Cauvery is perhaps among the highest in the world (350 people/ km^2; Smakhtin et al., 2006) indicating that potential for human disturbance is inevitable along the basin. The watershed regions of the Cauvery river is strongly affected by water stress in recent years (Ferdin, et al., 2010). Besides meeting industrial and agricultural needs, drinking water demands from the two major urban centres namely Bangalore (6th largest city in India) and Mysore with a millions population is increasing at an faster rate. The river being completely dependent on the monsoon for replenishment, the amount of water the Cauvery can provide to the various users varies with the fluctuating

http://dx.doi.org/10.5772/58355

strength of the monsoon rainfall (Ferdin, et al., 2010). Providing clean water and improving the chemical quality of waters for both human consumption needs and ecosystem health have become important policy goals in the worldwide. Management of riparian vegetation is one strategy to achieve these goals. *Terminalia arjuna* is one of the key species in the Cauvery river to fulfill the strategy to maintain the river quality healthier. The widespread rootmat of this species protect the waterway from erosion and pollutants entering the river. It acts has a natural wall along the river bank resists soil erosion during flooding thereby avoiding the water loss due to the bank widening. Keeping increasing water scarcity and flood disaster in the lower reaches during monsoon, conservation and management of *Terminalia arjuna* in the upper reaches helps to reduce flood velocities and increase the further flow towards lower reaches, thereby maintaining the river water healthier.

Acknowledgements

We thank University Grant Commission for providing financial assistance, Karnataka State Forest Department in for extending the permission to carry out the studies and helping in field work.

Author details

B.C. Nagaraja*, C. Sunil and R.K. Somashekar

*Address all correspondence to: nagenvi@gmail.com

Department of Environmental Sciences, Bangalore University, Bangalore, India

References

[1] Amitha Bachan, KH. 2003. *Riparian Vegetation along the middle and lower zones of the Chalakkudy River*, Kerala, India. Limnological Association of Kerala, Iringalakkuda.

[2] Baskaran, N., Senthilkumar. K and Saravanan, M. 2011. A new site record of the Grizzled Giant Squirrel Ratufa macroura (Pennant, 1769) in the Hosur forest division, Eastern Ghats, India and its conservation significance. Journal of Threatened Taxa 3(6): 1837–1841.

[3] Blom, CWPM., Bogemann, GM., Laan, P., van der Sman, A.J.M., van de Steeg, H.M. and Voesenek, LACJ. 1990. Adaptation to flooding in plants from river areas. Aquatic Botany 38: 29 - 47.

[4] Braatne, JP., Rood, SB., Simons, RK., Gom, LA., Canali, JE. 2002. Ecology of Riparian Vegetation of the Hells Canyon Corridor of the Snake River: Field Data, Analysis and Modeling of Plant Responses to Inundation and Regulated Flows. Technical Report Appendix E.3.3-3. Copyright © 2003 by Idaho Power Company.

[5] Darveau, M., Beauchesne, P., Belanger, L., Huot, J. and LaRue, P. 1995. Riparian forest strips as habitat for breeding birds in boreal forest. Journal of Wildlife Management 59: 67–78.

[6] Ferdin, M., Gorlitz, S., Schworer, S. 2010. Water Stress in the Cauvery Basin, South India - How current water management approaches and allocation conflict constrain reform. ASIEN 117: 27-44

[7] Ferreira, LV. 1997. Effects of the duration of flooding on species richness and floristic composition in three hectares in the Jau National Park in floodplain forests in central Amazonia. Biodiversity and Conservation 6: 1353 -1363.

[8] Gregory, SV., Swanson, FJ., W. A. McKee, and Cummins, KW. 1991. An Ecosystem Perspective of Riparian Zones. Bioscience, 41:540 - 551.

[9] Gregory HW, Naiman RJ. 2000. Vulnerability of riparian zones to invasion by exotic vascular plants. Plant Ecol. 148(1): 105–114.

[10] Gundersen, P., Lauren, A., Finer, L., Eva Ring, Koivusalo, H., Saetersdal, M., Weslien, JO., Sigurdsson, BD., Hogbom, L., Laine, J., Hansen, K. 2010. Environmental Services Provided from Riparian Forests in the Nordic Countries. Ambio: 39:555–566.

[11] Hylander, K. 2006. Riparian zones increase regional species richness by harboring different, not more, species: Comment. Ecology 87: 2126–2128

[12] Jayaram, KC. 2000. (Ed) *Kaveri Riverine System: An Environmental Study*. The Madras Science Foundation., Chennai. Pp. 1-6.

[13] John L. Sabo, Ryan Sponseller, Mark Dixon, Kris Gade, Tamara Harms, Jim Heffernan, Andrea jani, Gabrielle Katz, Candan Soykan, James Watts and Jill Welte. 2005. Riparian zones increase regional species richness by harboring different, not more, species. Ecology, 86 (1): 56 - 62.

[14] Jones, CG., Lawton, HJ. and Shachak, M. 1994. Organisms as ecosystem engineers. Oikos 69: 373 – 386.

[15] Joshua, J. and Johnsingh, AJT. 1994. Ecology of the endangered Grizzled Giant Squirrel (*Ratufa macroura*) in Tamil Nadu, South India, Report. Wildlife Institute of India.

[16] Kelsey, KA. and West, SD. 1998. Riparian wildlife. In: *River Ecology and Management. Lessons from the Pacific Coastal Ecoregion.* ed. R.J. Naiman and R.E. Bilby, Springer. pp. 235–258. New York.

[17] Klement Tockner and Stanford AJ. 2002. Riverine flood plains: present state and future trends. *Environmental Conservation.* 29 (3): 308–330

[18] Knopf, FL. and Samson, FB. 1994.+ Scale perspectives on avian diversity in western riparian ecosystems. *Conservation Biology*. 8: 669–676.

[19] Lakra, WS., Sarkar, UK. and Gopalakrishnan, A. 2010. Threatened Fresh Water fishes of India. Army Printing Press, Lucknow, India. pp 16- 24.

[20] Lovett S, Price P, editors. 2007. Principles for riparian lands management. Canberra (ACT): Land and Water Australia.

[21] Malanson, GP. 1993. Riparian landscapes. Cambridge studies in ecology. New York (NY): Cambridge University Press.

[22] Manjunath. 2001. "Management plan of Cauvery Wildlife Division" Kanakapura. Karnataka Forest Department.

[23] Menges, ES. and Waller, DM. (1983). Plant strategies in relation to elevation and light in floodplain herbs. The American Naturalist. 122: 454 - 473.

[24] Munzbergova, Z. and Ward, D. 2002. Acacia trees as keystone species in Negev desert ecosystems. Journal of Vegetation Science 13: 227–236.

[25] Naiman, RJ., H. Decamps, and M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications. 3: 209-212.

[26] Naiman, RJ., Decamps, H. and McClain, ME. 2005. River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York.

[27] Natta, AK., Sinsin, B., Van der Maesen, LJG. 2003. Riparian forests and biodiversity conservation in Benin (West Africa). Paper submitted to XII World Forestry Congress, 2003, Quebec City, Canada.

[28] Nilsson, CM., Gardfjell, M. and Grelsson, G. 1991. Importance of hydrochory in structuring plant communities along rivers. Canadian Journal of Botany. 69: 2631-2633.

[29] Parson, A. 1991. The Conservation and Ecology of Riparian Tree Communities In the Murray Darling Basin, NSW A Review' NSW NPWS Hurstville.

[30] Plieninger, T., Pulido, FJ. And Konold, W. 2003. Effects of land-use history on size structure of holmoak stands in Spanish dehesas: implications for conservation and restoration. Environmental Conservation 30: 61–70.

[31] Pyse, P. and Prach K. 1994. How important are rivers for supporting plant invasions? In: De Waal L, Child LE, Wade PM, Brock JH, editors. Ecology and management of invasive riverside plants. New York (NY): Wiley. p. 23–31.

[32] Risser, PG. 1990. The Ecological Importance of land water ecotones' [in Naiman, R.J. and Decamps H. (eds) "The Ecology and Management of Aquatic - Terrestrial Ecotones'] UNESCO, Paris; Parthenon Publishing Group. Man and the Biosphere Series

[33] Shenoy, K. 2005. Otters in River Cauvery, Karnataka. New Delhi:Wildlife trust of India.

[34] Shigenari, M., Izumi, W. 2004. Invasive alien plant species in riparian areas of Japan: the contribution of agricultural weeds, revegetation species and aquacultural species. Global Environ Res. 8(1):89–101.

[35] Skagen, SK., Melcher, CP., Howe, WH. and Knopf, FL. 1998. Comparative use of riparian corridors and oases by migrating birds in Southeast Arizona. Conservation Biology. 12: 896 – 909.

[36] Smakhtin, V., Arunachalam, M., Behera, S., Chatterjee, A., Das, S., Gautam, P., Joshi, GD., Kumbakonam G. Sivaramakrishnan, KG. and Unni, KS. 2006. Developing the procedures for assessment of ecological value and condition of Indian Rivers in the context of Environmental Water Demand (pp. 9-10, 13). Retrieved 8 March 2008 from http://nrlp.iwmi.org/ pdocs/DReports/phase_01/18.

[37] Sunderraj, SFW. and Johnsingh, AJT. 2001. 'Impact of biotic disturbance on Nilgiri langur habitat, demography and group dynamics.' Current Science 80 (3): 428–436.

[38] Sunil, C., R.K. Somashekar, RK. And B.C. Nagaraja, BC. 2011. Impact of anthropogenic disturbances on riparian forest ecology and ecosystem services in Southern India, International Journal of Biodiversity Science, Ecosystem Services & Management.

[39] Sunil C, Somashekar RK, Nagaraja BC. 2010. Riparian vegetation assessment of Cauvery River Basin of South India. Environ Monit Asses. 170(1–4):545–553.

[40] Tews, J., Brose, U., Grimm, V., Tielborger, MC., Wichmann, MC., Schwager, M. and Jeltsch, F. 2004. Animal species diversity driven by habitat heterogeneity / diversity: the importance of keystone structures. Journal of Biogeography 31:79-92.

[41] Tiker, GM. and Evans, MI. 1997. Habitats for birds in Europe: A conservation strategy for the wider environment. Birdlife Conservation Series 6. Cambridge, UK: Birdlife International

[42] Tockner, K. and Stanford, JA. 2002. Riverine flood plains: present state and future trends. Environmental Conservation 29: 308-330.

[43] Varunprasath. and Daniel, AN. 2010. Comparison Studies of Three Freshwater Rivers (Cauvery, Bhavani and Noyyal) in Tamilnadu, India. Iranica Journal of Energy and Environment 1 (4): 315-320.

[44] Walter, T., Umbricht, M. and Schneider, K. 1998. Datenbank zur Fauna der Auen. FAL, Reckenholz, Switzerland [www document]. URL http:// www.admin.ch/sar/fal/aua/

http://dx.doi.org/10.5772/58355

[45] Warner, RF. 1983. Channel Changes in Sandstone and Shale Reaches of the Nepean River, NSW' in Nanson, G.C. and Young, R.W. (eds) 'Ecology and Management of Riparian Zones' Marcoola QLD Occasional Paper Series LWRRDC.

IntechOpen

IntechOpen