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HYDROLOGIC AND ANTHROPOGENIC IMPACTS ON RIPARIAN AREAS IN AGRICULTURAL DOMINATED LANDSCAPES OF GREECE

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ABSTRACT

Riparian areas are key ecosystems for conservation and protection because of the multiple and essential ecosystem services they provide despite occupying only a small percentage of the watershed. The greater soil water availability in the riparian areas compared to the adjacent terrestrial ecosystems leads to more productive, different and diverse terrestrial vegetation assemblages compared to the adjacent upland terrestrial ecosystems. Consequently, riparian areas have many services that range from reducing nonpoint sources pollutants, overland flows and floods, to wildlife and fish essential habitats, to recreational opportunities for humans. Humans have recognized these ecosystem services and have utilized them with various activities for thousands of years. This has led to the severe degradation of riparian areas that are considered as some of the most threatened ecosystems. In the European Union the importance of conserving and protecting riparian areas is recognized by the many riparian areas that have been designated as Natura 2000 sites. Additionally, the EU Water Framework Directive (2000/60/EC) has recognized their importance as essential features in the hydromorphological assessment of freshwater bodies. Riparian corridors are highly valuable and diverse habitats in Euro-Mediterranean-type environments, especially within agricultural dominant landscapes. In the Mediterranean region, large tracts of natural habitat have been replaced by agriculture and urban areas that has simplified their diversity and their ecosystem services. The objective of this study was to use an ocular protocol to estimate the condition of characteristic Mediterranean riparian habitats in agricultural dominated landscapes in Northern Greece. The characteristic riparian habitats surveyed were: a) natural woody vegetation along a stream with perennial flow adjacent to agricultural fields (Ste-Ag), b) natural woody vegetation along a torrent with intermittent flow adjacent to agricultural fields (Tor-Ag), and c) natural woody vegetation along a stream with perennial flow adjacent to forested areas (Ste-For). The Stream Visual Assessment Protocol (SVAP) was implemented in 20 survey plots in each studied riparian habitat. The protocol was developed in the United States and is widely used as an easy technique to evaluate riparian habitats adjacent to farmlands. For this study it was modified for the Euro-Mediterranean environments. Based on the average SVAP values of the 20 survey points the Ste-Ag and Ste-For were not statistically different. In contract, the Tor-Ag had significantly lower values that the other two habitats. Overall, this modified SVAP could be used with to meet the requirements to assess riparian Mediterranean ecosystems. This could be a valuable and easy to use tool that will help manage riparian areas more effectively in Greece.

Keywords: SVAP, conservation, visual assessment, stream types.

1 INTRODUCTION

Riparian areas are unique transitional ecosystems that exist in all biomes (Gregory et al. 1991; Ffolliott et al. 2004). They are transitional ecosystems between aquatic and terrestrial ecosystems (Malanson 1997). They are linear in nature and adjacent to a freshwater body (stream, river or lake). Thus, they are characterized by more water availability that makes them stand out compared to the adjacent terrestrial ecosystems. The excess soil water leads to different vegetative assemblages along with higher densities and many canopy layers. In addition, these areas are disturbance driven since they are frequently flooded and the vegetation present is hydrophyllic and typically young in age (Naiman et al. 2005). Finally, the frequent floods also lead to soils that are undeveloped and young. Overall, the three main characteristics of riparian areas are the greater water availability (soils and flooding), young undeveloped and rich in nutrient soils and unique dense with many canopy layers vegetative assemblages (National Research Council 2002).

The uniqueness of riparian areas has led to their many ecosystem services (Malanson 1997). These services cover a wide range and differ substantially. They provide habitat to support wildlife (e.g. foliage, food) enhance native fish populations and are corridors for the transportation and movement of wildlife and other material (Naiman and Decamps 1997). In addition they are the links or buffers between aquatic and terrestrial ecosystems (Pieczynska 1990). The dense vegetative assemblages can reduce overland flows and the nonpoint sources pollutants entering water bodies by filtrating and retaining sediments and nutrients and immobilizing, storing and transforming chemicals from terrestrial upland runoff (Correll 1997; Lowrance et al. 1985; Osborne and Kovacic 1993). At the same time the dense vegetative assemblages also reduce out-of-bank floods and floodwater runoff (Schultz et al. 2000). The deep roots of the dense vegetation can stabilize stream banks and/or build-up new stream banks (Zaimes et al. 2008, 2009). The ability of the riparian areas to capture runoff and floodwaters helps store water in the soil and recharge subsurface aquifers. Finally

riparian areas can also provide opportunities for leisure activities such as nature walks, running and fishing, education, and ecotourism (Naiman et al. 2005).

These services that riparian areas can offer have been recognized and utilized by humans for thousands of years (Naiman et al. 2005). As a consequence riparian areas are considered worldwide as some of the most degraded ecosystems by humans (National Research Council 2002). One of the main culprits is agriculture that has transformed many riparian areas into agricultural fields due to the their fertile soils that can lead to high crop productions. Riparian areas despite occupying only a small patio of the watershed offer disproportionately larger amount of ecosystem services (Patten 1998). This indicates that a simple solution in agricultural landscapes that can provide many benefits is leaving or re-establishing the riparian vegetation along the water body, a conservation practice that has been extensively implemented in North America (Zaimes et al. 2011c). Another main culprit is urbanization that can lead to the fragmentation of riparian areas (Iakovoglou et al. 2013; Hutmacher et al. 2014). Connectivity is a key characteristic of riparian areas in order to maintain its ecosystem services (Zaimes and Emmanouloudis 2012).

In Southern Europe the maintenance and re-establishment of riparian areas is a necessary task, but at the same time extremely difficult since most riparian areas have experienced an extensive history of intensive land-use changes and other human disturbances (Decamps et al. 1988; Corbacho et al. 2003). The importance of conserving and protecting them In the European Union (EU) has been recognized by the many riparian areas that have been designated as Natura 2000 sites (European Commission 2007). Additionally, the EU Water Framework Directive (2000/60/EC) has recognized their importance as essential features in the hydromorphological assessment of freshwater bodies.

In Greece, in most lowland areas where agricultural activities are prevalent, riparian areas have been eliminated or have been severely degraded (Zaimes et al. 2010). Zaimes et al. (2011a) found that the mountainous region riparian areas of the Nestos River Basin in northern Greece, are primarily intact with forest/shrub vegetation (natural vegetation). In contrast, in the lowland areas, the tributaries of Nestos River are cultivated up to the edge of the stream with the riparian vegetation, in most cases, being completely eliminated. Only the adjacent areas of the main reach of Nestos River are forested that belongs to the Natura 2000 network.

Overall, in most developed countries, the study and conservation of riparian areas has been conducted and implemented for decades. In Greece, the study and conservation of riparian areas has been brought to the forefront only in the last decade (Zaimes et al. 2011b). The purpose of this study was to assess the hydrologic and the anthropogenic impact on characteristic lowland riparian areas of Greece and of the greater Euro-Mediterranean region. This was done with a commonly used worldwide visual assessment tool that was modified to the characteristics of the Euro-Mediterranean environment. This tool will allow land managers to quickly assess riparian area conditions in order to decide what and if any management actions should be taken to enhance the riparian areas of interest.

2 METHODS AND MATERIALS

2.1 Study area

The study was conducted in the region of Eastern Macedonia in northern Greece in the prefectures of Kavala and Drama. In both prefects the lowlands are primarily in agriculture production with an approximate average yearly temperature and annual mean rsainfall of 15 ^{O}C and 540 mm, respectively. To select the study areas, a survey for the riparian areas of the two prefectures was conducted, initially through GOOGLE EARTH and afterwards with actual field visits. The goal was to find riparian areas representative of Mediterranean lowlands in close proximity to each other and with small elevation differences. Another important feature that was considered was the hydrologic regime of the adjacent water bodies (stream flow). Overall, three characteristic riparian areas were selected (Figure 1). The first riparian area was adjacent to the Old Kavala stream that has perennial flow. The length of the studied reach was approximately 2 km with the elevation ranging from 236 to 367 m. The riparian ecotype was the Forest Eastern Sycamore (*Platanion orientalis*) (NATURA 2000 code: 92C0) (Zogaris et al. 2007). The dominant species was the eastern Sycamore (*Platanus orientalis*), a common species in the northeastern Mediterranean region. The land-use beyond the riparian forest vegetation was mainly Holm oaks (*Quercus ilex*) and pastures as well as small areas with agricultural crops. The second reach was along the torrent of Kallifyto that had intermittent flow. Torrents are a characteristic type of water body with intermittent or ephemeral and frequent flash flood (Emmanouloudis et al. 2011). Since they are quite extensive in the Euro-Mediterranean region they are an important water body for the region and their adjacent riparian areas offer important ecosystems services. The reach length again was approximately 2 km with the elevations ranging from 128 το 152 m. The riparian

ecotype again was the Forest Eastern Sycamore (*Platanion orientalis*) (NATURA 2000 code: 92C0) (Zogaris et al. 2007). The dominant species were the eastern Sycamore tree (*Platanus orientalis*) and *Rubus* sp. The land-uses beyond the riparian vegetation were agricultural crops, pastures and grasslands. The final study area was along Lydia stream that had perennial flow. The reach was approximately 2 km with the elevation ranging from 58 to 62 m. The riparian ecotype differed and was the Forest Galleries with Willows (*Salix alba)* and Poplars (*Populus alba)* (NATURA 2000 code: 92A0) (Zogaris et al. 2007). The species that dominated were black poplar (*Populus nigra*), willow (*Salix alba*), white poplar (*Populus alba*), *Rubus* sp. This is also another characteristic riparian habitat of the Euro-Mediterranean region. The land-uses beyond the riparian area was mostly agricultural crops, such as corn, wheat, sunflower, alfalfa and a large variety of vegetables.

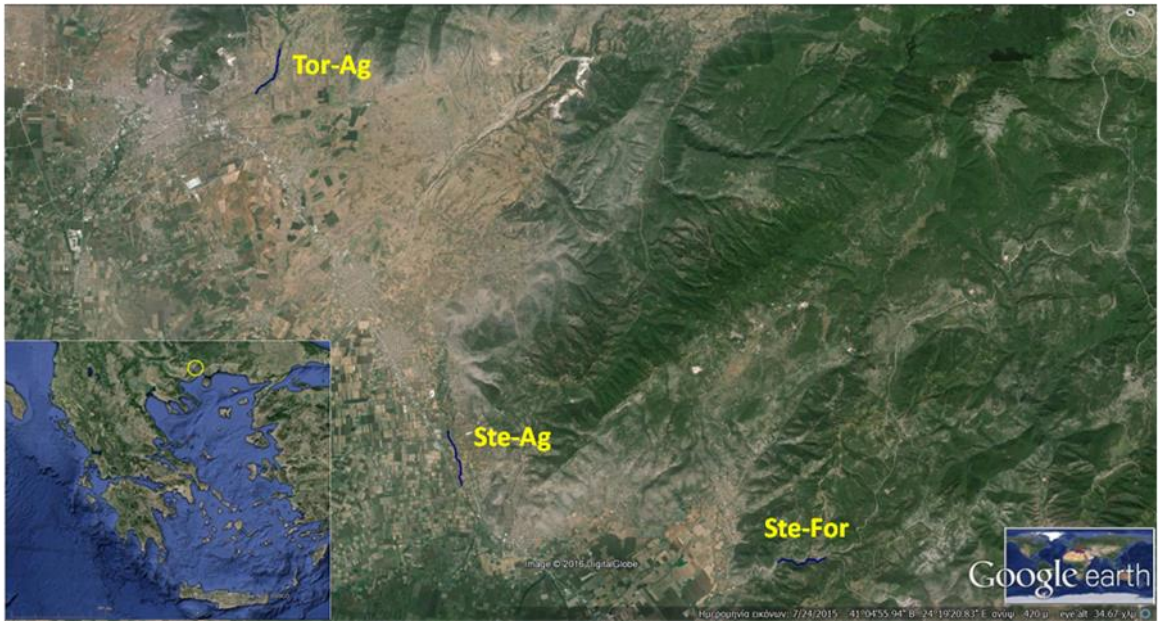

Figure 1. The location of the study areas in Greece (Bottom left corner). The surveyed riparian areas (in blue) of the study areas that were: a) Tor-Ag - natural woody vegetation along a torrent with intermittent flow adjacent to agricultural fields b) Ste-Ag - natural woody vegetation along a stream with perennial flow adjacent to agricultural fields, and c) Ste-For - natural woody vegetation along a stream with perennial flow adjacent to forested areas

The characteristic riparian habitats surveyed were: a) natural woody vegetation along a stream with perennial flow adjacent to agricultural fields (Ste-Ag), b) natural woody vegetation along a torrent with intermittent flow adjacent to agricultural fields (Tor-Ag), and c) natural woody vegetation along a stream with perennial flow adjacent to forested areas (Ste-For).

2.2 Stream Visual Assessment Protocol

The Stream Visual Assessment Protocol (SVAP) provides information on the ecological status of streams and riparian areas and was developed in the United States (Bjorkland et al. 1998, 2001). In this study it was modified to the needs of Greek riparian areas (Zaimes et al. 2010) that could also be applied to other Euro-Mediterranean countries.

In the datasheets that were used for the evaluation, the first page included the general information on the plot surveyed. In the second page the characteristics that were examined for the modified version were: a) Channel condition, b) Hydrologic alteration, c) Riparian zone condition, d) Bank stability, e) Water existence, f) Water appearance, g) Livestock shed presence, h) Instream fish cover, i) Pools, j) Insect/invertebrate habitat, k) Canopy cover, l) Manure presence, m) Biological wastewater treatment presence, and n) Garbage presence. The 14 characteristics were ranked with values of 0-10 depending on the actual conditions of the plot. The overall score for the plot was the average of the 14 characteristics. The categorization was as following:

- **Poor** with values lower than 6,
- **Moderate** with values from 6.1 to 7.4,
- **Good** with values from 7.5 to 8.9 and
- **Excellent** with values greater than 9.

2.3 Sampling design - Statistical Analysis

There were two riparian ecotypes (Forest Eastern Sycamore and Forest Galleries with Willows and Poplars) and two hydrologic regimes (streams with permanent flow and a torrent with intermittent flow). In each study area 20 sample plots were surveyed at a distance of approximately 100 m between them. The survey was conducted from November 10, 2015 until November 19, 2015. For the statistical analysis of the surveyed data the SPSS program was used. With this program the characteristics and the average value of the protocol for the three study areas were compared. Specifically the average value, standard deviation, standard error and statistical difference (Tukey test, p-value) were calculated.

3 RESULTS AND DISCUCSSION

Based on the SVAP evaluations, despite the fact that all three sites were categorized as moderate the Ste-For had the highest mean score with 7.35, while second was the Ste-Ag with 7.21 and last is the Tor-Ag 6.20 (Fig. 2). Significantly different was only the Tor-Ag from the other two areas. This indicated that riparian areas along torrents are more susceptible to agricultural activities than streams with perennial flows. It is also important to note the fact that all three areas were characterized as moderate, that indicates levels of ecosystem degradation. Hence, management actions need to be taken in order to improve and sustain the functionality of the stream and the ecosystem services of these riparian areas.

In addition, a closer look at each study area was performed by investigating the values for each assessed SVAP characteristics (Table 1). For each study area the 14 characteristics assessed with had substantially different values. Based on the results, the three study areas faced different problems that indicated that for each area different measurement actions need to be considered and taken.

Specifically, for the Ste-For significant hydrologic alterations (primarily lack of flooding) occurred that degraded the instream fish cover and also impacted the insect/invertebrate habitat. In addition, in all three areas the nearby towns did not have biological wastewater treatments. This fact should be a major concern. Again, for the Ste-Ag, major hydrologic alterations occurred that impacted the instream fish cover and the number of pools. In addition, in the study area, the adjacent agricultural activities degraded the riparian vegetation that also decreased the canopy cover over the stream channel. Finally in the Tor-Ag, the riparian zone was also impacted but less severely that was expressed by the more severe stream bank erosion, while the water appearance was also low. The impacted riparian zone also decreased the canopy cover over the channel. The extensive stream bank erosion of the Tor-Ag led to degraded instream fish cover and the insect/invertebrate habitat and decreased number of pools. Another major problem was the presence of manure that indicated probably more grazing in the riparian areas compared to the other two, although those also had grazing issues but to a smaller degree (presence of manure). The presence of garbage should also be addressed, especially in the Tor-Ag. Overall, most problems seemed to be related to human activities indicating that best management practices could help improve the functionality and services of the riparian areas.

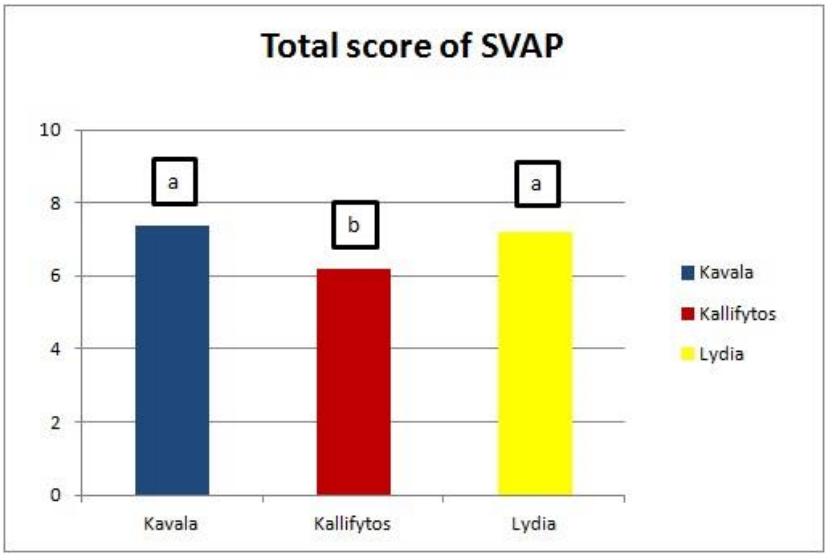

Figure 2. The mean scores for the three study areas based on the SVAP evaluations. Only the natural woody vegetation along a torrent with intermittent flow adjacent to agricultural fields (Tor-Ag) was statistically different from the other two areas. Still all areas are considered as moderate

Table 1. The average values of each SVAP characteristic assessed for the three study areas

Study Areas	**SVAP Characteristics**						
	Channel condition	*Hydrologic alteration*	*Riparian zone condition*	*Bank stability*	*Water existence*	*Water Apperance*	*Livestock Sheds*
Ste-For	9.50	1.20	8.00	9.20	9.80	9.45	10.00
Ste-Ag	10.00	1.80	4.80	8.00	10.00	10.00	9.90
Tor-Ag	8.15	9.00	7.00	5.20	9.15	8.60	8.80
	Instream fish cover	*Pools*	*Insect/ invertebrate habitat*	*Canopy cover*	*Manure presence*	*Biological wastewater treatment*	*Garbage presence*
Ste-For	2.60	9.50	7.50	8.90	7.50	1.00	8.80
Ste-Ag	6.85	6.35	9.85	5.80	8.00	1.00	8.65
Tor-Ag	2.25	5.45	6.40	4.65	4.10	1.00	7.00

4 CONCLUSIONS

The SVAP provides a quick assessment on the condition of the stream and riparian areas of interest. With the current modifications it meets the needs of the Euro-Mediterranean riparian environments. It must be noted that SVAP provides a first assessment and for the optimal best management practices additional measurements and monitoring are required.

In regards to the riparian areas of the study, they were characterized as moderate indicating that anthropogenic impacts have degraded the water body and the adjacent riparian areas. This indicates decreased functionality and services of the riparian area. Best management practices should be implemented to enhance the functionality and sustainable use of riparian areas. This measures could include minimizing or excluding grazing activities, prohibiting garbage disposal in the riparian areas and increasing the width of areas with riparian vegetation (planting of trees and shrubs). The riparian areas could be further enhanced with stream bank stability measures (e.g. bioengineering techniques, planting of willows) and re-establishing the connectivity of the riparian areas with streams/torrents (e.g. more frequent flooding).

Another important aspect that needs to be addressed is the awareness of the importance of riparian areas. As already mentioned in the introduction riparian area research has been brought in the forefront by the scientific community only in the last decade. The awareness of the general public is even smaller that clearly shows the importance of educational events. This should be easier achieved with the establishment of the UNESCO Chair on Conservation and Ecotourism of Riparian and Deltaic Ecosystems (Con-E-Ect) at the Eastern Macedonia and Thrace Institute of Technology, Kavala, Greece. The Chair will promote riparian areas though new studies, developing new material (interactive websites, leaflets) and events (workshops).

REFERENCES

Bjorkland, R., Pringle, C.M., and Newton, B. (1998). *Stream visual assessment protocol. National Water and Climate Center technical note 99-1,* U. S. Department of Agriculture, Natural Resources Conservation Service (NRCS) Aquatic Assessment Workgroup, Washington, DC, p. 36.

Bjorkland, R., Pringle, C.M., and Newton B. (2001). A stream visual assessment protocol (SVAP) for riparian landowners. *Environmental Monitoring and Assess*ment, **68**, 99-125. DOI:10.1023/A:1010743124570.

Corbacho, C., Sanchez, J.M., and Costillo, E. (2003). Patterns of structural complexity and human disturbance of riparian vegetation in agricultural landscapes of a Mediterranean area, *Agriculture, Ecosystems and Environ*ment, **95**, 495–507. DOI: 10.1016/S0167-8809(02)00218-9

Correll, D.L. (1997). Buffer zones and water quality protection: General principles. In N.E. Hancock et al. (Eds.), *Buffer zones: Their processes and potential in water protection* (pp. 7-20). Hertfordshire: Quest Environmental.

Decamps, H., Fortune, M., Gazelle, F., and Patou, G. (1988). Historical influence of man on the riparian dynamics of a fluvial landscape, *Landscape Ecol.,* **1**, 163-173. DOI:10.1007/BF00162742

Emmanouloudis D., García Rodríguez, J.L., Zaimes, G.N., Giménez Suárez M.C., and Filippidis, E. (2011). Euro-Mediterranean torrents: Case studies on tools that can improve their management. In K.E. Richards (Ed.) *Mountain Ecosystems: Dynamics, Management and Conservation* (pp. 1-44). Hauppauge: Nova Science Publishers Inc.

European Commision (2007). Nature & Diversity. http://ec.europa.eu/environment/nature/index_en.htm. Accessed 16 December 2014.

Ffolliott, P.F., Baker, M.B., DeBano, L.F. and Neary, D.G. (2004). Introduction. In M.B. Baker et al. (Eds.), *Riparian areas of the Southwestern United States: Hydrology, ecology and management* (pp. 1-9). Boca Raton: CRC Press.

Gregory, S.V., Swanson, F.J., McKee, W.A., and Cummins, K.W. (1991). An ecosystem perspective of riparian zones, *BioScience*, **41**, 540-551. DOI: 10.2307/1311607

Hutmacher, A.M., Zaimes, G.N., Martin, J., and Green, D.M. (2014). Vegetation structure along urban ephemeral streams in southeastern Arizona, *Urban Ecosystems*, **17**(1), 349-368. DOI: 10.1007/s11252-013-0293-4

Iakovoglou, V., Zaimes, G.N., and Gounaridis, D. (2013). Riparian areas in urban settings: Two case studies from Greece, *International Journal of Innovation and Sustainable Development*, **7**(3), 271-288. DOI: 10.1504/IJISD.2013.056944

Lowrance, R.R., Leonard, R., and Sheridan, J. (1985). Managing riparian ecosystems to control nonpoint pollution, *Journal of Soil and Water Conservation*, **40**, 87-91.

Malanson, G.P. (1997). *Riparian landscapes*, Cambridge University Press, New York, pp. 308.

National Research Council (NRC) (2002). *Riparian areas: functions and strategies for management.* National Academy of Science, Washington, pp 444.

Naiman, R.J. and Decamps, H. (1997). The ecology of interfaces-riparian zones, *Annual Review of Ecology and Systematics*, **28**, 621–658. DOI: 10.1146/annurev.ecolsys.28.1.621

Naiman, R.J., Decamps, H., and McClain, M.E. (2005). *Riparia - ecology, conservation and management of streamside communities*, Elsevier Academic Press Publications, London, pp 448.

Osborne, L.L. and Kovacic, D.A. (1993). Riparian vegetated buffer strips in water-quality restoration and stream management, *Freshwater Biology*, **29**, 243-258. DOI: 10.1111/j.1365-2427.1993.tb00761.x

Patten, D.T. (1998). Riparian ecosystems of semi-arid North America: Diversity and human impacts, *Wetlands*, **18**, 498-512. DOI: 10.1007/BF03161668

Pieczynska, E. (1990). Lentic aquatic-terrestrial ecotones: their structure, functions and importance. In R.J. Naiman & H. Decamps (Eds.), *The ecology and management of aquatic-terrestrial ecotones* (pp. 103-140). Paris: UNESCO and the Parthenon Publishing Group.

Schultz, R.C., Colletti, J.P., Isenhart, T.M., Marquez, C.O., Simpkins, W.W., and Ball, C.J. (2000). Riparian Forest Buffer Practices. In H.E. Garett et al. (Eds.), *North American Agroforestry: An integrated science and practice* (pp. 189-281). Madison: American Society of Agronomy Inc.

Zaimes, G.N., Schultz, R.C., and Isenhart, T.M. (2008). Streambank soil and phosphorus losses under different riparian land-uses in Iowa, *Journal of American Water Resource Association*, **44**(4), 935-947. DOI: 10.1111/j.1752-1688.2008.00210.x

Zaimes, G.N., Schultz, R.C., and Tufekcioglu, M. (2009). Gully and Stream Bank Erosion in Three Pastures with Different Management in Southeast Iowa, *Journal of the Iowa Academy of Science*, **1-4**, 1-8.

Zaimes, G.N., Iakovoglou, V., Emmanouloudis D., and Gounaridis, D. (2010). Riparian areas of Greece: their definition and characteristics, *Journal of Engineering Science and Technology Review*, **3**, 176-183.

Zaimes, G.N., Gounarids D., and Fotakis, D. (2011a). Assessing riparian land-uses/vegetation cover along the Nestos River in Greece, *Fresenius Environmental Bulletin*, **20**, 3217-3225.

Zaimes G.N. and Emmanouloudis, D. (2012). Sustainable Management of the Freshwater Resources of Greece, *Journal of Engineering Science and Technology Review*, **5**(1), 77-82.

Zaimes, G.N., Gounarids, D., Iakovoglou, V., and Emmanouloudis, D. (2011b). Riparian area studies in Greece: A Literature review, *Fresenius Environmental Bulletin*, **20**, 1470-1477.

Zaimes, G.N, Lee, K-H., Tufeckoglu, M., Long, L.A., Schultz, R.C., and Isenhart, T.M. (2011c). The Effectiveness of Riparian Conservation Practices in Reducing Sediment in Iowa Streams. In B.P. Hendriks (Ed.), *Agricultural Research Updates. Volume 2* (pp. 117-166). Hauppauge: Nova Science Publishers Inc.

Zogaris, S., Hatzirvassanis, V., Economou, A.N., Hatzinikolaou, Y., Giakoumi S., and Dimopoulos, P. (2007). *Παρόχθιες Ζώνες στην Ελλάδα: Προστατεύοντας τις Παραποτάμιες Οάσεις της Ζωής* [*Riparian Zones in Greece: Protecting riverine oases of life*], Institute of Inland Waters of the Hellenic Center for Marine Research (HCMR), Athens, pp. 95. [in Greek]