*International Research Journal of Environment Sciences*_____ ISSN 2319–1414
Vol. **4(5),** 85-90, May **(2015)** *Int. Res. J. Environment Sci.*

Review Paper

Concept of plant invasion Ecology as Prime Factor for Biodiversity Crisis: Introductory review

Prabhat Kumar Rai
Department of Environmental Science, Mizoram University, Tanhril, Aizawl-796004, Mizoram, INDIA

Available online at: www.isca.in, www.isca.me
Received 22nd January 2015, revised 14th March 2015, accepted 2nd April 2015

Abstract

Biodiversity is extremely precious resource issue in current civilization as it is inextricably linked with sustainable development. Plant invasion is the priority threat to global biodiversity and hence deleterious to both ecology and economy of any nation. Exotic invasive plant species poses serious threat to the native biodiversity. Invasive plants transmogrify the landscape ecology in a highly complex manner leading to a sort of ecological explosion. Global terrestrial as well as aquatic ecosystems are invaded by various invasive plant species. Invasive species are alien species whose introduction and spread threatens ecosystems, habitats or species with socio-cultural, economic and/or environmental harm, and harm to human health. Present review precisely introduce to invasion ecology and its interrelated interaction with other anthropogenic perturbations.

Keywords: Invasion, biota, environmental problems, indigenous.

Introduction

In recent Anthropocene era, biodiversity extends to humankind multifaceted direct economic benefits and direct essential services through natural ecosystems and plays a prominent role in ecosystem function and stability[1-8]. In recent era of rapid industrialization and urbanization, anthropogenic perturbations are causing a biodiversity crisis, with species extinction rates up to 1000 times higher than background [9,1]. Plant invasions have caused an unprecedented loss of the global native biodiversity. Henceforth, in the current era of Anthropocene, unravelling the facts that what makes the replacement of indigenous climax communities originating through succession by exotic invasive species[1,10-14] is of extreme importance.

Plant invasion is one of the major threats to global biodiversity, being 'big five' environmental issues of public concern[1,15,16] and one of the six most serious environmental problems which may influence future economical and social development[1,17-19]. Earth Summit in Rio de Janeiro, 1992 regarded invasive species as one of the main reasons for the loss of biodiversity[20,21]. Through advent of communication, science and technology, various factors like transport, migration, and commerce, humans are continuing to disperse an ever-increasing array of species across previously insurmountable environmental barriers such as oceans, mountain ranges, rivers, and inhospitable climate zones[22,1].

Humans have extensively altered the global environment, changing global biogeochemical cycles, transforming land and enhancing the mobility of biota[23,1]. Further, high natural resource extraction, short food chains, food web simplification, habitat homogeneity, landscape homogeneity, heavy use of herbicides, pesticides, and insecticides, large importation of non-solar energy, large importation of nutrient supplements, convergent soil characteristics, modified hydrological cycles, reduced biotic and physical disturbance regimes, global mobility of people, goods, and services are some characteristics of intentionally modified ecosystems[24,1]. Gallagher and Carpenter (1997)[25] remarked on human-dominated ecosystems, the concept of a pristine ecosystem, untouched by human activity, "is collapsing in the wake of scientists' realization that there are *no places left on Earth that doesn't fall under humanity's shadow.*"

Distribution factors: Initially trade and then transportation systems of various kinds have distributed invasive species around the world[1,26,27] as Kaiser (1999)[28] notes, "The world's ecosystems will never revert to the pristine state they enjoyed before humans began to routinely crisscross the globe." Even those considered "natural" almost inevitably contain invasive species, frequently in dominant roles. Moreover, modern technological systems continue to increase the scale of these impacts[29]. Recent advances in genetics and molecular biology also paved the way for an open debate on their impacts on ecology and global biodiversity. The histories of invasions and agriculture are intimately linked, with many crop and livestock pests being invasive species and vice versa[30]. Particularly, agricultural biotechnology, i.e. the insertion of genes into crops, has generated concern over the risk of producing new invasive species or exacerbating current weed problems[1,31,30]. Also, it has been demonstrated that the sale and transport of prohibited invasive plants and their misidentification present the greatest risk associated with the horticultural trade[32].

In the light of aforesaid, it is clear that modern intensive agriculture paved the way for invasive plants through trade and transport all across the globe. Further, it leads to land use changes (conversion of forests/grasslands into agro ecosystems), habitat fragmentation as well as increase the level of persistent organic pollutants (POPs), hence, resulting in the increased level of CO_2/climate change. All these factors are directly or indirectly linked to biological invasions, in totality resulting in biodiversity loss (figure-1).

Although invasion results from multifaceted interrelated mechanisms, changes in biota resulting from habitat conversion and land use change, reduces genetic and species diversity; and due to the introduction of exotic species, leading to a homogenization of the global biota[33]. Climate and land use change also transmogrify the invasion process[15].

Land use systems: Land use change and habitat fragmentation may facilitate the invasion success, indirectly affecting the biodiversity. Land-use change is projected to have the largest global impact on biodiversity by the year 2100, followed by climate change, nitrogen deposition, species introductions and changing concentrations of atmospheric CO_2[15]. Land-use change is expected to be of particular importance in the tropics, climatic change is likely to be important at high latitudes, and a multitude of interacting causes will affect other biomes[23,34-36].
Land use and biological invasions have been the major drivers of grassland biodiversity change[37]. Invasive species bring changes in plant community composition which may be inextricably correlated with external land-use impacts[38]. Land use change resulting from agriculture may be the major driver for invasive plants since approximately 10^9 hectares of natural ecosystems would be converted to agriculture by 2050[39]. Furthermore, the homogenization of Earth's biota through the establishment and spread of alien species may also be attributed to increased trade and tourism linked with[40-42].

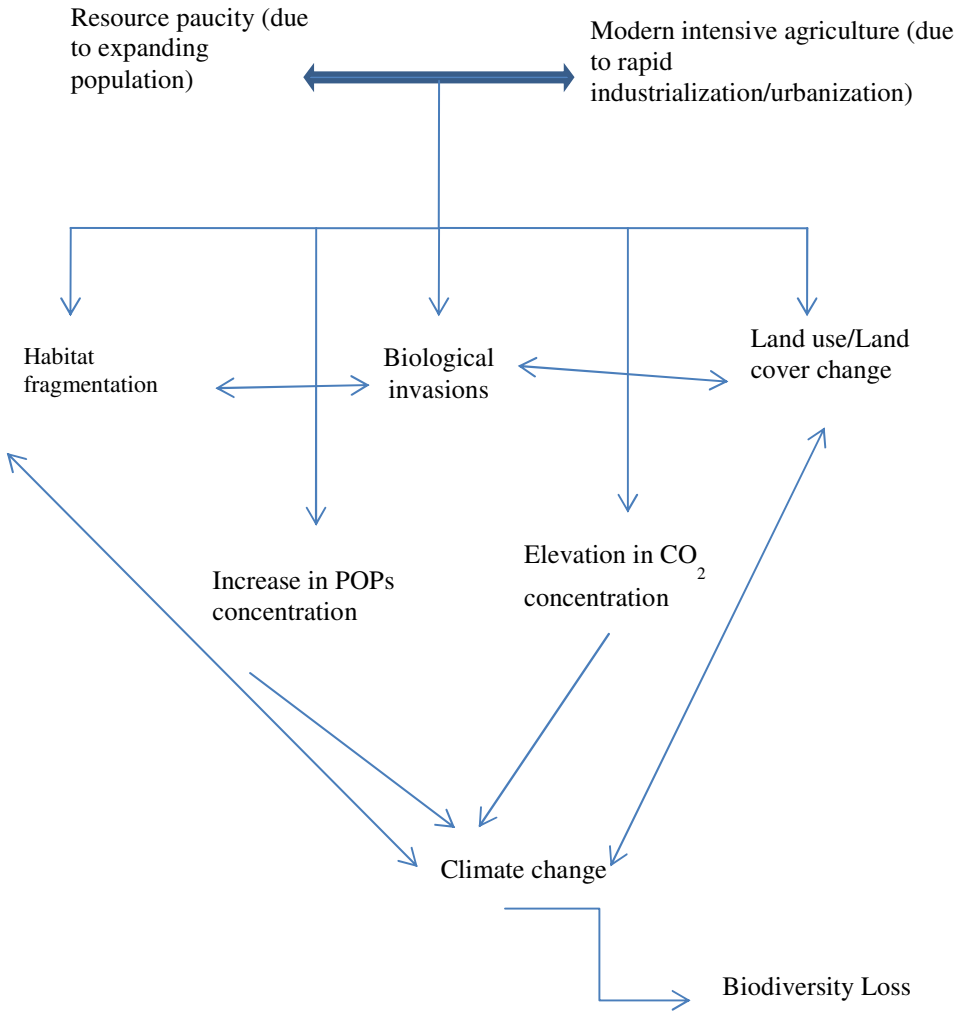

Figure-1
Paradigm of global interlinked ecological issues or concerns

Invasive Plants and the issues: It is worth to mention a few prominent invasive species *e.g. Lantana camara*, *Mikania micrantha*, *Chromolaena odorata*, *Eupatorium adenophorum*, *Cytisus scoparius*, *Mimosa invisa*, *Parthenium hysterophorus* and *Prosopis juliflora* among terrestrial exotics, and *Eichhornia crassipes* and *Pistia stratiotes* among aquatics, have posed serious threat to the native flora[43,44]. Henceforth, it will be better if we can provide a differential categorisation of invasion in terrestrial and aquatic ecosystems. There is a huge documentation of literature on ecosystem level impacts of plant invasion. The impacts may be further expanded on terrestrial (forest, riparian) ecosystems and aquatic (fresh water and marine) ecosystems. Ecosystem structures in terrestrial and aquatic ecosystems have many similarities; however, certain variations may have implications in context of invasion ecology. In terrestrial ecosystems, the plant-soil system involves a complex network of interactions and feedbacks and may function almost in isolation from the surrounding landscape[45]. Terrestrial ecosystems receive inputs from the atmosphere and from adjacent ecosystems. In contrast, aquatic systems have separate subsystems within the water column, at the water-sediment interface, and within the sediments. It is worth to mention that all these components can exchange materials with each other, as well as with other ecosystems and the atmosphere. Water movements play an important structuring role, and the dynamics of sediments are as important as the dynamics of nutrients, oxygen, and carbon in determining aquatic ecosystem function. Thus, it may be that invasive alter aquatic and terrestrial ecosystems through different pathways[1,45].

Invasion ecology is not very old field and attained pace from 20th century, and mostly the researches in its multifaceted disciplines attained pace during last fifty years[46]. Although the first paper on species invasions[47] appeared in 1919, study of the phenomenon is often traced back to Darwin's *Beagle* voyage, when he documented many European plants thriving as aliens in South America. He pointed out that escape from the parasites and diseases that attack them in their native range may contribute to the rapid spread of invading plants and animals[48].

In eighteenth century, plant invasion was generally being recognized as ecological phenomenon. However, in current scenario, invasive species are the second largest threat to global biodiversity just after habitat destruction and is the prime factor responsible for species extinction in most island states[43,49]. Global terrestrial as well as aquatic ecosystems are invaded by various invasive plant species[50-52]. In present era of ecological sciences, concept of plant invasion may be treated as a sort of ecological explosion[53]. Invasion of exotic invasive species is among the most important ecological perturbation experienced by natural ecosystems[43]. Such perturbation drives and regulates the dynamic ecosystems[1,43,54,55]. In order to understand plant community patterns, it has been suggested to investigate that plant-plant replacements, first by sampling long-term vegetation plots in order to map them, and then by manipulating mechanisms and tolerances in field experiments in order to understand what causes them[56].

Several reviews have enriched the ecological literatures with the several facets of invasion ecology, however, multifaceted issues in totality, associated with this ecological phenomenon were lacking. Present book aims to provide a critical review on mechanisms, impact and management of invasive species particularly in context of plants. However, at some places, biological invasions would be described in terms of animals also. Now, before going into details of the present review, it is pertinent to understand the generalized definitions and terms associated with invasion ecology. Davis[57] in his book mentioned different views and terminology imposed in invasion ecology and unlikely to reach any consensus.

Definition: *The Convention on Biological Diversity held in 1992, defines an invasive species as "an alien species whose introduction and spread threatens ecosystems, habitats or species with socio-cultural, economic and/or environmental harm, and/or harm to human health"* [57-59].

Whereas the scientific biological definition neglects the perspective of impacts and describes the naturalisation and unintended spread of unwanted organisms in areas where they have not previously occurred naturally[60,59]. *Organisms immigrating to new localities and their descendants have been referred to as alien, adventive, exotic, introduced and non-indigenous*[22, 43].

Species that have been transported by humans from one region to another are defined as alien or exotic[61,62].

Although there are several definitions of alien invasive species, however, the one given by GISP (2003)[63] seems to be most relevant in totality i.e.: *'Invasive alien species are non-native organisms that cause, or have the potential to cause, harm to the environment, economies, or human health'*. Thus establishment and spread of these species threatens landscape in terms of economy as well as environment[43,64].

Established: A species with a self-sustaining population outside of its native range. Indigenous species: a species found within its native range.

Invasive species: a nonindigenous species that spreads from the point of introduction and becomes abundant.

Nonindigenous species: a species introduced to areas beyond its native range by human activity.

Noninvasive species: A nonindigenous species that remains localized within its new environment.

Transition: One step in the invasion sequence (e.g. transportation, release and establishment).

Conclusion

A principal result of the Industrial Revolution and subsequent technological development is the evolution of a planet where the dynamics of major natural systems are increasingly affected by human activity (Rai, 2013). Invasive species are a serious problem for the world, both ecologically and economically. The impact of invasive species on native species and ecosystems has been immense. Literatures revealed that 10% of the 260,000 vascular plant species is assumed to be potential invaders (Rai, 2013). Eighty conifer taxa (79 species and one hybrid; 13% of species) are known to be naturalized, and 36 species (6%) are 'invasive'.

Majority of research studies on biological invasions is reported from developed countries, with scanty information on plant invasions in the biodiversity-rich developing countries, including India, and these gaps have serious implications for global environmental policy making. Towards filling these knowledge gaps, categorization of invasive alien biota is the crucial starting point in developing countries With reference to developing countries like India having four biodiversity hotspots, developing the consolidated strategy in order to combat the problems of plant invasion is the need of the hour. The conservation, enhancement and sustainable and equitable use of biodiversity should be accorded high priority in all national environment protection programmes. In the recently held CABI (Commonwealth Agricultural Bureau International)-MSSRF Workshop on Alien Invasive species at Chennai, India the seven point action plan was developed to manage the invasive alien species with a focus on public awareness; research to fill gaps in our knowledge of the invasive alien species and measure the social, economic and ecological impact of invasive alien species, as well as to evaluate traditional ecological knowledge at the local level; Action at local, state level., national level, regional level and global level should be taken in this regard. Scientific literature on biological invasions in the developing world is currently scarce. India, a fast-globalizing country, faces a high risk of biological invasions. However, research and policy efforts on biological invasions in India are presently inadequate.

In order to address the scale and impacts of this anthropogenic mixing of biotas, as well as an opportunity for basic biological insight, invasion biology has become a rapidly developing discipline with broad ecological and conservation implications. Preparing a comprehensive database of alien floras has been an essential tool for the understanding of plant invasions in different parts of world. Biodiversity threats are not evenly distributed, therefore, prioritization is essential to minimize biodiversity loss arising out of the invasion.

Invasion papers were least likely to be cross-linked (6%) with other fields, whereas gap/patch dynamics papers were most likely to be cross-linked (15%). This tendency toward intellectual isolation may be impeding efforts to achieve more powerful generalizations in ecology by reducing the number of potentially productive exchanges among researchers.

Furthermore, there is need for greater vigil against alien invasive species, since with growing world trade in food grains and other agricultural commodities, there is an increasing possibility of introducing new pests, weeds and harmful micro-organisms. Recent methods based on analyses of genetic markers have provided tools for the retracing of invasion routes and the history of the invading populations from their geographic origin to their final spread in the invaded area. Further, it is worth to mention that future studies in invasion ecology must ensure the links between species traits, ecosystem stocks, ecosystem flows and ecosystem services in order to have appropriate impact assessment to suggest sustainable management approaches. Invasion biologists across the different countries developed different model frameworks for the invasion process in conjunction with different taxa and different environments leading to a plethora of confusing concepts. Therefore, a unified framework for biological invasions that reconciles and integrates the key features of the most commonly used invasion frame- works into a single conceptual model that can be applied to all human-mediated invasions (Rai, 2013).

References

1. Rai P.K., Plant invasion ecology, Impacts and Sustainable management, Nova Science Publisher, New York, 196 **(2013)**

2. Rai P.K., Land Use Changes in North Eastern Himalayan Region (an Indo-Burma Hot spot) and its Impact on Human Health. In K.N. Tiwari and S. Lata (Editors), Biodiversity and Sustainable Development, Prasanna Prakashan, Bhopal, 175-192 **(2011)**

3. Rai P.K., Assessment of Multifaceted Environmental Issues and Model Development of an Indo- Burma Hot Spot Region, *Environ. Monit. Assess,* **184**, 113–131 (**2012**)

4. Rai P.K. and Lalramnghinglova H., Threatened and less known ethnomedicinal plants of an Indo-Burma hotspot region: conservation implications, *Environ. Monit. Assess,* **178**, 53–62 **(2011)**

5. Rai P.K. and Panda L.S., Dust capturing potential and air pollution tolerance index (APTI) of some roadside tree vegetation in Aizawl, Mizoram, India: An Indo-Burma hot spot region, *Air quality, Atmosphere and Health,* **7(1)**, 193-101 (**2014a**)

6. Rai P.K. and Panda L.S., Leaf dust deposition and its impact on biochemical aspect of some roadside plants in Aizawl, Mizoram, North-East India, *Int. Res. J. Environment Sci,* **3(11)**, 14-19 (**2014b**)

7. Rai P.K. and Chutia B.M., Assessment of Ambient air quality status Before and after shifting cultivation in an

Indo-Burma hot spot region, *Int. Res. J. Environment Sci,* **3(11)**, 1-5 (**2014**)

8. Rai P.K., Plant invasion ecology of an Indo-Burma hot spot region along the disturbance gradient: A case study, *Int. Res. J. Environment Sci.*, In Press, **(2015)**

9. Brooks et al., Global Biodiversity Conservation Priorities, Science, **313**, 58-61 **(2006)**

10. Lovel G.L., Global change through invasion, *Nature*, **388**, 627 **(1997)**

11. Rejmánek M., Holocene invasions: finally the resolution ecologists were waiting for!, *Trends in Ecol. Evol*., **14(1)**, 18-20 **(1999)**

12. McNeely J.A., An introduction to human dimensions of invasive alien species. Human dimension of the consequences of invasive alien species, ISSG, IUCN, www.issg.org, **(2001)**

13. Van Kleunen M. et al., Are invaders different? A conceptual framework ofcomparative approaches forassessing determinants of invasiveness, *Ecol. Lett*., **13**, 947–958 **(2010)**

14. Crossman N.D., Bryan B.A. and Cooke D.A., An invasive plant and climate change threat index for weed risk management: Integrating habitat distribution pattern and dispersal process, *Ecol. Indi.*, **11**, 183–198 **(2011)**

15. Sala O.E., Chapin F.S. III, Armesto J.J., Berlow E., Bloomfield J., Dirzo R., Huber-Sanwald E., Huenneke L.F., Jackson R.B., Kinzig A., Leemans R., Lodge D.M., Mooney H.A., Oesterheld M., Poff N.L., Sykes M.T., Walker B.H., Walker M. and Wall D.H., Global biodiversity scenarios for the year 2100, *Science*, **287**, 1770–1774 **(2000)**

16. Didham RK., Tylianakis JM., Hutchison MA, Ewers RM and Gemmell N.J., Are invasive species the drivers of ecological change?, *Trends Ecol. Evol*., **20(9)**, 470-474 **(2005)**

17. Gewin V., Industry lured by the gains of going green, *Nature* **436**, 173 **(2005)**

18. Mooney H., Cropper A. and Reid A., Confronting the human dilemma, *Nature*, **434**, 561-562 **(2005)**

19. Huang H., Zhang L., Guan Y. and Wang D., A cellular automata model for population expansion of *Spartina alterniflora* at Jiuduansha Shoals, Shanghai, China, *Est. Coas. Shelf Sci.,* **77**, 47-55 **(2008)**

20. Keane R.M. and Crawley M.J., Exotic plant invasions and the enemy release hypothesis, *Trends in Ecol. Evol*., **17(4)**, 164-170 **(2002)**

21. Born W. and Rauschmayer F.B.I., Economic evaluation of biological invasions: A survey, *Ecol. Econ*, **55**, 321–336 **(2005)**

22. Mack R.N., Simberloff D., Lonsdale W.M., Evans H., Clout M. and Bazzaz F.A., Biotic invasions: Causes, epidemiology, Global Consequences and Control, *Ecol. Appl*., **10**, 689–710 **(2000)**

23. Chapin F.S., Zavaleta E.S., Eviner V.T., Naylor R.L. and Vitousek P.M., Consequences of Changing Biodiversity, *Nature* **405**, 234-242 **(2000)**

24. Western D., Human-modified ecosystems and future evolution, *Proc. Nati. Acad. Sci*., **98(10)**, 5458–5465 **(2001)**

25. Gallagher R. and Carpenter B., Human-dominated ecosystems: Introduction, *Science*, **277**, 485 **(1997)**

26. Barlow C., Green space, green time, New York: Springer-Verlag, **(1997)**

27. Jabolonski D., Extinctions: A Paleontological perspective, *Science*, **253**, 754-757 **(1991)**

28. Kaiser J., Stemming the tide of invading species, *Science*, **285**, 1836-1841 **(1999)**

29. Palumbi S.R., Humans as the world's greatest evolutionary force, *Science*, **293**, 1786-1790 **(2001)**

30. Guillemaud T., Ciosi M., Lombaert E. and Estoup A., Biological invasions in agricultural settings: Insights from evolutionary biology and population genetics, *C. R. Biologies*, **334,** 237–246 **(2011)**

31. Parker I.M. and Kareiva P., Assessing the risk of invasion for genetically engineered plants: Acceptable evidence and reasonable doubt, *Biol. Con*, **78,** 193-203 **(1996)**

32. Maki K. and Galatowitsch S., Movement of invasive aquatic plants into Minnesota (USA) through horticultural trade, *Biol. Cons.*, **118**, 389–396 **(2004)**

33. Chapin III F.S., Walker B.H., Hobbs R.H., Hooper D.U., Lawton J.H., Sala O.E. and Tilman D., Biotic Control over the Functioning of Ecosystems, *Science*, **277**, 500-504 **(1997)**

34. Ramakrishnan P.S., Ecology of Biological Invasion in the Tropics, International Scientific Publications, New Delhi, **(1991)**

35. Pimm S.L., Russell G.J., Gittleman J.L. and Brooks T.M., The future of biodiversity, *Science*, **269**, 347-350 **(1995)**

36. Lavergne S., Mouquet N., Thuiller W. and Ronce O., Biodiversity and Climate Change: Integrating Evolutionary and Ecological Responses of Species and Communities, *Annu. Rev. Ecol. Evol. Syst*., **41,** 321–50 **(2010)**

37. Zavaleta E.S., Hobbs R.J. and Mooney H.A., Viewing invasive species removal in a whole-ecosystem context, *Trends in Ecol. Evol.,* **16(8)**, 454-459 **(2001)**

38. Maskell L.C., Firbank L.G., Thompson K., Bullock J.M. and Smart S.M., Interactions between non-native plant species and the floristic composition of common habitats, *J. Ecol*, **94,** 1052–1060 **(2006)**

39. Tilman D., Fargione J., Wolff B., Carla D.Õ., Antonio Dobson A., Howarth R., Schindler D., Schlesinger W.H., Simberloff D. and Swackhamer D., Forecasting Agriculturally Driven Global Environmental Change, *Science*, **292**, 281 **(2001)**

40. Mooney H.A. and Hobbs R.J, Invasive Species in a Changing World, Island Press, Washington, DC, **(2000)**

41. Rahel F.J., Homogenization of fish faunas across the United States, *Science*, **288**, 854-856 **(2000)**

42. Kolar C.S. and Lodge D.M., Ecological Predictions and Risk Assessment for Alien Fishes in North America, *Science*, **298**, 1233 **(2002)**

43. Sharma G.P., Raghubanshi A.S. and Singh J.S., *Lantana* invasion: An overview, *Weed Biol. Manag.*, **5**, 157–165 **(2005)**

44. Timsina B., Shrestha B.B., Rokaya M.B. and Münzbergová Z., Impact of *Parthenium hysterophorus L.* invasion on plants pecies composition and soil properties of grassland communities in Nepal, *Flora*, **206**, 233–240 **(2011)**

45. Ehrenfeld J.G., Ecosystem Consequences of Biological Invasions, *Annu. Rev. Ecol. Evol. Syst*.**, 41**, 59-80 **(2010)**

46. Richardson D.M., Fifty Years of Invasion Ecology: The Legacy of Charles Elton, Wiley-Blackwell, **(2011)**

47. Grinnell J., The English sparrow has arrived in Death Valley: an experiment in nature, *Am. Nat*., **53**, 468 **(2000)**

48. Sax D.F., Stachowicz J.J. and Gaines S.D., Species Invasions: Insights into Ecology, Evolution, and Biogeography, Sinauer, Sunderland, MA, 509 **(2005)**

49. Schei P.J., Conclusions and recommendations from the UN/ Norway conference on alien species, *Sci. Int*., 63, 32-36 **(1996)**

50. Usher M.B., Kruger F.J., MacDonald I.A.W., Loope L.L. and Brockie R.E., The ecology of biological invasions into nature reserves: an introduction, *Biol. Cons*. **44**, 1-8 **(1988)**

51. Lonsdale W.M., Global patterns of plant invasion and the concept of invasibility. *Ecology*, **80**, 1522–1536 **(1999)**

52. Totland O., Nyeko P., Bjerknes A., Hegland S.J. and Nielsen A., Does forest gap size affects population size, plant size, reproductive success and pollinator visitation in *Lantana camara*, a tropical invasive shrub?, *For. Ecol. Manage*, **215**, 329-338 **(2005)**

53. Elton C.S., The ecology of invasions by animals and plants, John Wiley and Sons, **(1958)**

54. Sousa W.P., The role of disturbance in natural communities, *Annu. Rev. Ecol. Syst*., **15**, 353–391 **(1984)**

55. Gurevitch J. and Padilla D.K., Are invasive species a major cause of extinctions?, *Trends Ecol. Evol*. **19**, 470–474 **(2004)**

56. Myster R.W., Plants Replacing Plants: The Future of Community Modeling and Research, *Bot. Rev*., **78**, 2-9 **(2012)**

57. Davis A.M., Invasion Biology, Oxford University Press, 244 **(2009)**

58. COP, Review and consideration of options for the implementation of Article 8(h) on alien species that threatens ecosystems, habitats or species. Conference of the parties to the Convention on Biological Diversity (COP), UNEP/CBD/COP/6/18/Add.1/ Rev.1. 26-3-2002, **(2000)**

59. Born W., Rauschmayer F. and Bra¨uer I., Economic evaluation of biological invasions: A survey, *Ecol. Econ*, **55**, 321– 336 **(2005)**

60. Jay M., Morad M. and Bell A., Biosecurity, a policy dilemma for New Zealand, *Land Use Policy*, **20**, 121-129 **(2003)**

61. Richardson D.M. et al., Naturalization and invasion of alien plants – concepts and definitions, *Div. Distrib*., **6**, 93–108 **(2000)**

62. Villaseñor J.L. and Espinosa-Garcia F.J., The alien flowering plants of Mexico. *Div. Distrib*., **10**, 113–123 **(2004)**

63. GISP, The IAS problem. The Global Invasive Species Programme, http://www.gisp.org/about/IAS.asp., **(2003)**

64. GISP, Global strategy on invasive alien species. Global Invasive Species Programme workshop, Cape Town, South Africa, **(2000)**