

**DIVERSITY AND DISTRIBUTION OF INVASIVE ALIEN
PLANT SPECIES ALONG ROAD NETWORK IN
CENTRAL NEPAL**

**A Dissertation Submitted to the
Central Department of Botany, Tribhuvan University, for the Partial
Fulfillment of the Requirements of Masters of
Science in Botany**

Submitted by

Nirmala Paudel

Ecology and Resource Management Unit

Exam Roll No: 18217

Batch: 068/069 (2011/013)

TU Reg. No: 5-2-48-4186-2007

Central Department of Botany, Tribhuvan University

Kirtipur, Kathmandu, Nepal

April 2015



TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
CENTRAL DEPARTMENT OF BOTANY
OFFICE OF THE HEAD OF DEPARTMENT

No.

Tribhuvan University
Central Department of Botany
Kirtipur, Kathmandu

KIRTIPUR, KATHMANDU
NEPAL

RECOMMENDATION

This is to certify that the dissertation work entitled “**Diversity and Distribution of Invasive Alien Plant Species along Road Network in Central Nepal**” submitted by Nirmala Paudel has been carried out under my supervision. The entire work was based on the results of her primary fieldwork and has not been submitted for any other academic degree. I therefore, recommend this dissertation to be accepted for the partial fulfillment of Masters of Science in Botany from Tribhuvan University, Kathmandu, Nepal.

(Dr. Bharat Babu Shrestha)

Assistant Professor

Central Department of Botany

Tribhuvan University

Kathmandu, Nepal

Date: March 17, 2015

i

Phone: 4331322, 4333722 Fax: ++977-1-4332636, Post Box: 26429
E-mail: info@cdbtu.edu.np, Webpage: www.cdbtu.edu.np



TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
CENTRAL DEPARTMENT OF BOTANY
OFFICE OF THE HEAD OF DEPARTMENT

Tribhuvan University
Central Department of Botany
Kirtipur, Kathmandu

KIRTIPUR, KATHMANDU
NEPAL

LETTER OF APPROVAL

This dissertation paper entitled “Diversity and Distribution of Invasive Alien Plant Species along Road Network in Central Nepal” submitted to the Central Department of Botany, Tribhuvan University by Nirmala Paudel has been accepted for the partial fulfillment of requirements of Masters of Science in Botany.

EXPERT COMMITTEE

(External Examiner)

Dr. Naresh Subedi

Senior Scientific Officer

National Trust for Nature Conservation

(NTNC) Khumaltar, Lalitpur

(Internal Examiner)

Dr. Ram Kailash Prasad Yadhav

Associate Professor

Central Department of Botany

TU, Kathmandu, Nepal

(Supervisor)

Dr. Bharat Babu Shrestha

Assistant Professor

Central Department of Botany

TU, Kathmandu, Nepal

(Head of the Department)

Dr. Pramod Kumar Jha

Professor

Central Department of Botany

TU, Kathmandu, Nepal

Date of Examination: April 23, 2015.

ACKNOWLEDGEMENTS

I have received much help and support from many people in completing this work. Although, it is not possible to mention all by names, I would like to extend my sincere and special gratitude to the following individuals.

I am greatly indebted to my supervisor Dr. Bharat Babu Shrestha, Assistant Professor of Central Department of Botany, Tribhuvan University, Kirtipur, who guided me in all steps of this work through constructive suggestions, techniques and mechanics of research. I want to thank him very much for his support and critical comments and for always having an open door.

I am extremely grateful to Prof. Dr. Pramod Kumar Jha, Head of the Central Department of Botany, Tribhuvan University, Kirtipur for his administrative and moral support.

I owe my deep gratitude to Prof. Dr. Krishna Poudel, Central Department of Education (Geography) for his guidance and help during distribution map preparation using Arc GIS. I am grateful to Dr. Anjana Devkota, Dr. Ram Kailash Prasad Yadav, Dr. Chitra Bahadur Baniya and all other teachers and staffs of the Central Department of Botany for their encouragement and moral support.

My special thanks to my friend Ms. Sushmita Poudel and senior Ms. Kusum Pokhrel for their help during field visit. I am also thankful to my friends Seeta Kharel, Usha Adhikari, Til Kumari Chhetri, Renu DC and Prakash Gaire for their assistance, encouragement and support. I want to thank (Narayan, Rajkumar and Sunil) for their help during our field visit.

I must thank International Foundation for Science (IFS), Sweden for the partial financial support through grants to my supervisor.

Last but not the least, my deep appreciation goes to my parents Mr. Krishna Paudel and Mrs. Sita Paudel for being a source of inspiration and courage at all times ever. I am greatly indebted to my life partner Mr. Santosh Chiluwal for his support and inspiring encouragement in every step of my masters' study. I am also thankful to my brothers Sagar and Samundra Paudel and sister Srijana Paudel for their overall support and inspiration in every step of my academic career.

Nirmala Paudel

CONTENTS

CHAPTER	PAGE NO.
TITLE PAGE	
RECOMMENDATION	i
ACKNOWLEDGEMENTS	ii
CONTENTS	iii
ABSTRACT	vi
LIST OF FIGURES, TABLES, APPENDICES AND PHOTOPLATES	vii
LIST OF ABBREVIATION AND ACRONYMS	ix
1. INTRODUCTION	1-5
1.1 Background	1
1.2 Justification of the study	2
1.3 Hypothesis	3
1.4 Objectives	4
1.5 Limitations	5
2. LITERATURE REVIEW	6-14
2.1 Biological Invasions	6
2.2 Origin and Distribution of IAPS	7
2.3 Dispersal of IAPS	9
2.4 Community Invasibility	10
2.5 IAPS in Nepal	11
2.6 Management of IAPS	13
3. MATERIALS AND METHODS	15-22
3.1 Study Area	15

3.2 Survey of invasive alien plant species	18
3.3 Data Analysis	21
RESULTS	23-49
4.1 Frequency of IAPS	23
4.2 Frequency of dominant IAPS	23
4.3 Species richness of IAPS along elevation gradient	25
4.4 Invasive alien plant species richness across land use types	26
4.5 Distribution of IAPS across land use types	27
4.6 Relationship between frequency and first reported date in Nepal	28
4.7 Relationship between elevation limit and minimum residence time of IAPS	28
4.8 Elevational range of IAPS	30
4.9 Distribution of IAPS	32
4.9.1 Distribution of <i>Chromolaena odorata</i>	32
4.9.2 Distribution of <i>Ageratum conyzoides</i>	33
4.9.3 Distribution of <i>Argemone mexicana</i>	34
4.9.4 Distribution of <i>Cassia tora</i>	35
4.9.5 Distribution of <i>Bidens pilosa</i>	36
4.9.6 Distribution of <i>Cassia occidentalis</i>	37
4.9.7 Distribution of <i>Mimosa pudica</i>	38
4.9.8 Distribution of <i>Amaranthus spinosus</i>	39
4.9.9 Distribution of <i>Xanthium strumarium</i>	40
4.9.10 Distribution of <i>Ageratina adenophora</i>	41
4.9.11 Distribution of <i>Ipomoea carnea subsp. Fistulosa</i>	42
4.9.12 Distribution of <i>Lantana camara</i>	43
4.9.13 Distribution of <i>Mikania micrantha</i>	44
4.9.14 Distribution of <i>Hyptis suaveolens</i>	45
4.9.15 Distribution of <i>Oxalis latifolia</i>	46

4.9.16 Distribution of <i>Parthenium hysterophorus</i>	47
4.9.17 Distribution of <i>Alternanthera philoxeroides</i>	48
4.9.18 Distribution of <i>Eichhornia crassipes</i>	49
4.10 Distribution of Biological control agents	50
4.10.1 Distribution of <i>Procecidochares utilis</i>	50
4.10.2 Distribution of <i>Zygogramma bicolorata</i>	51
4.11 Species richness pattern of IAPS along road network in Central Nepal	51
4.12 Comparison with earlier reports	52
5. DISCUSSION	54-61
5.1 Frequency of invasive alien plant species	54
5.2 Invasive alien plant species richness pattern	55
5.3 Comparison of IAPS richness across land use types	58
5.4 Distribution of IAPS	59
6. CONCLUSIONS AND RECOMMENDATIONS	62-63
6.1 Conclusions	62
6.2 Recommendations	63
REFERENCES	64-76
APPENDICES	a-d
PHOTOPLATES	e-f

ABSTRACT

Invasive alien plant species are spreading rapidly in Nepal and can have irreversible environmental and economic problem if not managed in time. For the proper management of IAPS detail information regarding their diversity and distribution is needed. In this study a detail survey of IAPS distribution was carried out during June- July in 2013 along road networks in Central Nepal. The study also dealt with the variation in species richness pattern across land use types and along elevation gradient. IAPS distribution was assessed through systematic location of sample plots at an interval of 10km in plain areas and 5km in hilly areas. At every specified distance, a 10 × 10 m² plot was defined along the sides of the road. At each plot, IAPS encountered within the plot, their phenophases, presence of biocontrol agents and three most dominant IAPS in terms of cover were recorded. The cover was estimated visually and the frequency of individual IAPS was calculated. The geographical distribution map of each IAPS and overall species richness distribution pattern map was prepared using Arc GIS. A total of 340 plots were sampled covering 2075km of road network. Among the 18 species of invasive alien plants recorded from roadside vegetation, *Bidens pilosa* had the highest frequency whereas *Eichhornia crassipes* had the lowest. And *Ageratina adenophora* was the first dominant species in 30% of the sample plots. IAPS richness showed unimodal pattern of distribution along the elevation gradient. There was significant difference in species richness across land use types. Grazing and fallow land was more vulnerable to invasion, as reflected by the highest species richness in comparison to other land use types (Agricultural land>Shrubland>Forest>Wetland). A negative linear relationship was obtained between frequency (%) and year of record of the IAPS. There was no significant relationship between elevational limit and minimum residence time of IAPS. Most of the IAPS were concentrated to the tropical and sub-tropical region. Middle mountains had greater IAPS richness in comparison to other physiographic regions. This study concludes that IAPS have been spreading rapidly along road networks in Central Nepal. The road networks are acting as dispersal corridors and source areas for plant invasion. Therefore, comprehensive study of IAPS distribution and their impacts has to be carried out at national level which may be useful to develop management strategies for controlling biological invasion.

Keywords: Biological invasion, Invasive alien plant species, Species richness, Elevation gradient, Disturbance, Road network, Frequency, Residence time, Distribution maps.

LIST OF FIGURES, TABLES, APPENDICES AND PHOTOPLATES

A. FIGURES

Figure 1: Map of the study area.

Figure 2: Frequency (%) of individual invasive alien plant species.

Figure 3: Frequency (%) of first most dominant invasive alien plant species.

Figure 4: Frequency (%) of second most dominant IAPS.

Figure 5: Frequency (%) of third most dominant IAPS.

Figure 6: Relationship between average invasive plant species richness (number/100m²) and elevation (m).

Figure 7: Invasive alien plant species richness across land use types.

Figure 8: Relationship between frequency (%) and year of record of invasive alien plant species.

Figure 9: Relationship between altitudinal range and minimum residence time of different IAPS.

Figure 10: Altitudinal range of different IAPS.

Figure 11: Geographic distribution of *Chromolaena odorata* in Central Nepal.

Figure 12: Geographic distribution of *Ageratum conyzoides* in Central Nepal.

Figure 13: Geographic distribution of *Argemone mexicana* in central Nepal.

Figure 14: Geographic distribution of *Cassia tora* in Central Nepal.

Figure 15: Geographic distribution of *Bidens pilosa* in Central Nepal.

Figure 16: Geographic distribution of *Cassia occidentalis* in Central Nepal.

Figure 17: Geographic distribution of *Mimosa pudica* in Central Nepal.

Figure 18: Geographic distribution of *Amaranthus spinosus* in Central Nepal.

Figure 19: Geographic distribution of *Xanthium strumarium* in Central Nepal.

Figure 20: Geographic distribution of *Ageratina adenophora* in Central Nepal.

Figure 21: Geographic distribution of *Ipomoea carnea* ssp. *fistulosa* in Central Nepal.

Figure 22: Geographic distribution of *Lantana camara* in Central Nepal.

Figure 23: Geographic distribution of *Mikania micrantha* in Central Nepal.

Figure 24: Geographic distribution of *Hyptis suaveolens* in Central Nepal.

Figure 25: Geographic distribution of *Oxalis latifolia* in Central Nepal.

Figure 26: Geographic distribution of *Parthenium hysterophorus* in Central Nepal.

Figure 27: Geographic distribution of *Alternanthera philoxeroides* in Central Nepal.

Figure 28: Geographic distribution of *Eichhornia crassipes* in Central Nepal.

Figure 29: Geographic distribution of *Procecidichares utilis* in Central Nepal.

Figure 30: Geographic distribution of *Zygogramma bicolorata* in Central Nepal.

Figure 31: Species richness pattern of IAPS along road network in Central Nepal.

B. TABLES

Table 1: Invasive alien plant species considered in the present research.

Table 2: Percentage of occurrence across different land use types.

Table 3: Number of districts with particular IAPS.

C. APPENDICES

Appendix 1: Field data sheet used during our survey of IAPS along road network in Central Nepal (2013).

Appendix 2: District wise distribution of individual IAPS obtained from our survey.

Appendix 3: Elevational range of individual IAPS.

Appendix 4: Minimum residence time of IAPS with their first reported date in Nepal.

D. PHOTOPLATES

LIST OF ABBREVIATION AND ACRONYMS

IAPS	Invasive Alien Plant Species
IAS	Invasive Alien species
m	meter
asl	above sea level
ANOVA	Analysis of variance
GIS	Geographic Information System
SPSS	Statistical Package for Social Science
d.f.	Degree of freedom
p	Level of Significance
R ²	Coefficient of Determination
mm	Millimeters
km	Kilometers
m ²	meter square
GPS	Global Positioning System
Vs.	Versus
Yr	Year
IUCN	The World Conservation Union
GISD	Global Invasive Species Database
MFSC	Ministry of Forest and Soil Conservation