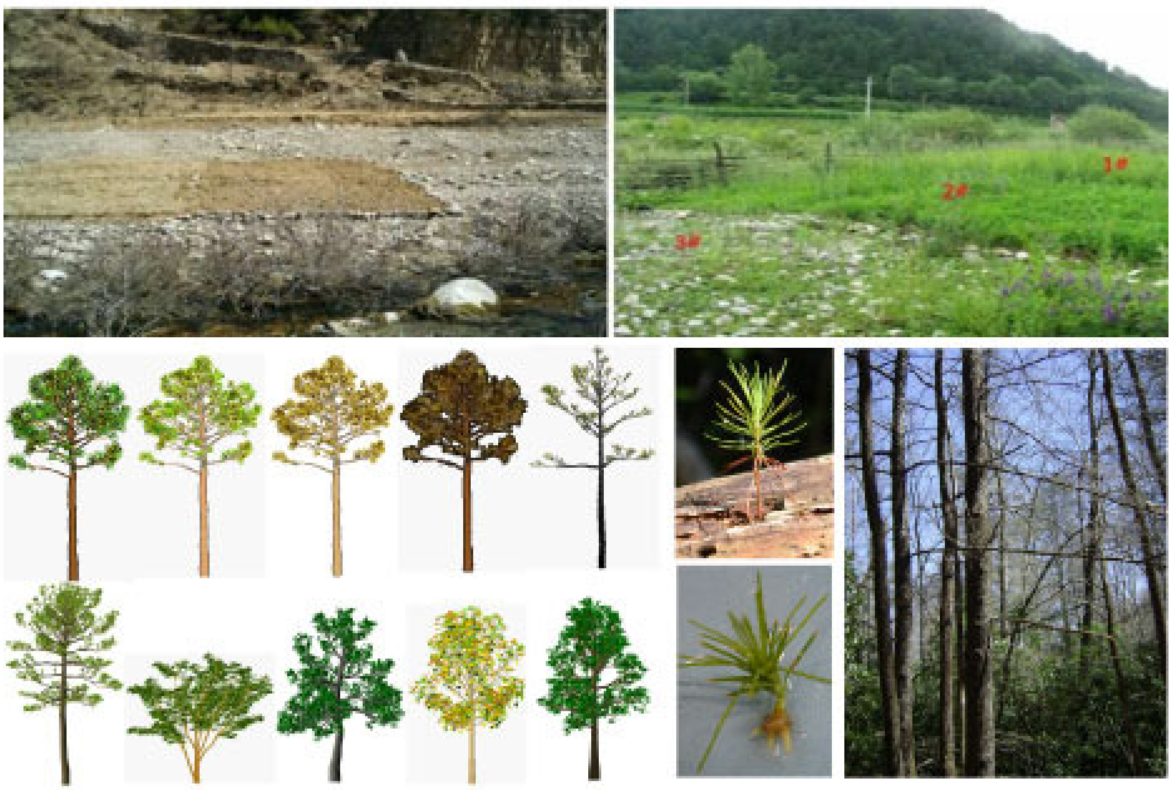
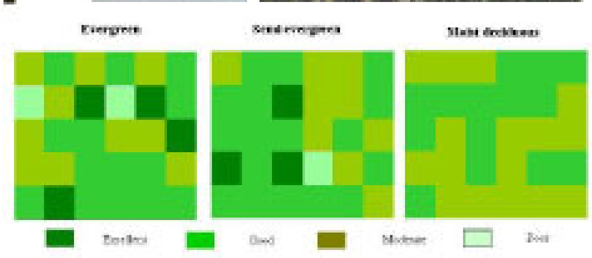
Volume 6, Special Issue 1, 2012

ISSN 1752-3753
ISBN 978-4-903313-89-4

Tree and Forestry Science and Biotechnology



Forest Restoration



Guest Editor: Weimin Xi

GLOBAL SCIENCE BOOKS

Tree and Forestry Science and Biotechnology

Abbreviation: Tree For. Sci. Biotech. (TFSB)
Print: ISSN 1752-3753
Frequency and Peer status: Biannual, Peer reviewed

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Tree and Forestry Science and Biotechnology primarily wishes to examine:
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2) Mycorrhizal symbioses (and effects on plant physiology, productivity, reproduction and disease resistance);
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4) Physiology, genetics, molecular biology, structural botany (integrated, pure and applied);
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10) Forestry policy as that which benefits society, the economy, and maintains genetic diversity.

For publication in *Tree and Forestry Science and Biotechnology* the research must provide a highly significant new contribution to our understanding of tree and forestry species and must generally be supported by a combination of either: physiological, biochemical, genetic or molecular analyses. All areas of study are welcome and the experimental approaches used can be wide-ranging. Results that simply provide a description without an integrated multi-disciplinary approach will generally not be considered.

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Guest Editor

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Cover photos: Top plate: Pre- and post-project comparison in the RI plot (riparian areas of the Qin River) (Qi *et al*., pp 75-80). Bottom, left: Computer-designed tree images used and created through OnyxTree Professional (Onyx Computing Inc. 1992-2008, http://www.onyxtree.com) (Chou *et al*., pp 40-50). Center, bottom: *In vitro* rooting showing roots derived from callus at the shoot base of *Pinus taeda* L. derived from juvenile material (de Oliveira *et al*., pp 96-101). Center, right: A hemlock woolly adelgid infested stand in the Coweeta water-shed along a riparian corridor in western North Carolina, USA (Jonas *et al*., pp 22-26). Bottom, right: Classification of large ecological plot into “sites” based on SQI in three forest communities (Prasad and Dutt, pp 116-121).

Printed in Japan on acid-free paper.
Published: February, 2012.

The Guest Editor

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Dr. Weimin Xi is a broadly trained senior ecologist with expertise in the interface of forest ecology, landscape ecology, disturbance ecology, restoration ecology, conservation biology, ecological modeling, eco-informatics, and global change impacts on vegetation. He received his PhD in Biology from the University of North Carolina at Chapel Hill, and completed his postdoctoral work in the Department of Entomology of Texas A&M University. He is currently a senior researcher at the Department of Forest and Wildlife Ecology, University of Wisconsin-Madison. Dr. Xi is also Adjunct Professor in Southwest University and the Institute of Applied Ecology, Chinese Academy of Sciences.

Dr. Weimin Xi has accomplished an record of successful publishing of over 80 papers in respected journals, including *Ecology, Ecology Letters, Landscape Ecology, Forestry, Journal of Forestry, Ecological Modeling, Environmental Modelling & Software, Ecological Restoration,* and *Journal of Plant Ecology.* He has co-authored over 10 book chapters on topics such as post-damage management and restoration of southern pine forests, the complexity of catastrophic wind disturbance on temperate forests; impacts of invasive species on forest landscapes, and landscape modeling for forest restoration. He presented more than 30 presentations at numerous scientific conferences, including a best paper award. Dr. Weimin Xi has over ten years experience in teaching and instructing undergraduate and graduate students as Associate Professor.

Dr. Weimin Xi is a Certified Senior Ecologist by the Ecological Society of America. He is currently an Associate Editor-in-Chief for *Chinese Agricultural Science Bulletin*, a Guest Editor for *Global Science Books (Japan)*, Editorial Board Member for four international journals, and served as reviewer for over 20 peer-review international journals. He is a selected full member for the Scientific Research Society (Sigma Xi) and member for the Ecological Society of America (ESA), the International Association for Vegetation Science (IAVS), and the Society for Ecological Restoration (SER) International.

Preface

Forest Restoration in a Changing World: Lessons from Diverse Ecosystems

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Key words: natural disturbance; forest ecosystem dynamics; adaptive and sustainable management; ecological models; forest restoration

INTRODUCTION

This special issue of 'Tree and Forestry Science and Biotechnology' on 'forest restoration' contains 14 selected papers authored by 60 scientists from five countries (Denmark, India, China, Russia, and the United States). It includes 8 original research papers, 1 research note, and 5 invited reviews. The regions that the papers focus on include the central and southwest China, Taiwan, the middle Ural of Russia, the Highlands of Eastern Mizoram of India, and the eastern United States (the Great Smoky Mountains National Park, Carolina Piedmont, South Carolina Coastal Plain). Due to the geographic locations of these focused areas, this special issue is clearly biased towards North America and Southeast Asia. This 'forest restoration' project was initialized in 2009, and has been under a collaborative effort among Texas A&M University, the University of Wisconsin-Madison (USA) and Global Science Books Ltd. (UK). The objective of this special issue is to provide new scientific knowledge of forest restoration. The intended audience is forestry and restoration professionals, and natural resource interest groups, undergraduate and graduate students of forestry and natural resource, and interested members of the public.

DISTURBANCES AND ECOSYSTEM DYNAMICS

In this special issue, the authors from diverse backgrounds bring many points of view to bear on scientific problems of 'forest restoration'. Collectively, this special issue discusses a wide array of themes that are important to forest restoration efforts in the study regions, ranging from natural tree regeneration and forest recovery after strong windstorm events, to soil and water conservation, regional restoration and sustainable management, the role that social conflict is likely to play in forest restoration projects, and to how to manage social conflict when conducting a forest restoration project. This special issue also presents several novel approaches and techniques of restoration projects (e.g., new approach to select sites for restoration, three-dimensional landscape visualization techniques for forest restoration scenarios), in which the scientists were actively involved.

A fundamental issue in restoration ecology is how to define restoration goals. Several authors, based on their expertise and survey data, in this special issue suggest that forest managers should set more realistic, site-specific feasible goals. Past studies have shown several levels of restoration goals: restoration of species, restoration of ecosystem function, and restoration of ecosystem service. Both advantages and disadvantages have been discussed. The community of ecologists, foresters and landowners, and even so with the public, should be more realistic of what restoration can accomplish. As reference conditions vary greatly among ecosystems, their varying nature need to be studied carefully as it is critical in establishing regional restoration goals. There are several key issues that this special issue that was not be able to include such actions as restoring ecological service, assist with climate change mitigation, adaptation while providing other tangible co-benefits to coupled humans and natural systems in an era of global environmental change. Interested readers can learn more in the reference section of each paper.

ADAPTIVE AND SUSTAINABLE MANAGEMENT

There is an immediate need to establish a framework for identifying restoration goals and priorities, promoting result-based managements and restoration interventions. Scientists around the world are further exploring the mechanisms of forest ecosystem changes and developing firm scientific frameworks for forest restoration. For example, Covington and his colleagues developed a stepwise systematic analytic approach to the design of ecosystem restoration experiments. The research papers in this special issue add more detailed and solid evidence for better understanding of the complexity of varied forest ecosystems and the role of natural disturbances on the dynamics of those ecosystems. Many previous studies have shown that forest ecosystems are extremely diverse and complex, and often difficult, possibly even impossible to accurately predict the impacts of managements and restoration actions on future conditions. In addition, natural disturbances such as wildfires, windstorms and insects, are key factors limiting ecosystem dynamics and therefore affect the process of ecosystem recovery. Moreover, human influence and activities such as harvesting, farming, gardening and restoration under global warming scenarios make these interactions among all disturbance factors more complex. As a result, adaptive and sustainable management of forest resource can be of great importance.

A key issue in conducting forest restoration projects is how to integrate social science with natural science to maximize the efficiency and effectiveness of forest restoration efforts. Until now, most restoration projects tend to see the restoration job as strictly natural science and technical projects. It has been increasingly recognized that humans are important and key agents of ecological change. Given the wide variety of human needs and goals, it seems unlikely that vast areas will be restored to completely natural conditions. Consequently, ecological restoration efforts require all sciences, including social ones. In recent years, there have been increasing discussions within the scientist community to emphasize the importance of societal involvement in proposed restoration efforts. This special issue provides needed information on regional sustainable forestry development; the role that social conflicts is likely to play in forest restoration projects, including how to manage social conflicts when conducting a forest restoration project, which can serve as a starting point on this important, but under addressed issue in ecological restoration.

EPILOGUE

Forest restoration has been and will remain a challenging task around the world. There are a number of challenges to ecological restoration that need to be addressed. The major challenges include understanding the forest ecosystem processes (e.g., reference condition), setting feasible and site-specific restoration goals, and identifying sets of management actions to accelerate recovery of the ecosystem. Making detailed restoration plans prior to implementing any restoration practices is also challenging. These management actions should be viewed as hypotheses that are being tested. The adaptive and sustainable management and other key issues such as the role of forest restoration in reducing greenhouse gas emissions are important and need to be addressed further in the future. In recent years, we have seen encouraging efforts and increasing opportunities to conserve natural forests and restoring degraded ecosystem. One good example is that since the late 1990s, China has launched several nationwide programs that aim at both solving regional environmental problems and improving domestic ecological conditions and rural livelihoods. Remarkable progress has been made since achieving the program goals. Another good example is that the Reducing Emissions from Deforestation and Forest Degradation (REDD+) project has provided developing nations with significant funding for forest restoration activities that contribute to climate change mitigation, sustainable management, and carbon-stock enhancement. Newly emerged concepts (e.g., reference conditions, coupled natural and human systems) and scientific frameworks (e.g., adaptive and sustainable forestry, mitigation and adaptation for climate change) are bringing fresh air to forest restoration projects in various ecosystems around the world. As part of the worldwide on-going forest ecological restoration research effort, I believe that this special issue on ‘forest restoration’ has not only improved forest restoration research but also enabled a better understanding of knowledge gaps. I hope that we have contributed the communication of the current knowledge on forest restoration.

ACKNOWLEDGEMENTS

I thank all authors for their contributions and numerous reviewers for their assistance. This special issue was supported by Texas A&M University and the University of Wisconsin-Madison. I thank the staff of both universities for their logistic help. I greatly appreciate Dr. Jaime A. Teixeira da Silva (Editor-in-Chief) and the staff at Global Science Books (UK and Japan), who all worked hard to improve the content and the text of the manuscripts. I also want to thank Drs. Peter S. White (Director of North Carolina Botanical Garden and Professor of the Department of Biology, University of North Carolina) and John A. Stanturf (Project Leader, the Center for Forest Disturbance Science, the Southern Research Station of the US Forest Service) kindly wrote the Forewords for this special issue on 'forest restoration'.

REFERENCES

Alexander S, Nelson C, Aronson J, Lamb D, Cliquet A, Erwin KL, Finlayson MC, Groot de RS, Harris J, Higgs E, Hobbs RJ, Lewis III RRR, Martinez D, Murcia C (2011) Opportunities and Challenges for Ecological Restoration within REDD+**.** *Restoration Ecology* **19**, 683-689

Covington WW, Niering WA, Starkey E, Walker J (1999) Ecosystem restoration and management: Scientific principles and concepts. In Proceedings of the Workshop "*Toward a Scientific and Social Framework for Ecologically Based Stewardship of Federal Lands and Waters*," held in Tucson, AZ, December 4-14, 1995. Humans as Agents of Ecological Change: 599-617

Hobbs RJ, Cole DN, Yung L, Zavaleta ES, Aplet GH, Stuart Chapin F. III, Landres PB, Parsons DJ, Stephenson NL, White PS, Graber DM, Higgs ES, Millar CI, Randall JM, Tonnessen KA, Woodley S (2010) Guiding concepts for park wilderness stewardship in an era of global environmental change. *Frontiers in Ecology* **8**:483-490

Stanturf JA, Madsen P (Eds.) (2005) Restoration of boreal and temperate forests. CRC Press

Xi W, Bi H, He B (2011) Forest landscape restoration in China. In P. Madsen and J. Stanturf (eds.). *A Goal-oriented Approach to Forest Landscape Restoration*. Springer (In press)

Xi W, Peet RK (2011) The complexity of catastrophic wind impacts on temperate forests. In: Lupo A (Ed) Recent Hurricane Research - Climate, Dynamics, and Societal Impacts, pp 503-534

White PS, Walker JL (1997) Approximating nature s variation: selecting and using reference sites and reference information in restoration ecology. *Restoration Ecology* **5**:338-249.

February, 2012

Foreword

Forest Restoration in a Time of Climate Change

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We restore forests for many reasons: ecosystem services, sustainable forestry, natural beauty, spiritual renewal, cultural history, outdoor recreation, and the protection of biodiversity on its own terms, whether useful to humans or not. This is a wide range of goals and a first observation is that we have to articulate goals as clearly as we can, with defendable and testable outcomes. But forests are long-lived and complex and so we must also allow for periodic reconsideration of those goals as new information comes to light. Forest restoration was never an easy task, but climate change adds to our challenges—and also emphasizes the importance of the quality of resilience in ecosystems. As a perspective on this special issue, I offer this outline the major issues we face:

Disparate starting points, disparate goals. Forest degradation spans a wide spectrum, from sites with drastic soil erosion and high concentration of toxic chemicals to ecosystems that are still forested but have lost key native species or key processes, such as fire, or gained invasive species. The feasibility of restoration goals varies across this spectrum of degradation. At one extreme, the reestablishment of soils and tree cover is the first goal, whereas, at the other end of the spectrum, we may be simply reintroducing fire or a few species that have been lost.

The reference model for restoration. A reference model describes the composition, structure, and function that we aim to restore. Since there are many sources of variation in natural ecosystems, we must build this reference model from all available information, including undegraded sites that are nearby, on similar soils, and in similar environments, historical data, photographs, and descriptions, and legacies of previous conditions within the site to be restored. There will always be uncertainties; we must understand the sources of variation and use these to approximate the reference conditions. We must always keep in mind that we are restoring forest to an envelope of variation, rather than a single homogeneous state.

Natural dynamics. A forest is made up of dynamic populations and is affected by a wide variety of disturbances, such as windstorms, fire, drought, and flood, depending on location. The species of a forest have varying adaptations to these disturbances, including species that are dependent on them and others that are intolerant.

Scale issues. Many properties of a forest are dependent on the area of that forest. The larger the area, the more likely it includes spatial heterogeneity, patches of different successional age, important wildlife species that require large areas, and intact natural disturbance regimes. This also means that that area sets the feasibility of restoration goals and the need for ongoing management.

Climate change and resilience. Resilience encompasses two contrasting qualities: the ability to return to a predisturbance state and the ability to adapt to changed conditions. As an example, let's take a functional property, the rate of carbon storage. A resilient forest continues to fix and store carbon, whether it is recovering to a previous state or changing to a new one. One important premise is that resilience depends first on the diversity of elements that make up the forest: the access of species with different adaptations to the site that is being restored. If a project is large enough to have patches of different successional age and a wide range of species life histories with regard to disturbance, then we can think of the recovery aspect of resilience as mostly likely a direct function of this diversity. Adaptive change can be the result of local diversity (changes in dominance of existing species with environmental change), but, if it is drastic enough, would require connections to populations at greater distances, and therefore on connectivity between restoration sites (or, in absence of connections, "assisted migration" of species in the absence of adequate connection and dispersal). The problem of climate change points out the need for scientists and managers to be in communication over the next decades—that projects be linked in connected networks in both a real and virtual sense.

Understanding forest restoration is both challenging and exciting. The challenges exceed the duration of our own lives and careers. We should think of our job as passing on the best possible state of ecosystems to future managers. This is more like a relay race in which we pass a baton rather than the finish line of a sprint. All sites have a highest and best use for conservation, even though these are constrained by degree of degradation and scale. If there is one single goal it would be to maximize diversity and heterogeneity at appropriate scales as this diversity is the raw material of future change.

February, 2012

Foreword

The Challenge of Ecological Restoration

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Recent estimates by the World Conservation Union (IUCN) and World Resources Institute (WRI) suggest that over 2 billion ha of forests are degraded and in need of restoration. Goren Persson, former prime minister of Sweden, proposed the formation of a Global Restoration council to implement the Bonn Challenge to restore 150 million ha of degraded forests by 2020. The importance of forest land cover to climate change mitigation is reflected in international efforts to Reduce Emissions from Deforestation and Degradation (REDD+) of tropical forests, while at the same time enhancing biodiversity and other conservation goals. In accepting the importance of restoring degraded forests, the scientific community must respond with approaches informed by defensible concepts of what defines a forest, what is the threshold between acceptable (because it is somehow natural) disturbance and degradation, and how should current restoration goals be altered to accommodate future climates?

Restoration ecology is a science only recently emerging from practical, site-specific attempts to reverse the effects of degradation. Explicit in much literature (and most guidelines) is the premise that ecological restoration means a return to conditions matching a reference site, a non-disturbed "natural" condition. Practitioners within the restoration ecology community and other resource professionals have challenged the notion of naturalness as an objective. The crux of the debate is whether naturalness represents a scientifically defensible concept or is simply a statement of a preference for one kind of ecosystem or another.

Crucial to the debate are the starting and ending points, and a practitioner's perception of the extent of human influence in a forested ecosystem, both in the past and the uncertain future. What constitutes successful restoration is defined within a cultural and ecological context that also determines what constitutes degradation. Understanding the effects of past disturbances and the likelihood of future disturbances is critical to designing appropriate restoration techniques, but disturbance ecologists typically focus only on natural disturbance regimes, eschewing human-caused degradation. This ignores that forests today are human-dominated systems. Global ecosystems have been altered by anthropogenic activity to an extent unprecedented in the historic record. Land cover changes such as deforestation and wetland conversion, river channelization and damming, and soil erosion are just some of the overt drivers of change leading to loss or diminishment of species, ecosystem functions, and quality of life.

Added to the muddle of when does disturbance become degradation and what is the appropriate goal for restoring degraded forests is the challenge from climate variability and future climate change; how to set the balance between rebuilding past ecosystems and building resilient systems for the future. The effect of climate variability on forested ecosystem processes and disturbances (both biotic and abiotic) is uncertain, adding to the complexity caused by our imperfect understanding of these relationships under today's climate. Most climate change work looks at effects of changing mean conditions between now and some future date as if there will be a gradual, albeit rapid change of mean conditions to which species will react. However, one of the salient features of climate change will be more extreme events with greater year-to-year variation in weather. More intense or frequent extreme events are likely to occur sooner than changes in climatic means, increasing the need for restoration. The short-term forecast, therefore, is for increases in degraded forests in spite of restoration efforts. In fact, some restoration that seeks a return to former conditions may result in further degradation.

Anticipating future conditions and planning adaptive responses will be more complex than simulating increases in temperature and decreases in precipitation and seeking current communities adapted to future conditions. Critical changes will affect limiting conditions for regeneration, pest and disturbance dynamics. Native and non-native species will invade new habitat or change competitive relations. Changed conditions will cause effects at variable rates and over a range of scales, complicating strategies for responding especially in regions of mixed land ownerships. Because species within a forest ecosystem will respond individually to radical shifts in local climate, the resulting novel ecosystems will be comprised of species assemblages without current analogs. These novel ecosystems may be transient with shifts in species dominance driven by continued climate variability. Further, the social responses to climate change/variability are unpredictable and will vary according to the “social capacity” of individual societies.

How are we to respond? First, we can recognize that setting restoration goals is essentially a social (i.e., political) process that can be informed, but not determined, by ecological understanding. Second, we should recognize that our understanding of past, current, and future environments is limited and likely incomplete, therefore subject to change. Third, with humility we must accept that decisions taken today likely will be seen as wrong by future generations. Our challenge is to devise strategies that are robust; they must be highly likely to result in good outcomes even if they are not optimal. Additionally, these strategies should be adaptive and allow for corrective actions in the future. The ultimate goals for restoration ecologists are to provide managers with guidelines for setting appropriate restoration objectives within a given social context and state of ecological understanding and to provide them with reliable techniques for restoring sustainable forest ecosystems that are robust in the face of climate variability and change and that continue to meet human needs for commodities, ecosystem services, and spiritual reflection.

SPECIAL ISSUE: CONTENTS

Regular papers

Steven E. Daniels (USA), Jens Emborg (Denmark), Gregg B. Walker (USA) Seeing the Forest for the Trees: Managing Social Conflict and Forest Restoration (pp 1-6)

ABSTRACT

Invited Mini-Review: This paper examines the role that social conflict is likely to play in forest restoration projects. A definition of conflict as "perceived goal interference among interdependent parties" serves as a point of departure for the discussion, and the nature of forest restoration conflict is systematically examined by focusing on each aspect of the definition: perceptions, goal interference, the parties, and their interdependence. Agencies undertaking restoration projects are encouraged to adopt a discourse orientation, wherein they recognize that 1) their public involvement efforts are creating a discourse that can incorporate a wide array of values and voices and 2) groups may create competing discourses if they feel that the agency's process disenfranchises them.

Hai Ren, Hongfang Lu, Jun Wang, Nan Liu (China), Qinfeng Guo (USA) Forest Restoration in China: Advances, Obstacles, and Perspectives (pp 7-16)

ABSTRACT

Invited Review: Because of the prolonged history of disturbance caused by intense human activities, restoration in China has been a major task facing many ecologists and land managers. There are six major forest types in China: cold temperate coniferous forest, temperate coniferous and broad-leaved mixed forest, warm temperate deciduous broad-leaved forest, subtropical evergreen broad-leaved forest, tropical rainforest and monsoon forest, and Qinghai-Tibet Plateau alpine vegetation. All of them suffer from degradation due to human interference and various methods and specific techniques have been applied in their restoration. As ecology research on succession is maturing and theories and models on restoration are becoming established, restorationists and ecologists are optimistic. In addition to reporting on the history and progress of forest restoration in China, this article describes its obstacles and future perspectives.

ShiLi Miao, Yi Li, QinFeng Guo (USA), Hua Yu, JiangQing Ding, FeiHai Yu, Jian Liu (China), XingHai Zhang (USA), Ming Dong (China) Potential Alternatives to Classical Biocontrol: Using Native Agents in Invaded Habitats and Genetically Engineered Sterile Cultivars for Invasive Plant Management (pp 17-21)

ABSTRACT

Invited Mini-Review: The development of an effective approach to control and eradication of invasive species has become a major challenge to scientists, managers, and society. Biocontrol has been widely utilized to control exotic plants in the past few decades with some degree of success. However, there have been an increasing number of controversies pertaining to this approach, largely due to the potential environmental risks when introduced natural enemies attack non-targeted species. Here we present two alternatives in addition to classical biocontrol of invasive plants using case studies, and discuss the possibility that there may be more than one formula for a success. One strategy is to search for native agents (other than introduced from elsewhere) in the invaded ranges to manage invasive plants that have been difficult or risky to control or eliminate with classical biocontrol methods. Another new approach is to use traditional breeding or modern transgenic technologies to produce sterile cultivars for economically important exotic plants used in horticulture and forestry.

Sarah Z. Jonas, Weimin Xi, John D. Waldron, Robert N. Coulson (USA) Impacts of Hemlock Decline and Ecological Considerations for Hemlock Stand Restoration Following Hemlock Woolly Adelgid Outbreaks (pp 22-26)

ABSTRACT

Invited Review: We present a synthesis of current knowledge and information of hemlock woolly adelgid (HWA, *Adelges tsugae* Annand) impact on hemlock forests and a conceptual framework of restoring damaged hemlock stands by HWA infestation. Native to Asia, HWA has been thriving in the eastern United States since the early 1950s and has become a serious pathological agent of both eastern hemlock (*Tsuga canadensis* (L.) Carrière) and Carolina hemlock (*Tsuga caroliniana* Engelm.) even since. By 2007, it was established in portions of 16 States from Maine to Georgia, where infestations covered about half of the range of hemlock and continuously spreading. The impacts of HWA induced hemlock mortality and decline on key ecosystem resource and processes are still not fully understood. Successful and effective restoration of the declined hemlock population is challenging and involves a complex process that commonly spans many years. Development of a management and restoration strategy that will establish priorities, standards, and practices could facilitate objective decisions and allocation of limited resources. In addition to encourage natural regeneration of hemlock in the damaged forest stands and both chemical and biological control, three strategies seem to stand out as possibilities: growing off-site stocks of hemlock seedlings for replant, creating hybrid hemlocks that are resistant to HWA, and replanting with the already resistant western hemlock or Chinese hemlock. Other ecological considerations in the context of restoring hemlock forests following HWA are also discussed.

Weimin Xi, Szu-Hung Victoria Chen (USA), Yi-Chien Chu (Taiwan) The Synergistic Effects of Typhoon and Earthquake Disturbances on Forest Ecosystems: Lessons from Taiwan for Ecological Restoration and Sustainable Management (pp 27-33)

ABSTRACT

Invited Mini-Review: Taiwan is a mountainous island in which 58.5% covered by subtropical and monsoon rain forests. Degradations of forestlands and resources often occur due to fragile geological formations and by frequent major typhoons and earthquakes. We summarized the impacts of typhoons and earthquake as natural disturbance events on forest ecosystems from various perspectives, including vegetation changes, nutrient dynamics, and watershed protection. Considering the unique environmental conditions of Taiwan, we address the synergistic effects of multiple natural disturbances. We also discuss the basic principles and framework related to post- major disturbance forest restoration and sustainable management. Moreover, we examine the potential issues of current management practices and provide insights for future directions and research needs.

R. Todd Jobe (USA) Remote Areas as Potential Restoration Sites in Conservation Landscapes (pp 34-39)

ABSTRACT

Original Research Paper: The effects of roads and trails on species composition and diversity at landscape scales are uncertain. This leads to uncertainty about the best way to select sites for restoration. Three datasets were used in this analysis: a model that estimates the remoteness of a landscape by calculating the energetic cost required to walk through it, a set of 246 0.1 ha plant species abundance samples, and a remotely sensed plant community map. These data were used to ask three questions about the selection of restoration sites in Great Smoky Mountains National Park (Tennessee and North Carolina, US). First, does compositional similarity within a plant community change as a function of remoteness? Second, does plant species diversity, particularly of rare species, change with remoteness? Finally, how does the patch area of plant communities change as a function of remoteness? Compositional distance among pairs of sites increased as difference in energetic cost to reach the sites increased. Regression of Shannon-Wiener diversity against the multiplicative effects of energetic cost and community type revealed no significant effect of accessibility on diversity. Energetic cost also showed no significant effect on the proportion of species which occur only once in the dataset. Analysis of the landscape distribution of vegetation communities revealed that the average area of community patch does not vary by remoteness. These results suggest that accessible restoration sites are equivalent to remote sites for conserving diversity and landscape structure. Species composition of remote sites does help inform the acceptable variance in composition of restored communities.

Chiao-Ying Chou, Bo Song, Thomas M. Williams, Roy L. Hedden, Joseph D. Culin, Christopher J. Post (USA) Three-dimensional Landscape Visualizations of Forest Restoration Scenarios for Southern Pine Beetle-Infected Forests (pp 40-50)

ABSTRACT

Original Research Paper: Setting appropriate goals for projects is a primary challenge facing forest restoration. Not only is it difficult to achieve a complete restoration of an ecosystem, but deciding restoration goals that involves a set of values from diverse stakeholders is also very challenging. In this study, an integrated technique of geographic information systems (GIS), historic remotely sensed images, and three-dimensional (3-D) landscape visualization was used to construct a variety of realistic images and animations depicting effects following southern pine beetle (SPB) infestations on different forest restoration scenarios in the upper Piedmont of South Carolina. The alternative restoration treatments included prescribed burning, mechanical thinning, and the combined effect of both. We also compared the effect of species mixture: pure loblolly pine stands and mixed pine stands within the thinning treatment and thinning + burning treatment. The results indicated that 1) thinning treatment responded the best (i.e., least damage) to SPB infestation for both pure pine stands and mixed forest stands, 2) the presence of other pine or hardwood species would not affect the tree susceptibility but does alter the distance between susceptible trees, 3) the short-term effectiveness of prescribed burning was not obvious in our study, and 4) the thinning + burning treatment may have resulted in too much stress that increases the stand’s susceptibility for SPB infestations. In addition,

the spatial trends of infestation were illustrated by the photo-realistic geographical visualized medium to simplify the complicated information. This resulted in improvement of the representation and understanding of the SPB restoration scenarios for different decision makers without considerable training or experience with map reading and forest restoration.

Weimin Xi, Robert K. Peet, Dean L. Urban (USA) The Impacts of a Large, Infrequent Hurricane on Understory Sapling Dynamics and Diversity in North Carolina Piedmont Forests, USA (pp 51-59)

ABSTRACT

Original Research Paper: We analyzed population dynamics of saplings (tree or shrub stems >50 cm in height and < 1 cm diameter at breast height) and changes in species diversity and composition during an interval lasting from 5 years before the 1996 Hurricane Fran to 5 years post-hurricane through use of permanent transects where individual sapling stems had been censused annually in the Piedmont plateau, North Carolina, USA. We hypothesized that understory sapling dynamics was largely influenced by the canopy tree damage caused by the large, infrequent hurricane, canopy disturbance enhances recruitment of light-demanding species, and increases growth rates of established saplings. Our results showed that sapling damage by Hurricane Fran was largely secondary (i.e. about 44-70% of damaged saplings were pinned by their large neighbor trees). All survey transects experienced decreased in sapling density, as a result of increased mortality. Average mortality rate of saplings nearly doubled, increasing from 7.04 ± 3.98% to 13.22 ± 5.71%. Whereas the changes in sapling density were dramatic, species diversity of saplings, however, remained relatively stable or decreased slightly due to the hurricane-induced damage. Large gaps created by the hurricane resulted in the release of established shade-intolerant or mid-tolerant saplings. We concluded that large, infrequent windstorms appear to be responsible for temporal and spatial variations in understory regeneration, which contribute to a diverse but temporally relatively stable canopy layer.

Bo Song, Charles A. Gresham, Carl C. Trettin, Thomas M. Williams (USA) Recovery of Coastal Plain Forests from Hurricane Hugo in South Carolina, USA, Fourteen Years after the Storm (pp 60-68)

ABSTRACT

Original Research Paper: Overstory species composition dynamics following a major disturbance integrates both the characteristics of individual species and competitive interactions. The purpose of this study was to monitor species composition shifts in several wetland and upland ecosystems receiving varying levels of damage from Hurricane Hugo that took place in 1989. Fifty permanent plots were established among four study sites in the Coastal Plain of South Carolina in 1994 and the trees and saplings re-inventoried in 1997, 2000, and 2003. Over the 10-year study period, the species composition and dominance of most of the species did not change greatly; there was just the expected slow growth of basal area. On several of the sites, especially those more heavily damaged, there was a large increase in the density of species in the sapling size class that were not in the tree size class. Loblolly pine, hornbeam, redbay, deciduous holly, and wax myrtle are examples of such species.

Vladislav Soukhovolsky, Stanislav Mochalov, Elena Zoteeva, Darya Sotnichenko, Olga Sekretenko, Anton Kovalev (Russia) Early Stages of Forest Restoration after Windthrow in Ural (Russia): Observations and Mathematical Models (pp 69-74)

ABSTRACT

Original Research Paper: This study presents data analysis and a model of early phases of forest regeneration after windthrow. Processes occurring in these phases are competition between young trees and herbaceous plants, development of young trees, and competition among different species of young trees. The model of early phases of forest regeneration after windthrow presented in the study is based on the authors' long-term observation data on forest regeneration collected in the area in the Middle Urals that had suffered heavy windthrow.

Shi Qi (China), Yaoqi Zhang (USA), Hui Wang, Linying Li, Jinxiu Wang, Di Wang, Xiaoyan Yu, Jin Liu (China) Restoration of Forest Riparian Buffer Strips on the Upper Reaches of the Qin River, Shanxi Province (pp 75-80)

ABSTRACT

Original Research Paper: Forest riparian buffer strips have long been recognized for their important functions that include providing shade to reduce water temperature, enhancing deposition of sediments and other contaminants, reducing nutrient loads of streams, stabilizing stream banks with vegetation, reducing erosion caused by uncontrolled runoff, and providing habitats for riparian wildlife. To rehabilitate and reconstruct the riparian buffers at the source of the Qin River in Shanxi Province, China, a field survey and experiments were conducted to provide an example of forest riparian buffer construction in the region. An assessment index system was used to evaluate the Chishiqiao and Zihong rivers, both first-level tributaries of the Qin River. A comprehensive evaluation index system offered indicators of vegetation structural intactness and bank stability including vegetation continuity along the river channel, vegetation coverage and height, abundance of floristic components, associations among vegetation, rock, and soil types, bank structure, and soil erosion modulus. Results indicated that the Chishiqiao River was generally in good condition, and the condition of the Zihong River was average. Ratings for the abundance, arrangement, and coverage of riparian vegetation along the Zihong River were low due to the structural intactness subindex. To improve vegetation coverage, abundance, and collocation forms, we chose typical riparian vegetation zones, including grassland, shrub land, and shrub-grass land, and implemented different treatments, i.e. fencing the vegetation zones, planting grasses or shrubs, and covering with soil and turf. We found that soil hygroscopic coefficient, soil fertility, and total nitrogen content were strongly enhanced. Certain types of riparian buffer strips that would be suitable in this region are suggested.

Uttam K. Sahoo, Pebam Rocky, Keny Vanlalhriatpuia, Kalidas Upadhyaya (India) Species Composition, Production and Energetic Sustainability of Homegardens in the Highlands of Eastern Mizoram, India (pp 81-92)

ABSTRACT

Original Research Paper: An in-depth study was undertaken in three villages taking 38 farms to analyze different components of homegardens and to critically analyze into various functional attributes so as to propose options for their improvement. We found homegarden sizes from 0.035 ha to 2 ha area (median =1925 m^2). All together 199 plant species belonging to 67 families of which 80 were trees and 22 were shrubs were recorded from the homegardens. Mean number of species per garden was significantly higher in large gardens (53±10.8) as compared to small and medium (P<0.01). Shannon Weiner index for trees and shrubs was also higher in large gardens (*H´*=3.73, P<0.005). Mean number of species per garden and no of tree and shrubs species per garden significantly increases from small to large garden (P<0.01) where as there is no significant difference for herbs while mean number of species per 100 m^2 and trees and shrubs per 100 m^2 significantly decreases from small to large gardens (P<0.005). The energy input ranged from 125 MJ per m^2 in small to 31 MJ per 100 m^2 in large gardens. The energy efficiency was found to significantly (P<0.04) vary from 27 in small garden to 36 and 54 in medium and large gardens respectively. The monetary input significantly (P<0.02) varies from Rs. 928 per 100 m^2 in small to Rs. 228 per 100 m^2 in large gardens while there is no significant difference for the monetary output and the output-input ratio significantly (P<0.05) varies from 2.6 in small to 4.4 and 6.6 in medium and large gardens respectively. Mean net financial value of the homegardens ranged from Rs. 19,890 in small gardens to Rs. 1,31,476 in large gardens and the proceeds from the sale contributes 29.2% (small garden) to 52% (large gardens) of the total household income.

Bin Wang, Yuping Zhao (China), Xubin Pan (China/USA) Centennial Forestry Development of North Dakota State and its Lesson for China (pp 93-95)

ABSTRACT

Research Note: The “Dust Bowl” happened in the Great Plains (including the North Dakota state) in the 1930s, and people wanted to plant trees to improve the environment. After a century of a hard work and many failures, forest land now covers 1.6% of the area in North Dakota. Now, the Conservation Reserve Program has been implemented in North Dakota, which is very similar to the Conversion of Cropland to Forest and Grassland project in China, such as Xilingol League. Tree species selection and price support measures will also be suggested for adoption in China.

Leandro Francisco de Oliveira, Luciana Lopes Fortes Ribas, Marguerite Quoirin, Henrique Soares Koehler, Erika Amano, Antonio Rioyei Higa (Brazil) Micropropagation of *Pinus taeda* L. from Juvenile Material (pp 96-101)

ABSTRACT

Original Research Paper: The purpose of this study was to develop a protocol for the micropropagation of *Pinus taeda* from juvenile material. Apical shoots and nodal segments were inoculated into MS, DCR or WV medium. After 90 days, the explants were transferred to WV5 medium supplemented or not with 6-benzyladenine (BA) (2.0 μM) in order to induce multiple shoot formation. For root induction, a medium composed of water and agar and a combination of 1-naphthaleneacetic acid (NAA) (2.69 μM) and BA (0.44 μM) was used for periods of 7, 9 or 12 days followed by transfer to growth regulator-free GDm/2 or

GDm/4 medium. During *in vitro* establishment, nodal segments showed better responses than apical shoots, with an average of 4.3 to 5.8 shoots per explant after 90 days of culture. WV5 medium proved better than all other media due to a higher survival rate (86%) and higher elongation percentage (85.2%). BA did not promote better multiplication compared to the control, with approximately 2.4 to 3.0 shoots per explant. The alternate use of BA concentrations (2.00, 0.25 and 1.00 μM in each subculture) in WV5 culture medium can increase the multiplication rate. The estimated production was 7530 shoots from 100 explants in 9 months of culture. The best rooting percentage (47.5%) was obtained when shoots were inoculated in a medium with 2.69 μM NAA and 0.44 μM BA for 12 days. In the roots derived from calluses, the vascular connection was established when roots were longer than 0.6 cm and this size was recommended as the minimum for transplanting. Acclimatized plants showed 90% survival after 90 days. It can be concluded that micropropagation of *P. taeda* from axillary buds excised from seedlings is feasible.

Célestin Niyongere (Burundi/Kenya), Turoop Losenge, Elijah Miinda Ateka (Kenya), Désiré Nkezabahizi (Burundi), Guy Blomme (Uganda), Pascale Lepoint (Burundi) Occurrence and Distribution of Banana Bunchy Top Disease in the Great Lakes Region of Africa (pp 102-107)

ABSTRACT

Original Research Paper: Banana bunchy top disease (BBTD) was first reported in 1958 in sub-Saharan Africa at the INEAC Yangambi research station in the Democratic Republic of Congo (DR Congo). Cases were reported in 1987 in the Rusizi valley encompassing the borders of Burundi, DR Congo and Rwanda. Since then, no study about BBTD had been carried out in this region. A survey was conducted from September to October, 2008 in three provinces (Bujumbura rural, Cibitoke and Bururi) of Burundi, two districts (Kamanyola and Nyangezi) in South Kivu, DR Congo and the Rusizi district in the Western province of Rwanda. A total of 7,830 banana mats, 30 randomly selected per plot, were assessed on 261 farms. A structured questionnaire was used to assess, cultivar diversity, BBTD incidence and severity, presence and occurrence of the aphid vector (*Pentalonia nigronervosa* Coquerel) and farmers' awareness about BBTD management. Leaf samples were randomly collected on symptomatic plants for further PCR analysis to confirm the disease. PCR results of samples collected in the three countries confirmed the presence of BBTV. Similar banana varieties are grown across the three countries, indicating the cross-border movement of planting materials which may have influenced disease spread over the past decennia. The regional average of BBTD incidence and aphid occurrence was 25% and 46%, respectively. However, no significant relationship between aphid occurrence and BBTD incidence (R=0.3, P= 0.623) was observed. Among the interviewed farmers, 90% were able to recognize advanced BBTD symptoms; while 95% of farmers were unaware of disease management options and stated that no locally cultivar is resistant to the disease. This pinpoints the need for farmers' awareness raising and that tolerant cultivars should be part of control option packages.

Thogatabalija Latha, Gudipalli Padmaja (India) RAPD Analysis for Detection of Genetic Variability and Sex in *Givotia rottleriformis* Griff. (pp 108-115)

ABSTRACT

Original Research Paper: *Givotia rottleriformis* Griff. is an economically important dioecious tree species known for the softwood used in making toys. Knowledge of genetic variation in a dioecious tree species is important for devising strategies for its successful management and conservation. Studies were conducted to examine the genetic variation in *Givotia* plants using RAPD (random amplified polymorphic DNA) analysis and to identify molecular marker(s) linked to sex, if any. RAPD analysis was initially performed using 32 random decamer primers in DNA bulks of 5 male and 5 female plants. Out of 32 random primers tested, 24 resulted in DNA amplification of male and female plants whereas no amplification was observed with the remaining 8 primers used. Analysis of individual male and female plants with 24 random primers revealed a total of 142 amplified bands of which 86 were polymorphic accounting for an average polymorphism of 52.9%. The highest number of amplified bands (11) was generated from primer OPAL-08, 8 of which were polymorphic; the highest number of polymorphic bands (10) was generated from primer OPG-16. Cluster analysis constructed from pooled RAPD data using Jaccard's similarity coefficient showed grouping of males and female plants into three clusters at a 70% similarity level. Twelve random primers which produced sex-specific bands in DNA bulks of males and females when tested in individual male and female plants exhibited a variable banding pattern except for primer OPT-17, which amplified a 1000-bp band in all 5 females and also in 1 male thus exhibiting partial association with sex.

P. Rama Chandra Prasad, C. B. S. Dutt (India) Community Classification and Species Assemblage Limit within the Forests of North Andaman Islands, India (pp 116-121)

ABSTRACT

Original Research Paper: In the present study, three large ecological plots of 3 ha each were surveyed in 3 different forest types of North Andaman Islands. Each 3-ha plot (30 sub-plots of 0.1 ha each) was classified into different classes based on site quality as either excellent, good, moderate or poor using an index developed by utilizing vegetation parameters such as species richness, diversity, density, among others. Analysis revealed most of the area to be under the good category in three forest communities, indicating that forests of North Andaman are potential sites of species richness and diversity. The "general limit of species assemblage" with respect to higher angiosperm taxa in North Andaman was observed based on two independent approaches of sampling: stratified random plots and the large area ecological plots. The general limit of species assemblage was in the range of 14-33 species. The present analysis provides a base for future investigations to identify subplot characteristics that provide variation in species dominance, richness and diversity within a small unit area, which has made it possible to classify the 3-ha plots into four classes.

Dilip Nandwani (USA), Jaime A. Teixeira da Silva (Japan) Field Evaluation of Tissue Cultured Banana (*Musa* spp.) Using a Narrow Pit System under Atoll Environment Conditions (pp 122-125)

ABSTRACT

Original Research Paper: Bananas are widely grown in the Marshall Islands and are an important food crop for domestic consumption. This study reports on the field evaluation of new varieties of tissue cultured banana in the local soil and climatic conditions of the Marshall Islands using a narrow pit system. The study was conducted during Yr. 2002-2004 at the College of the Marshall Islands experimental station in Arrak village, Majuro atoll. A dozen local varieties of banana were documented with their usage as either dessert or cooking type. Plant height, bunch weight, number of hands/bunch, stem diameter, color, and maturity of 11 new varieties were determined. Var. Robusta and FHIA-17 were recorded as being dwarf (180 cm) while Saba was the tallest variety (390 cm). Longest cycling time (15 months) was observed in Saba compared to Pesang Ceylan (12.2 months). The weight of the fruit bunch varied considerably with accession, ranging from 6.3 kg for Pesang Ceylan to 23.2 kg for Robusta. Girth or stem diameter of the pseudostem was also significant among varieties. Saba demonstrated the largest diameter (85.0 cm) and produced a high number of fruits (fingers), 122/bunch. The reaction of varieties to yellow or black Sigatoka and panama (Fusarium wilt) diseases was assessed. Introduced cooking or dessert varieties produced fruits and performed well under the soil and climatic conditions of the Marshall Islands in a narrow pit system.

Srinivasan Ganeshan, Punathil Ellath Rajasekharan, Sunitha Bhaskaran (India) *In Vitro* Conservation of *Artocarpus heterophyllus* Lam. (pp 126-129)

ABSTRACT

Short Communication: Jackfruit (*Artocarpus heterophyllus* Lam.) is a tropical fruit tree indigenous to rainforests of Western Ghats and distributed throughout India, Burma, Sri Lanka, Southern China, Malaya and the East Indies. Though cultivated to a certain extent in India and the East, this species has been reported to be regionally endangered in South India. Tissue culture techniques for propagating identified elite scion varieties would help to retain genotypic characters and produce a large number of plant material. *In vitro* methods for propagation of jackfruit are in a developmental stage in 8 South Asian countries. There is no report on *in vitro* conservation of *A. heterophyllus* to date. Thus, in order to overcome recalcitrance, retain genetic purity of elite varieties and prevent escalation of this species in the hierarchy of the Red Data Book, this study on *in vitro* conservation was taken up, where micropropagation formed a pre-requisite for conservation studies. Protocols have been optimized to conserve germplasm *in vitro* at 10^{o}C without an intervening subculture for 4 years, which could support jackfruit conservation programs *ex situ*. The present paper highlights the use of *in vitro* conservation methods for jackfruit under reduced culture conditions for establishment of *In vitro* Active Genebank (IVAG).

Rajesh Kumar, Ashwani Tapwal (India), Jaime A. Teixeira da Silva (Japan), Debu Moni Baruah, Sabi Gogoi (India) Seasonal Dynamics of Leaf Litter Decomposition and Fungal Population in an Undisturbed *Dipterocarpus* Forest of North East India (pp 130-134)

ABSTRACT

Research Note: The impact of climatic factors such as rainfall, temperature and seasonal variations on the rate of leaf litter decomposition and on the occurrence and abundance of microfungi were studied in an undisturbed *Dipterocarpus* forest in

Manipur, North East India. The decomposition of leaf litter was determined by the litter bag method and culturable microfungal quantities were determined using serial dilution and plate count methods. The results of the study revealed a decline in the microfungal population and decomposition in environments with scanty rainfall. Significant positive correlations were observed between weight loss, rainfall, microfungal quantities and temperature. Significant variation in fungal colonies was observed in different seasons. Depletion in rainfall may be one of the important causes for the decrease in decomposition rate, which may have affected the nutrient dynamics and occurrence of microfungi. It may also affect overall forest productivity if similar adverse climatic conditions continued in the region in the future.