

NITRIFICATION POTENTIALS IN PRIMARY AND SECONDARY SUCCESSION¹

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Abstract. Potential nitrogen mineralization and nitrification were measured in soils from a primary successional sequence developed on sand dunes and from a secondary successional sequence on old fields. Potential nitrogen mineralization in soils from the primary were increased through the first five stages and then leveled off. Nitrogen mineralization was relatively constant in soils from the secondary series, except that the highest rates were observed in the oldest site. Nitrification was very closely correlated with nitrogen mineralization in soils from both the primary and secondary series. Only one site had both substantial nitrogen mineralization and low nitrification.

The results of this study do not support the hypothesis that nitrification is progressively inhibited in the course of ecological succession.

Key words: *dunes; Indiana; mineralization; New Jersey; nitrogen; nutrient cycling.*

INTRODUCTION

Rice and Pancholy (1972) proposed that nitrification, the microbial oxidation of ammonium to nitrite and nitrate, progressively decreases in the course of ecological succession. They suggested that the mechanism causing the decrease is allelochemical inhibition of nitrification, and that the decrease is selectively advantageous to mature ecosystems because it conserves both nitrogen and energy. Nitrogen could be conserved by the inhibition of nitrification because ammonium, a cation, is retained within the soils by cation exchange, whereas nitrate, an anion, is excluded from cation exchange sites and easily leached from most soils. They suggested that energy could be conserved because the inhibition of nitrification increases ammonium and decreases nitrate concentrations in soil, thus favoring use of ammonium as a plant nitrogen source. Plants can incorporate ammonium directly into amino acids whereas the assimilation of nitrate involves two reduction steps that can be energetically costly.

Several lines of evidence have been used in support of this hypothesis. Warren (1965) reported that soil nitrate concentrations and numbers of nitrifying bacteria decreased along a South African grassland sere, and concluded that nitrification rates changed similarly. Rice and Pancholy (1972, 1973) took a similar but more comprehensive approach by studying three different three-point seres, one grassland and two forest, in southern Oklahoma. They too found that soil nitrate concentrations and numbers of nitrifying bacteria tended to decrease with succession in each sere, and

that soil ammonium concentrations increased. Lodhi (1979) reported similar results in a mine spoil succession in North Dakota. Todd et al. (1975) studied numbers of nitrifiers and nitrate losses from several southern Appalachian watersheds and also concluded that nitrification decreased through succession. Vogt and Edmonds (1977) suggested that allelochemical inhibition of nitrification caused low nitrate and high ammonium concentrations in old low-site-quality Douglas-fir stands in western Washington. Monro (1966) and Rice and Pancholy (1973, 1974) found that various organic compounds in soils and plant extracts were highly toxic to soil or solution cultures of nitrifiers and were found in generally increasing amounts in soils from progressively later stages of succession, although Neal (1969) found the opposite trend in a Canadian prairie sere. Rice (1974, 1979) has thoroughly reviewed much of this research.

Haines (1977), after examining the relative uptake of applied ammonium and nitrate in a Georgia old-field to forest sere, concluded that plants from the younger stages preferentially utilized nitrate while those from the older stages used ammonium. Franz and Haines (1977) examined levels of nitrate reductase in foliage in the same sere and reached the same conclusion.

We question both the evolutionary basis of this hypothesis and the evidence that has been used to support it. As stated, the evolutionary rationale (Rice and Pancholy 1972, Haines 1977) relies mainly on the ecosystem as a unit of selection. While the evolutionary argument could be reformulated in terms of more realistic models of selection, we are more concerned with the evidence that has been used to examine changes in nitrification through succession. Relying on nitrate or ammonium pool size and numbers of nitrifiers to indicate relative rates of nitrification implicitly assumes that (1) nutrient pool size reflects the rate of nutrient utilization, and (2) reported population sizes of nitrifying bacteria accurately reflect nitrifier activi-

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Nitrification Potentials In Primary And Secondary Succession

Jin-Ying Zhang



Nitrification Potentials In Primary And Secondary Succession:

The Characterization and Control of Nitrification in Primary and Secondary Succession G. P. Robertson, 1980

Ecology of Arable Land — Perspectives and Challenges M. Clarholm, L. Bergström, 2012-12-06 Agriculture in the industrial world has gone through dramatic changes over the past decades. A common interest of the contributors is increasing the understanding of the turnover of carbon in terrestrial ecosystems. Mechanization in combination with high inputs of and inorganic nutrients in fertilizers and pesticides has turned deficits of agricultural products into surplus. Over the same directions depending on their interests and experience we have experienced increased environmental difficulties. Difficulties are identified in the quantification of problems in both the atmosphere and our water below ground production where death and resources which have been associated with the regrowth if incorporated into the calculations changes in management practices can change production figures considerably. Concern about the potential pollution by compared to values derived from peak estimates nitrogen fertilizers as well as the low utilization. The role of root derived carbon is investigated in efficiency of applied nitrogen by plants has created relation to nutrient competition between roots and a need for a better understanding of nitrogen microorganisms the cost of N₂ fixation and the cycling in the plant soil water system. To achieve decomposition of organic nitrogen Mycorrhizae this it is necessary to study process interactions use root derived carbon and their roles in phosphorus and process regulation in an ecosystem context phosphorus conservation and in supplying nutrients to. During the last decade many ecosystem studies the host are exemplified.

Allelopathy S.J. Rizvi, 2012-12-06 Science is essentially a descriptive and experimental device. It observes nature constructs hypotheses plans experiments and proposes theories. The theory is never contemplated as the final truth but remains ever subject to modifications changes and rejections. The science of allelopathy in a similar way has emerged and exists on a similar footing. Our endeavour should be to keep it fresh and innovative with addition of newer information and concepts with the rejection of older ideas and antiquated techniques. During the past few decades encouraging results have been obtained in various aspects of allelopathic researches. However in addition to continuing efforts in all these directions constant attempts are to be made to describe the mechanics of allelopathic activity in molecular terms and to discover ways and means to exploit it for the welfare of mankind. We feel that multidisciplinary efforts are the only tool to achieve this goal. It is the hope of the editors that this book will serve as a document which identifies an integrated approach through which research both to understand and exploit allelopathy can be conducted. The present volume arose out of an attempt to bring together eminent scientists in allelopathy to describe their work of a highly diverse nature under one title. **Plant Strategies and the Dynamics and Structure of Plant Communities** David Tilman, 2020-03-31 Although ecologists have long considered morphology and life history to be important determinants of the distribution abundance and dynamics of plants in nature this book contains the first theory to predict explicitly both the evolution of plant traits and the effects of

these traits on plant community structure and dynamics David Tilman focuses on the universal requirement of terrestrial plants for both below ground and above ground resources The physical separation of these resources means that plants face an unavoidable tradeoff To obtain a higher proportion of one resource a plant must allocate more of its growth to the structures involved in its acquisition and thus necessarily obtain a lower proportion of another resource Professor Tilman presents a simple theory that includes this constraint and tradeoff and uses the theory to explore the evolution of plant life histories and morphologies along productivity and disturbance gradients The book shows that relative growth rate which is predicted to be strongly influenced by a plant's proportional allocation to leaves is a major determinant of the transient dynamics of competition These dynamics may explain the differences between successions on poor versus rich soils and suggest that most field experiments performed to date have been of too short a duration to allow unambiguous interpretation of their results

Biogeochemistry W.H. Schlesinger, 1997-02-20 This book considers the effects of life on the Earth's chemistry on a global level

Air Quality Criteria for Oxides of Nitrogen Dennis J. Kottmar, J. H. Garner, Donald Gardner, Beverly Comfort, 1996-07 Evaluates the latest scientific data on health effects of NO_x measured in laboratory animals and exposed human populations and the effects of NO_x on agricultural crops forests and ecosystems as well the NO_x effects on visibility and non biological materials Other chapters describe the nature sources distribution measurement and concentrations of NO_x in the environment Covers all pertinent literature through early 1993 Glossary of terms and symbols Extensive bibliography Charts tables and graphs

Proceedings for the Eight Biennial Southern Silvicultural Research Conference M. Boya Edwards, 2001 Presents the research of 189 investigators studying the patterns vegetation management pest management natural disturbance biometrics economics site productivity site impacts ecophysiology genetics regeneration silvicultural systems stand development intermediate management

Nitrogen Cycling in Ecosystems of Latin America and the Caribbean G. Philip Robertson, R. Herrera, T. Rosswall, 2012-12-06 The large and rapidly expanding body of literature related to nitrogen cycling in both managed and native terrestrial ecosystems reflects the importance accorded to the behaviour of this vital and often limiting nutrient Research at the organism ecosystem and landscape levels commonly addresses questions concerning nitrogen acquisition internal cycling and retention Goals for this research include increased agricultural productivity and a better understanding of human impact on local regional and global nitrogen cycles Nitrogen cycle research in tropical regions has a long and distinguished history Research on different aspects of nitrogen cycling in ecosystems of the tropics has been carried out in many regions In relatively few instances has there however been a focus on the biogeochemical cycles at the ecosystem level The meeting resulting in this volume was an attempt to bring together existing information on nitrogen cycling in ecosystems of Latin America and the Caribbean and discuss this in an ecosystem context

Vegetation science applications for rangeland analysis and management P.T. Tueller, 2012-12-06 Natural grasslands pastures and meadows are among the vegetation types most frequently investigated with phytosociological

methods This was one of the reasons why volume 13 Application of vegetation science to grassland husbandry and agriculture edited by W Krause appeared as one of the first volumes of this handbook It appeared under the chief editorship of Prof R Tiixen and in his time main emphasis of the handbook was placed on Ziirich Montpellier methods and the European vegetation When we redesigned the handbook we felt the need to include other methods and aims of grassland analyses as well as a more global coverage of grasslands Especially the natural dry and semidry areas of the world needed to be covered was very fortunate in getting Prof Tueller of the University of Reno I Nevada as an editor for this volume He and the colleagues he motivated to compile volume 14 on Application of vegetation science to rangeland analysis and management have created a truly global coverage of the topics interesting for vegetation analyses in natural grasslands Since volume 13 covered the problems of anthropogenically created grasslands this topic was not expressly treated in order to avoid duplication For the same reason no specific attempt was made to get more papers from Europe and the temperate forest region in general The cooperation with Dr Tueller has been very rewarding for me Methods of Soil Analysis, Part 2 Peter J. Bottomley, J. Scott Angle, R. W. Weaver, 2020-01-22 One of the primary references on analytical methods in soil science Part 2 of the Methods series will be useful to all biogeoscientists especially those with an interest in microbiology or bioremediation **Biodiversity and Ecosystem Function** Ernst-Detlef Schulze, 1994-07-26 With the accelerating loss of biodiversity there is increasing concern about how this loss may be affecting ecosystem processes or services that are of benefit to human well being The limited studies that address the principal question directly species numbers versus system function are evaluated Moreover the degree of redundancy within systems the ubiquity of keystone species the tightness of species interactions from mutualisms to food webs the resilience of systems to perturbation the interactions of landscape units are explored as is also how policy decisions are driven in this research area This book brings together the disciplines of population biology and ecosystem science both directed toward evaluating the consequences of human driven disruptions of natural systems Semiarid Lands and Deserts J. Skujins, 1991-04-16 A compendium of current information on arid soils Provides a comprehensive background of the various soils and biota of arid regions as well as a detailed account of the current understanding of degradation processes and includes methodologies for arid land maintenance and rehabilitation and for *General Technical Report PNW-GTR*, 1999 **Soil Biochemistry** Bollag, 1993-05-13 Stressing the potential application of biochemical processes in soil to environmental biotechnology this state of the art reference considers the vital role that such biochemical processes have in the environment emphasizing the activity of micro organisms in soil An up to date analysis of biological reactions in soil Volume 8 of Soil Biochemistry highlights traditional as well as molecular and immunological techniques for detecting specific micro organisms in soil the fate of introduced genetically modified organisms the problem of competition by the indigenous microbial populations with the introduced organisms the use of a white rot fungus *Phanerochaete chrysosporium* for bioremediative purposes in soil the interaction of xenobiotics such as pesticides

with soil organisms generic microbial metabolism and degradation pathways the inhibition of the nitrification process by allelochemicals released by plants the microbial mineralization of various compounds under anaerobic conditions explaining its importance in the global carbon cycle the formation of soil organic matter particularly in forest soils and CPDAS 13C NMR spectroscopy a major analytical technique to determine the chemicals or chemical groups involved in the humification process Presenting a multidisciplinary approach to the field by internationally acclaimed scientists Soil Biochemistry Volume 8 is intended for professionals and students in the fields of soil science microbiology biochemistry environmental science engineering and technology biogeochemistry biotechnology agronomy plant pathology and microbial ecology **General Technical Report NC.** ,1981 Ecosystems of Disturbed Ground L.R. Walker,1999-12-17 As the human population inexorably grows its cumulative impact on the Earth's resources is hard to ignore The ability of the Earth to support more humans is dependent on the ability of humans to manage natural resources wisely Because disturbance alters resource levels effective management requires understanding of the ecology of disturbance This book is the first to take a global approach to the description of both natural and anthropogenic disturbance regimes that physically impact the ground Natural disturbances such as erosion volcanoes wind herbivory flooding and drought plus anthropogenic disturbances such as forestry grazing mining urbanization and military actions are considered Both disturbance impacts and the biotic recovery are addressed as well as the interactions of different types of disturbance Other chapters cover processes that are important to the understanding of disturbance of all types including soil processes nutrient cycles primary productivity succession animal behaviour and competition Humans react to disturbances by avoiding exacerbating or restoring them or by passing environmental legislation All of these issues are covered in this book Managers need better predictive models and robust data collections that help determine both site specific and generalized responses to disturbance Multiple disturbances have a complex effect on both physical and biotic processes as they interact This book provides a wealth of detail about the process of disturbance and recovery as well as a synthesis of the current state of knowledge about disturbance theory with extensive documentation An Integrative Approach to Successional Dynamics Scott J. Meiners,Steward T. A. Pickett,Mary L. Cadenasso,2015-03-26 Much of what is considered conventional wisdom about succession is not as clear cut as it is generally believed Yet the importance of succession in ecology is undisputed since it offers a real insight into the dynamics and structure of all plant communities Part monograph and part conceptual treatise An Integrative Approach to Successional Dynamics presents a unifying conceptual framework for dynamic plant communities and uses a unique long term data set to explore the utility of that framework The fourteen chapters each written in a nontechnical style and accompanied by numerous illustrations and examples cover diverse aspects of succession including community population and disturbance dynamics diversity community assembly heterogeneity functional ecology and biological invasion This unique text will be a great source of reference for researchers and graduate students in ecology and plant biology as well as others with an

interest in the subject **High-Latitude Rainforests and Associated Ecosystems of the West Coast of the Americas**
Richard G. Lawford, Paul Alaback, Eduardo Fuentes, 2012-12-06 Regional intercomparisons between ecosystems on different continents can be a powerful tool to better understand the ways in which ecosystems respond to global change Large areas are often needed to characterize the causal mechanisms governing interactions between ecozones and their environments Factors such as weather and climate patterns land ocean and land atmosphere interactions all play important roles As a result of the strong physical north south symmetry between the western coasts of North and South America the similarities in climate coastal oceanography and physiography between these two regions have been extensively documented High Latitude Rain Forests and Associated Ecosystems of the West Coast of the Americas presents current research on West Coast forest and river ecology and compares ecosystems of the Pacific Northwest with those of South America *Methods in Ecosystem Science* Osvaldo E. Sala, Robert B. Jackson, Harold A. Mooney, Robert W. Howarth, 2013-12-01 Ecology at the ecosystem level has both necessitated and benefited from new methods and technologies as well as those adapted from other disciplines With the ascendancy of ecosystem science and management the need has arisen for a comprehensive treatment of techniques used in this rapidly growing field *Methods in Ecosystem Science* answers that need by synthesizing the advantages disadvantages and tradeoffs associated with the most commonly used techniques in both aquatic and terrestrial research The book is divided into sections addressing carbon and energy dynamics nutrient and water dynamics manipulative ecosystem experiments and tools to synthesize our understanding of ecosystems Detailed information about various methods will help researchers choose the most appropriate methods for their particular studies Prominent scientists discuss how tools from a variety of disciplines can be used in ecosystem science at different scales *The Rainforest Edge* John Hemming, 1994

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