

NITRIFICATION POTENTIALS IN PRIMARY AND SECONDARY SUCCESSION¹

G. PHILIP ROBERTSON² AND PETER M. VITOUSEK³

Department of Biology, Indiana University, Bloomington, Indiana 47405 U.S.A.

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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² Present address: Department of Microbiology, Swedish University of Agricultural Sciences, S-750 07 Uppsala, Sweden.

³ Present address: Department of Botany, University of North Carolina, Chapel Hill, North Carolina 27514 U.S.A.

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David Tilman



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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 fertilizers and pesticides has turned deficits of agricultural products into surplus. Over the same directions depending on their interests and experiences we have experienced increased environmental problems. Difficulties are identified in the quantification of 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 of 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 plants. During the last decade many ecosystem studies the host are exemplified.

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.

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

Air Quality Criteria for Oxides of Nitrogen Dennis J. Kotchmar, 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 *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 **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 *Soil Sampling and Methods of*

Analysis M.R. Carter, E.G. Gregorich, 2007-08-03 Thoroughly updated and revised this second edition of the bestselling *Soil Sampling and Methods of Analysis* presents several new chapters in the areas of biological and physical analysis and soil sampling Reflecting the burgeoning interest in soil ecology new contributions describe the growing number and assortment of new microbiological techniques describe in depth methods and demonstrate new tools that characterize the dynamics and

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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

General Technical Report PNW-GTR ,1999

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Table of Contents Nitrification Potentials In Primary And Secondary Succession

1. Understanding the eBook Nitrification Potentials In Primary And Secondary Succession
 - The Rise of Digital Reading Nitrification Potentials In Primary And Secondary Succession
 - Advantages of eBooks Over Traditional Books
2. Identifying Nitrification Potentials In Primary And Secondary Succession
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Nitrification Potentials In Primary And Secondary Succession
 - User-Friendly Interface
4. Exploring eBook Recommendations from Nitrification Potentials In Primary And Secondary Succession
 - Personalized Recommendations
 - Nitrification Potentials In Primary And Secondary Succession User Reviews and Ratings
 - Nitrification Potentials In Primary And Secondary Succession and Bestseller Lists
5. Accessing Nitrification Potentials In Primary And Secondary Succession Free and Paid eBooks
 - Nitrification Potentials In Primary And Secondary Succession Public Domain eBooks
 - Nitrification Potentials In Primary And Secondary Succession eBook Subscription Services
 - Nitrification Potentials In Primary And Secondary Succession Budget-Friendly Options

6. Navigating Nitrification Potentials In Primary And Secondary Succession eBook Formats
 - ePub, PDF, MOBI, and More
 - Nitrification Potentials In Primary And Secondary Succession Compatibility with Devices
 - Nitrification Potentials In Primary And Secondary Succession Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Nitrification Potentials In Primary And Secondary Succession
 - Highlighting and Note-Taking Nitrification Potentials In Primary And Secondary Succession
 - Interactive Elements Nitrification Potentials In Primary And Secondary Succession
8. Staying Engaged with Nitrification Potentials In Primary And Secondary Succession
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Nitrification Potentials In Primary And Secondary Succession
9. Balancing eBooks and Physical Books Nitrification Potentials In Primary And Secondary Succession
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Nitrification Potentials In Primary And Secondary Succession
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Nitrification Potentials In Primary And Secondary Succession
 - Setting Reading Goals Nitrification Potentials In Primary And Secondary Succession
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Nitrification Potentials In Primary And Secondary Succession
 - Fact-Checking eBook Content of Nitrification Potentials In Primary And Secondary Succession
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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