Curriculum Vitae

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Areas of interest: Climate change adaptation and mitigation, Ecosystem dynamics, Terrestrial carbon sequestration (Forest, Agroforestry, Grassland), Land degradation and restoration, Regenerative Agriculture

Qualifications:

Qualification	Year	University	Subject/Specialization	Class/ division	Mentor
Post Doctorate [Fulbright Scholar]	2019-2020	The Ohio State University, USA	**Soil Carbon Management and Sequestration** (Project: Soil erodibility and carbon management of (i) no-till, (ii) plow-till and (iii) forest land under rainfall simulator emphasizing better climate adaptive soil	-	Prof. Rattan Lal [World Food Prize Laureate 2020 Nobel Laureate- IPCC Nobel Peace Prize 2007]
Post Doctorate [Shastri Indo-Canadian Scholar]	2019	University of Toronto, Canada	**Agroforestry and Carbon management** (Project: Modelling carbon sources and sinks in temperate willow monoculture and agroforestry)	-	Dr. Marney Isaac
Ph. D. [Erasmus Scholar]	2013-2018	Assam University, India & University of Oxford, UK (Split PhD)	**Ecology & Environmental Science** (doctoral project: carbon storage & sequestration opportunities of *Imperata* grassland in rural landscape of Assam)	-	Dr. Arun Jyoti Nath Prof. Ashesh Kr. Das Prof. Yadvinder Malhi, FRS-UK
M. Sc.	2010	Assam University, India	**Ecology & Environmental Science** (Specialization: Environmental monitoring & management)	**I**	Prof. Susmita Gupta
B. Sc.	2008	Gauhati University, India	**Botany**	**I**	-

Fellowships and Grants:

- Fulbright-Kalam Climate Postdoctoral Fellowship' 2019 by United State-India Education Foundation, Republic of India and U. S. Department of State

- Shastri Indo-Canadian Postdoctoral fellowship' 2018 by Shastri Indo-Canadian Institute, MHRD, Govt. of India.
- Department of Biotechnology (Govt. Of India) Senior Research Fellowship in 2017
- Erasmus Mundus doctoral scholarship, 2015 of European Union.
- Sponsored Indian youth by ICIMOD (International Centre for Integrated Mountain Development) in Asia Pacific Youth Forum, 2013 in Kathmandu, Nepal.

Awards and Honors:

- Fulbright Scholar' 2019 by Fulbright Commission, India & U. S. Department of State.
- Accredited by printing media, *Niyomiabarta*, *Axomiya Pratidin*, *The Sentinel* from Assam for showcasing India's North-Eastern grassland research at international platform (2019)
- Shastri Fellow' 2018 by Ministry of Human Resource, Government of India
- "*ANANYA of the Month*"- title awarded in 2018 for Environmental research and international research collaboration by *Nandini*, a women magazine from Assam, India.
- Accredited by '*All Assam Kalita Community'*, an organization of indigenous people of Assam, India for Scientific research and international research collaboration (2018)
- Erasmus Scholar' 2015 by European Commission

List of Publication:

Research papers in Peer-reviewed Journal:

1. Nath A. J., Sileshi G. W., Laskar S. Y., **Pathak K.**, Reang D., Nath A. and Das A. K. (2020) Quantifying carbon stocks and sequestration potential in agroforestry systems under divergent management scenarios relevant to NDC. **Journal of Cleaner Production.** (paper accepted) (IF 7.3)

2. Laskar S. Y., Sileshi G. W., **Pathak K.**, Yasmin K., Denbath N., Singnar P., Nath A. J. and Das A. K. (2020) Variations in soil organic carbon content with chronosequence, soil depth and aggregate size under shifting cultivation, **Science of the Total Environment**. (paper accepted) (IF 6.6)

3. Nath A. J., **Pathak K.**, Das A. K, Ray R. (2020) Traditional bamboo products: are they green? **Current Science,** 118 (9): 1339-1342 (IF 0.8)

4. **Pathak K.**, Malhi Y., Sileshi G. W., Das A. K. and Nath A. J. (2018). Net Ecosystem Productivity and carbon dynamics of the traditionally managed *Imperata* grasslands of North East India**. Science of the Total Environment,** 635: 1124-1131. (IF 6.6)

5. Brahma B., **Pathak K**., Lal R., Kurmi B., Das M., Nath P. C., Nath A. J. and Das A. K. (2018) Ecosystem carbon sequestration through restoration of degraded lands in North East India. **Land Degradation and Development**, 29 (1):15-25. (IF 3.8)

6. **Pathak K.**, Nath A. J., Das A. K, Bhar M. (2018) Litter dynamics in *Imperata cylindrica* grassland under culturally managed system in North East India. **Journal of Tropical Agriculture**, 56 (2): 99-106. (IF 0.4)

7. **Pathak K.,** Nath A. J., Sileshi G. W., Lal R. and Das A. K. (2017). Annual burning enhances biomass production and nutrient cycling in degraded *Imperata* grasslands. **Land Degradation and Development**, 28 (5): 1763-1771. (IF 3.8)

8. Nath A. J., Brahma B., **Pathak K.** and Das A. K. (2016). Why should we preserve wetlands? **Current Science**, 110(9): 1619-1620. (IF 0.8)

9. **Pathak K.**, Nath A. J. and Das A. K. (2015) *Imperata* grasslands: carbon source or sink? **Current Science,**

108(12): 2250-2253. (IF 0.8)

10. **Pathak K.,** Nath A. J., and Das A. K. (2014) Traditional fire management in *Imperata* grassland as a tool for its sustainability. **Indian Journal of Applied Research**, 4(7): 241-242.

11. Das T., **Pathak K.** and Devi M. B. (2011) Phytoplankton and zooplankton community of an oxbow lake in Barak Valley, Assam. **Assam University Journal of Science & Technology**, 7(1):67-75.

12. **Pathak K.,** Das A. K. and Sarma G. C. (2009) Bamboo diversity of North Salmara sub-division of Bongaigaon District, Assam. **Journal of Advanced Plant Science**, 4(3&4):113-115

Paper communicated:

13. **Pathak K**., Moonilall N. I., Lal R. (2020) Long-Term no-till effects on soil organic carbon stock and water infiltration: A rainfall simulation study. **Environmental Research.** (IF 5.73)

Selected conference proceedings:

14. **Pathak K.**, Nath A. J. and Das A. K. (2016) Are grasslands carbon negative, Association for Tropical Biology and Conservation (ATBC), 2016 Montpellier, France.

15. **Pathak K.**, Malhi Y., Nath A. J. and Das A. K. (2016) Are grasslands green? European Conference of Tropical Ecology, 2016 Gottingen, Germany.

16. **Pathak K.**, Das J., Nath A. J. and Das A. K. (2014) Effect of fire on Soil Organic Carbon and Dissolve Organic Carbon. Sustainable development in Mineral and Earth Resources 2014, New Delhi, India.

17. **Pathak K.**, Nath A. J. and Das A. K. (2014) Traditional management of *Imperata* grassland for environmental sustainability. RET Plants of North East India and their Conservation Strategies, 2014, Guwahati, India.

Research experiences:

Research Project	Study site	Institution	Position	Year
Soil erodibility, infiltration and soil carbon management under no-till, plowed and forest land management (Climate-resilient agriculture)	Ohio, USA	The Ohio State University, USA	Postdoctoral Researcher (Fulbright)	September 2019-present
Willow monoculture vs willow agroforestry: modelling carbon source and sink	Guelph University Agricultural Research Station, Canada	University of Toronto, Canada	Postdoctoral Researcher (Shastri)	January 2019-May 2019
Production of Phytolith occulted carbon for advancing Climate change mitigation	North East India	Assam University, India	Senior Research Fellow (DBT, Govt. of India)	May 2017-November 2018
(i) Carbon Storage and sequestration Opportunities of Traditionally Managed *Imperata* grasslands (ii) Wood vessel structures in relation to different soil gradients (volunteery)	Barak Valley, India Brazil	University of Oxford, UK Assam University, India	Doctoral Researcher (Erasmus Mundus, EU)	2013-2017 (thesis submitted in August'2017)

Preparation of Ganga River Basin Management Plan: Thematic group-Environmental Science and Engineering and Water Resource Engineering	Ganga River Basin, Northern India	Indian Institute of Technology, Guwahati India	Junior Research Fellow (MoEFCC, Govt. of India)	March 2011-September 2012
An Ecological investigation of physico-chemical properties of water and planktonic communities of phulbari anua, an oxbow lake in Barak valley	North East India	Assam University, India	M. Sc. Student	2010

Teaching and mentoring Experiences:

- Assistant Professor in Abhayapuri College, Assam India (contractual basis) from August' 2010 to February' 2011.
- Mentored Environmental Studies semester project for undergraduate students in Abhayapuri College, Assam India in 2011
- Mentored two M.Sc. Student dissertation project in Assam University, India in 2015 and 2018.

Training Courses:

Training Courses	Institute	Year	Sponsorship
1. Basics Concept of Statistics	University of Oxford, UK	2016	Erasmus Mundus, European Union
2. Environmental pollution: Monitoring and control	Delhi Technological University, Delhi	2016	-
3. Statistical data analysis methods	Indian Statistical Institute, Kolkata	2015	ISI, GOI
4. Geospatial technologies	Chitkara University, Solan	2015	DST, GOI
5. Open Source Software Solutions for Geo-Spatial Domain	Indian Institute of Remote Sensing, ISRO, Dehradun	2012	-
6. Need of Watershed Based Planning for Hazard Mitigation	Indian Institute of Technology Guwahati	2012	-
7. Integrated Solid Waste Management	Indian Institute of Technology, Guwahati	2012	AICT, GOI

Invited talk and Conference presentation:

- **Pathak K.,** Lal R., and Nall M. L. (2020) Long term tillage practices: a strategy for soil and soil organic carbon conservation. College of Food, Agricultural and Environmental Sciences, The Ohio State University, USA.
- **Pathak K.**, Isaac M. E., Thevathasan N. and Cleman B. (2019) Willow monoculture vs willow agroforestry: modelling carbon sources and sinks. University of Toronto, Scarborough, Canada
- **Pathak K.** (2019) North East India: a social, cultural and ecological epitome. Carbon Management and Sequestration Centre, The Ohio State University, USA.
- **Pathak K.**, Malhi Y., Das A. K. and Nath A. J. (2016) Carbon budget in the *Imperata* grasslands of North East India. Environmental Change Institute, University of Oxford, UK.
- **Pathak K.,** Nath A. J. and Das A. K. (2016) Are grasslands carbon negative, Association for Tropical Biology and Conservation (ATBC), 2016 Montpellier, France
- **Pathak K.,** Malhi Y., Nath A. J. and Das A. K. (2016) Are grasslands green? European Conference of Tropical

Ecology, 2016 Gottingen, Germany

- **Pathak K.,** Das J., Nath A. J. and Das A. K. (2014) Effect of fire on Soil Organic Carbon and Dissolve Organic Carbon, “Sustainable development in Mineral and Earth Resources” 2014, Indian International Centre, New Delhi.
- **Pathak K.,** Nath A. J. and Das A. K. (2014) Need of commercialization of *Imperata* grasses in villages of Barak Valley, Assam, “Promotion of Villages Industries” 2014 in Assam University, India.
- **Pathak K.,** Nath A. J. and Das A. K. (2014) Traditional management of *Imperata* grassland for environmental sustainability, “RET Plants of North East India and their Conservation Strategies” 2014 in Gauhati University, India.
- **Pathak K.,** Nath A. J. and Das A. K. (2013) *Imperata* grassland as a climate change mitigation strategy, Asia Pacific Youth Forum 2013, Kathmandu, Nepal
- **Pathak K.,** Das A. K. and Sarma G. (2010) Bamboo diversity of North Salamara Sub-division, Bongaigaon Assam, Biodiversity Conservation (Forest & Land Resource Management)” 2010, in Assam University, India

Reviewer of Journal:

- Plos One; Science of the Total Environment; Land Degradation & Development

Community involvement:

- **Joint Secretary**, Assam University General Science Festival, 2017
- **General Member**, Aaranyak, an NGO in North East India for biodiversity conservation and environmental protection through participations of students and common people, 2005-2010.
- **Assistant General Secretary**, Students’ Union 2002-2003, J. N. M. Girls’ High School, Abhayapuri, Assam, India

Extra-curriculum activities:

- Interviewed by **Patagonia, Argentina** to promote regenerative agriculture (in 2019)
- Best Debater, Best Orator, Best Literate Prizes and Best performing drama group in graduate college and school

Academic Travels:

Country	**Date**	**Purpose**
United State	2020	International research collaboration and educational exchange program
Canada	2019	International research collaboration and educational exchange program
France	2016	Poster presentation at Annual meeting of Association for Tropical Ecology & Biodiversity Conservation’ 2016
Germany	2016	Invited talk in European conference of Tropical Ecology’ 2016
United Kingdom	2015	Doctoral research program; Bilateral education & research cooperation of India and European Union
Nepal	2013	Sponsored youth at Asia Pacific Youth Forum’ 2013
India	Enormous	Research collaboration, presentation and workshops in national institutions

Karabi Pathak

Karabi Pathak
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Variations in soil organic carbon content with chronosequence, soil depth and aggregate size under shifting cultivation

Sabina Yasmin Laskar [a], Gudeta Weldesemayat Sileshi [b,c], Karabi Pathak [a,d], Nirmal Debnath [a], Arun Jyoti Nath [a,*], Kaynath Yasmin Laskar [a], Pator Singnar [a], Ashesh Kumar Das [a]

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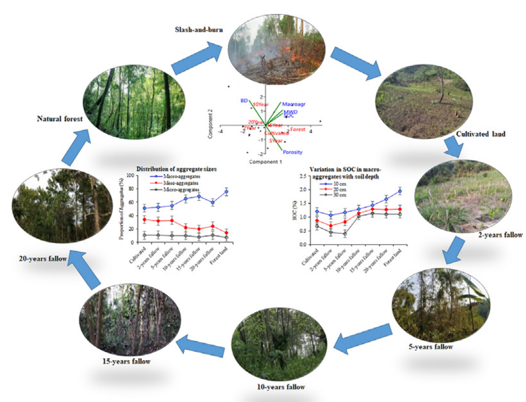
[b] Department of Plant Biology and Biodiversity Management, Addis Ababa University, Addis Ababa, Ethiopia
[c] University of KwaZulu-Natal, Private Bag X01, Pietermaritzburg 3209, South Africa
[d] Carbon Management and Sequestration Center, The Ohio State University, Columbus, OH 43210, USA

HIGHLIGHTS

- SOC content was positively correlated with MWD, GMD, and negatively with BD.
- Soil macro- and meso-aggregates significantly varied with land-use and soil depth.
- Macro-aggregates increased from cultivated land through the different fallow ages.
- Macro-aggregates had higher SOC content than meso- and micro-aggregates.

GRAPHICAL ABSTRACT



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ABSTRACT

Shifting cultivation is a globally important form of agriculture covering over 280 million hectares in the tropics, but it has often been blamed for deforestation and forest degradation. In North East India (NEI) it has been practiced for millennia and it is an important element of the cultural identity of indigenous communities. It is often practiced on slopping lands with fragile soils (mostly Acrisols), which are prone to rapid degradation with cultivation. The shortened fallow cycle as practised currently is ecologically unsustainable and economically not viable. This study aimed to quantify (i) changes in soil bulk density, aggregate stability and compaction in relation to chronosequence and soil depth, (ii) changes in the proportion of macro, meso, and micro aggregates and associated soil organic carbon (SOC) content in relation to soil depth and fallow chronosequence, and (iii) determine the minimum fallow length that achieves SOC stocks comparable with adjacent intact forest land. The proportion of soil macro-aggregates and meso-aggregates significantly varied with land-use and soil depth as well as their interactive effects. Across all soil depths, forest land had the highest proportion of macro-aggregates (75.6%), while the currently cultivated land had the least proportion (51.1%). The SOC contents in macro-aggregates increased with fallow age and decreased with soil depth; the highest (1.95%) being in the top 10 cm soil of 20 years old fallows and the lowest (0.39%) in 21–30 cm depth of 5 years old fallows. Multivariate analysis identified bulk density and porosity as the most important variables to discriminate between land use practices. The analysis provided evidence for significant changes in soil compaction, aggregate stability and SOC content with

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Net ecosystem productivity and carbon dynamics of the traditionally managed *Imperata* grasslands of North East India

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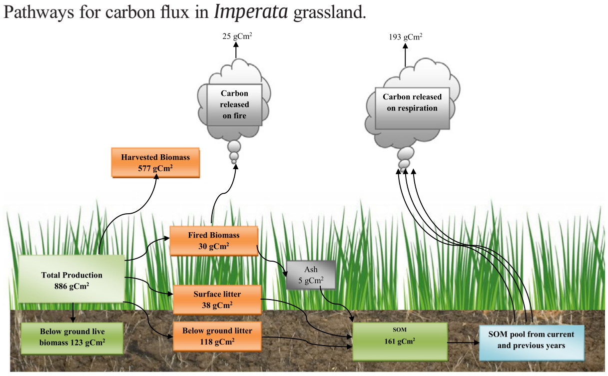
[c] Plot 1244 Ibex Meanwood, Lusaka, Zambia,
[d] School of Agricultural, Earth and Environmental Sciences, University of Kwazulu-Natal, Pietermaritzburg, South Africa

HIGHLIGHTS

- Annual harvest of biomass was the major pathway for carbon fluxes in *Imperata* grassland.
- Net ecosystem production (NEP) of *Imperata* grassland was estimated at 91 g m^{-2} yr^{-1}.
- NEP of *Imperata* grassland is greatly influenced by weather and fire management.

GRAPHICAL ABSTRACT

Pathways for carbon flux in *Imperata* grassland.



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Imperata grassland
Invasive alien
Net ecosystem production

ABSTRACT

There have been few comprehensive descriptions of how fire management and harvesting affect the carbon dynamics of grasslands. Grasslands dominated by the invasive weed *Imperata cylindrica* are considered as environmental threats causing low land productivity throughout the moist tropical regions in Asia. *Imperata* grasslands in North East India are unique in that they are traditionally managed and culturally important in the rural landscapes. Given the importance of fire in the management of *Imperata* grassland, we aimed to assess (i) the seasonal pattern of biomass production, (ii) the eventual pathways for the produced biomass, partitioned between *in situ* decomposition, harvesting and combustion, and (iii) the effect of customary fire management on the ecosystem carbon cycle. Comparatively high biomass production was recorded during pre-monsoon (154 g m^{-2} $month^{-1}$) and monsoon (214 g m^{-2} $month^{-1}$) compared to the post-monsoon (91 g m^{-2} $month^{-1}$) season, and this is attributed to nutrient return into the soil immediately after fire in February. Post fire effects might have killed roots and rhizomes leading to high belowground litter production 30–35 g m^{-2} during March to August. High autotrophic respiration was recorded during March–July, which was related to high belowground biomass production (35–70 g m^{-2}) during that time. Burning removed all the surface litter in March and this appeared to hinder surface decomposition and result in low heterotrophic respiration. Annual total biomass carbon production was estimated at 886 g C m^{-2}. Annual harvest of biomass (estimated at 577 g C m^{-2}) was the major pathway for carbon fluxes from the system. Net ecosystem production (NEP) of *Imperata* grassland was estimated at 91 g C m^{-2} yr^{-1} indicating that these grasslands are a net sink of CO_2, although this is greatly influenced by weather and fire management.

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ECOSYSTEM CARBON SEQUESTRATION THROUGH RESTORATION OF DEGRADED LANDS IN NORTHEAST INDIA

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ABSTRACT

This study evaluated the ecosystem carbon (C) stock and sequestration potential for predominant land uses converted from forest in Northeast India to advance the scientific knowledge and minimize the anthropogenic C emissions from land use change (LUC). Field assessments were conducted on 6 predominant land uses including (a) natural forest (NF), (b) degraded forest (DF), (c) rubber (*Hevea brasiliensis*) plantation (RP), (d) Areca (*Areca catechu*) plantation (ArP), (e) pan (*Piper betle)* jhum (slash and mulching) agroforestry (PB), and (f) *Imperata* grassland (IG) of Northeast India to assess changes in ecosystem C stock with progressive and retrogressive LUC. Ecosystem C stock was the highest for NF (300.5 Mg ha^{-1}) and the lowest under IG (110.4 Mg ha^{-1}). The ecosystem C stock under PB and IG was 11% and 63%, respectively, lower than that under NF. In comparison with DF, the gain in ecosystem C was in the order PB (125%) > RP (99%) > ArP (4%). The ratio of soil organic carbon to ecosystem C stock was ~50% for NF, PB, and RP and that shifted to ~80% for ArP/DF/IG. The LUC and management of DF through PB and RP indicated the ecosystem C sequestration rate of 5 and 4 Mg ha^{-1} year^{-1}, respectively. Similarly, the ecosystem C sequestration rate was 0.5 and 4 Mg ha^{-1} year^{-1}, respectively, when IG was converted into ArP and RP. Therefore, restoration of degraded lands (viz., DF and IG) through RP and PB enhanced ecosystem C sequestration rate and reduced CO_2 emissions from LUC. Copyright © 2017 John Wiley & Sons, Ltd.

KEY WORDS: carbon sequestration; land use change and management; progressive and retrogressive land use changes; SOC:ecosystem C stock

INTRODUCTION

Combating greenhouse gas emission through reducing sources or enhancing sinks has been the priority theme of global research since mid-1990s. Since, direct CO_2 emission from land use change (LUC) alone contributes ~10% of total anthropogenic emission (Le Quere et al., 2016); it is one of the most important human-driven anthropogenic sources of atmospheric CO_2 (IPCC, 2014). Therefore, understanding of the changes in pools and fluxes of carbon (C) in soil and vegetation in the terrestrial ecosystems has attracted the attention of scientific community (Sarkar et al., 2015) to advance the understanding of climate change adaptation/mitigation. Tropical forests are the major source/sink of C (Wei, Shao, Gale, & Li, 2014) due to their strong (46%) impact on the global terrestrial C cycle (Bloom, Exbrayat, Velde, Feng, & Williams, 2016). The annual C emission from deforestation related LUC is 0.9 Pg C year^{-1} (1 Pg = 1 gigaton = 10^{15} g = 1 million metric ton) compared with 9.0 Pg C year^{-1} for the decade of 2005 to 2014 (Le Quere et al., 2016). Fossil fuel combustion and LUC, mostly in the tropical zones (Houghton & Goodale, 2004), have increased atmospheric CO_2 concentration to >400 ppm in 2015 (Betts, Jones, Knight, Keeling, & Kennedy, 2016), and it is projected to exceed 500 ppm by 2050 (Ciais et al., 2013; WMO, 2016). Because the C in tropical forests are stored in different pools (vegetation and soil) and their accumulation rate and sink capacity vary with climatic variations, vegetative cover, and intensity of human interventions (Lal, 2008; Lawrence et al., 2007), the LUC from native land can be a C sink or source (Zhang et al., 2015). Hence, assessing C stored in different pools under tropical land uses can advance scientific understanding of LUC and the terrestrial C cycle. In tropical forests, 67% of the ecosystem C (C in vegetation and in soil) resides in vegetation and 33% in soil (Ngo et al., 2013). However, the potentiality of such ecosystems to store C in vegetation and soil is influenced by the vegetative cover, climate, species, management practices, and human interventions (Dung, Tue, Nhuan, & Omori, 2016; Ngo et al., 2013). The LUC from primary to secondary forests decreases both vegetation and soil C stocks (Ngo et al., 2013; Ogle, Breidt, & Paustian, 2005) and degrades soil properties (Abera & Wolde-Meskel, 2013; Saha, Kukul, & Sharma, 2011). Loss of biodiversity due to LUC from forest to plantations or grasslands degrades natural vegetative structure and lowers the ground water table (Ahrends et al., 2015), which further affect the ecosystem's C dynamics (De Camargo et al., 1999). Effect of LUC on either vegetation or soil C stock has been studied widely for diverse ecosystems (Fan et al., 2016; Hombegowda, Van Straaten, Kohler, & Holscher, 2016; Murty, Kirschbaum, McMurtrie, & McGilvray,

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ANNUAL BURNING ENHANCES BIOMASS PRODUCTION AND NUTRIENT CYCLING IN DEGRADED *IMPERATA* GRASSLANDS

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ABSTRACT

The invasive species *Imperata cylindrica* is a dominant grass covering a large part of degraded lands of India. *Imperata* is managed through traditional annual burning, a practice that is prevalent throughout tropical grasslands. A field experiment was conducted to quantify the effects of burning on aboveground and belowground biomass production and soil organic carbon (SOC), total nitrogen (TN), available phosphorus (Ave P), potassium (K^+), calcium (Ca^+), and magnesium (Mg^+) concentrations in 0- to 15-cm soil depth under *Imperata* grassland. The burnt site had 44% and 14% higher aboveground and belowground biomass over the un-burnt control plots after 300 days of the fire event. The concentrations of SOC, TN, and Ave P increased soon after the fire but decreased regressively with time after the fire in both micro and macro soil aggregate size fractions. In contrast, concentrations of K^+, Ca^+, and Mg^+ increased up to 30 days after the fire in both soil aggregate fractions. Burning did not significantly alter the stoichiometric ratios (C : N, C : P, and N : P) in macro aggregates. However, burning significantly reduced the C : N, C : P, and N : P ratios in micro aggregates during the first 0–30 days. Fire increased nutrient stocks (kg ha^{-1}) by 20–35% in the burnt site in comparison to an un-burnt control site. It is concluded that the conventional practice of annual burning increases soil nutrients in surface soils and supports higher biomass production in *Imperata*-covered degraded lands. Copyright © 2017 John Wiley & Sons, Ltd.

KEY WORDS: fire events; charred material; soil aggregates; soil organic carbon; stoichiometric ratios

INTRODUCTION

Grasslands are one of the most widespread vegetation types worldwide, covering~15 million square kilometers in the tropics and an additional nine million square kilometers in temperate regions, together nearly covering one-fifth of the world's land surface (Scurlock & Hall, 1998; Lal, 2008). Large areas of grasslands are located in tropical regions, where they are the source of livelihood for over one billion people (White *et al*., 2000). This vast distribution and extent of grassland ecosystems impact some vital ecosystem processes and functions including carbon and nutrient cycles. Fire is widely used as a tool to suppress secondary succession and promote sustainable management of grassland ecosystems (Lal, 2008; Dickie & Parsons, 2012). The "fertilizing" effect of burning is known since the beginning of agriculture and forestry (Doerr & Cerde, 2005). Burning increases availability of nutrients in soils, mainly in the form of water-soluble components of ash that become available to plants (Lal & Cummings, 1979; Hedo *et al*., 2015; Wang *et al*., 2015) and therefore influence biomass production rates (Xu & Wan, 2008). Increased soil nutrient levels after fire (Allen *et al*., 1969; Anderson & Menges, 1997) result in higher aboveground net primary productivity in semi-arid grasslands in northern China (Xu & Wan, 2008). However, data from detailed studies incorporating impacts of annual burning on soil nutrient status and biomass production are still scanty for tropical grassland of India and especially for *Imperata* grasslands. The transformations by fire on soil humus include the accumulation of partially combusted charred material (Lal & Cummings, 1979; Lasanta & Cerda, 2005). However, the direction and magnitude of these changes are difficult to predict because of fire frequency, severity and intensity, season of occurrence, and the timing and duration of post-fire sampling (Ansley *et al*., 2006; Guenon *et al*., 2013). Much of the uncertainty regarding the role of fire in global biogeochemical cycles is a result of limited understanding of the consequences of fire at the ecosystem scale (Pereira *et al*., 2013, 2015, 2016). Thus, several reports have highlighted the need for more quantitative assessments of the role of fire in nutrient dynamics and biomass production in grasslands (Doerr & Cerda, 2005; Pathak *et al*., 2015; Lu *et al*., 2015; Lin *et al*., 2015; Poeplau *et al*., 2016; Shaw *et al*., 2016).

The invasive species *Imperata cylindrica* (hereafter referred to only as *Imperata*) is considered to be one of the top ten worst weeds in the world because of its alterations in fire regimes (GISD, 2017), and in India, *Imperata* grassland covers around eight million hectares (Garrity *et al*., 1997). The *Imperata* grasslands of India are fire-dependent ecosystems and have evolved on the degraded or abandoned cultivated lands in the tropical humid climate (Astapati &

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Imperata grasslands: carbon source or sink?

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***Imperata* grasslands, among the oldest forms of managed village land use, provide rural people with subsistence and monitory benefits. Yet, little is known about their role in global carbon (C) budget under the scenario of changing climate. The present study was carried out in managed *Imperata* grassland in Cachar district, Assam, North East India. The study was designed to understand whether *Imperata* grasslands are C source or sink, because they are managed through annual fire practice. We studied (i) organic carbon accumulation rate in the soil, (ii) C input from aboveground biomass (CIAB), (iii) C input from belowground biomass (CIBB) and (iv) Soil CO_2 efflux/soil respiration (R_s) on monthly intervals from October 2013 to September 2014 following standard methods. Later monthly data were merged into four distinct seasons, viz. autumn, winter, summer and rainy season to have a clear vision of seasonal influence on C source/sink status. The study showed highest (2.52 g C m^{-2} $month^{-1}$) soil organic carbon accumulation during summer season. Highest values for CIAB (14.31 g C m^{-2} $month^{-1}$), CIBB (30.98 g C m^{-2} $month^{-1}$) and R_s (31.85 g C m^{-2} $month^{-1}$) were observed during rainy, autumn and summer seasons respectively. C budget analysis with respect to seasons showed *Imperata* grasslands act as C source during winter and summer, whereas they serve as sink during autumn and rainy seasons. However, annual C budget (across all the months) showed *Imperata* grasslands as a net sink of 38.45 g C m^{-2} $year^{-1}$ (0.40 Mg C ha^{-1} $year^{-1}$). Further research is needed to develop better management systems to enhance sink capacity of *Imperata* grasslands.**

Keywords: Carbon budget, climate change mitigation, *Imperata* grasslands, soil organic carbon, soil respiration.

THE global soil organic carbon (SOC) storage is estimated at 1500 Pg (1 Pg = 10^{15} g), which is larger than the sum of the atmospheric (500 Pg) and biotic C pools (800 Pg)[1]. Therefore, SOC storage is an important global C sink[2]. The use of C sinks has been included in many national and international policy plans designed to mitigate greenhouse gas emissions, including the Kyoto Protocol[3]. From a global perspective, grasslands store approximately 34% of the global terrestrial stock of C, whereas forests store approximately 39% and agro-ecosystems approximately 17% (ref. 4). Recommended management practices minimize soil disturbance, while they optimize productivity and increase the SOC pool[5]. However, unscientific management systems alter SOC stock resulting in significant impacts on the atmospheric concentration of CO_2 (ref. 6). Therefore, management systems determine the fate of an ecosystem to act as a source/sink of CO_2.

The *Imperata* grasslands of the tropical region are a vast underutilized natural resource and occupy about 35 million ha in Asia; India is the second largest area holder of such grasslands[7]. Annual fire practice is a key tool for the management of *Imperata* grasslands[7,8]. The grassland is exploited for monetary benefits[9], other than its traditional uses in thatching material. Biomass burning represents a major mechanism by which C is transferred between the terrestrial and atmospheric C pools[10,11]. The 'fertilizing' effect of fire is known since the beginning of agriculture and forestry[12]. Low-impact burning can promote herbaceous flora, increase plant available nutrients and accumulation of organic C, all of which can favour healthy systems[13]. However, high intensity of fire can substantially alter C cycling in ecosystems[14,15] by exacerbating the rate of mineralization leading to a decrease in the SOC pool[2]. Therefore, understanding the role of fire practice in grassland C budget is an important issue of environmental research in the event of climate change. The specific objective of the present study is to describe the C source/sink status of traditionally managed *Imperata* grasslands of Barak Valley, Assam, India. Keeping in view the role of annual fire practice in grassland management, the hypothesis tested was whether *Imperata* grasslands are the source of carbon or not.

The study was conducted in managed *Imperata* grassland in Rosekandy area of Cachar district, Barak Valley, NE India (24°41′N and 92°40′E, ca. 50 m amsl). The present grassland was originally a degraded tea plantation area. The size of the grassland is 1.2 ha. For the last 20 years this grassland has been managed for selling thatching material. Topography of the study area is undulating, dominated by small hillocks and low-laying waterlogged areas. Soil of the study area is acidic (pH = 4.5.0–5.2), with mean bulk density of 1.12 g cm^{-3}, water holding capacity of 35% and soil texture being silty clay loam. Woody tree species like *Balakata baccata*, *Macaranga peltala* and bamboo species (*Melocanna baccifera*) dominate the adjacent forest areas. The climate of the area is subtropical warm and humid with average rainfall of 2226 mm and average maximum and minimum temperatures 30.5°C and 20.3°C respectively.

Imperata grasslands in Barak Valley represented by *Imperata cylindrica*, are micro-scale in size (0.25–1.5 ha), being managed traditionally at individual level. These grasslands are inevitable to the rural dwellers for thatching material in traditional houses and also for monetary benefits which make them an important rural land use. Annual harvesting and fire practice are the foremost

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