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TABLE OF CONTENTS

PLENARY AND KEYNOTES 3

PEATLANDS IN HARMONY 43

THEME 1 INVENTORY, BIODIVERSITY, CONSERVATION & FUNCTIONS OF PEATLANDS 116

1.1 Peat Characteristics 117

1.2 Geochemistry, Hydrochemistry & Hydrology of Peatland 141

1.3 Peatland Remote Sensing, Aerial & Satellite Imagery 172

1.4 Peatland Conservation & Management 201

1.5 Peatland Biodiversity 213

1.6 Conservation of Peatland Forest & Wildlife 233

THEME 2 PEATLANDS & ECOSYSTEM MANAGEMENT 253

2.1 Peatland Carbon Balance, Stocks, Storage & Losses 254

2.2 GHG Emission from Natural & Managed Peatlands 286

2.3 Peat Forest-Wildfire-Impacts on Environment & Society 321

THEME 3 PEATLANDS AFTER-USE, RESTORATION & REHABILITATION OF EX- PRODUCTION PEATLANDS 399

3.1 Restoration of Boreal, Temperate & Tropical Peatlands 400

3.2 Rewetting & Re-Vegetation Techniques 455

THEME 4 PEAT USE, PEATLANDS TECHNOLOGY & AGROTECHNOLOGY 472

4.1 Peat Use, Peatland Technology & Agro-Technology 473

TABLE OF CONTENTS

THEME 5 RESPONSIBLE UTILIZATION & MANAGEMENT OF PEATLANDS 491

5.1 Agriculture & Forest Plantations on Peatland 492

5.2 Peatland Forestry 521

5.3 Peatland Management: Legislations, Regulations & Policies 538

THEME 6 CULTURAL,EDUCATIONAL,MEDICINAL & SOCIO-ECONOMIC ASPECTS OF PEATLANDS, PEAT & SAPROPEL 551

6.1 Cultural & Socio-economic Aspects of Peatland 552

6.2 Peatland & Local People 576

THEME 7 SPECIAL SESSION 594

7.1 Soft Soil Engineering 595

7.2 Peat for Horticulture & Energy 635

7.3 Publically Managed Peatland Carbon Storage, Ecosystem Services, & Management 661

7.4 Tropical Peatland Biodiversity & Conservation In Southeast Asia 706

7.5 Peatland Restoration: The Way Forward 735

7.6 Asia Flux 739

PLENARY & KEYNOTE SESSIONS

Plenary

A-414 History of Tropical Peatland in Southeast Asia…………………………….. 4
Hisao Furukawa

Keynote

A-405 Biomass Recovery in Secondary Mixed Peat Swamp Forest, Coastal Riau, Indonesia………………………………………………………………. 9
J. Bathgate, M. Iqbal, Zulnaidi and S. Marpaung

A-034 Carbon Balance of Tropical Peat Swamp Forest……………………………. 13
Takashi Hirano

A-455 Communicating Peat Science to Society…………………………………… 16
Kalyana Sundram

A-371 Emissions of Methane and Nitrous Oxide from Peatlands…………………. 17
Ryusuke Hatano

A-456 Key Agro-Environmental Management of Tropical Peatland……………..... 20
Lulie Melling and Auldry Chaddy

A-457 Planting Oil Palm in Peat Land: My Experience, Challenges and Opportunities…………………………………………………………... 25
Abdul Hamed Sepawi

A-060 Shifting Paradigms in Southeast Asian Peatland Management…………....... 26
Marcel Silvius

A-059 Sustainable Nutrient Management of Fen Grassland on Peat Soil………...... 28
J.Pickert, A. Behrendt and S. D. Bellingrath-Kimura

A-125 The Ring of Fire: Tackling Indonesia's Peatland Fire Dynamic…………..... 33
Susan Page, Aljosja Hooijer, Ronald Vernimmen, Jukka Miettinen, David Gaveau, Morten Rossé and Thomas E.L. Smith

A-454 What is the way forward on Indonesian Peatlands?………………………… 39
Supiandi Sabiham, Winarna, Heru Bagus Pulunggono, Dian Novarina and Bandung Sahari

PEATLANDS IN HARMONY

A-062 Best Management Practices for Sustainable Development of Oil Palm Planting on Peat: TH Plantations Berhad's Experience……………………… 46
Zainal Azwar Zainal Aminuddin, Radin Rosli Radin Suhardi, Abd Rashid Sahibjan, Muhammad Pilus Zambri and Khairul Ismadi Ismail

A-085 China: The Next Huge Peat and Growing Media Market in the World……… 51
Meng Xianmin

A-266 Degraded Peatlands in Sumatra, Indonesia: How Land Rights Influence the Abandonment and Burning of Land…………………………………………. 55
Kosuke Mizuno

A-416 Developing Sustainable Practices to Mitigate Impacts of Climate Change on Natural and Managed Tropical Peatlands……………………………………. 56
Shailendra Mishra, Yung Pui Yi, Umashankar Shivshankar, Daniela Moses, Aswandi Idris, Stephan Schuster and Sanjay Swarup

A-288 Eddy Covariance Measurement of Methane Flux above a Primary Tropical Peat Swamp Forest in Sarawak, Malaysia……………………………………. 61
Wong Guan Xhuan, Ryuichi Hirata,Takashi Hirano, Edward B. Aeries, Kevin K. Musin, Joseph W. Waili,Frankie Kiew and Lulie Melling

A-270 Forestry Use of Boreal Peatlands - Challenges and Possibilities…………….. 66
Harri Vasander, Meeri Pearson and Raija Laiho

A-301 Haze Control and the Oil Palm Farmer – A Review of Policy Options……… 70
Khor Yu Leng, Johan Saravanamuttu and Deborah Augustin

A-467 Impact of Mineral Nutrition Management on Ganoderma Incidence in Oil Palm Planted on Peat Soil…………………………………………………… 75
Pujianto, Achmad WS, Datian. P, Syaiful, Suhardi, Putri. AW and JP Caliman

A-391 Let China Open the New Life Activity of the Peat Industry………………. 79
Xiancheng Zeng

A-054 Long Term Perspectives for Water Management in Drained Peatlands; Experiences in Peat-Polder System in the Netherlands……………………… 83
J. M. Schouwenaars

A-287 Managing Peatland - Regulating Controlled Open Burning in Sarawak…….. 88
Peter Sawal and Tsai Koh Fen

A-322 Microbial Biodiversity and Ecosystem Functioning in Malaysian Peatswamp Forests……………………………………………………………………….. 93
Catherine M. Yule, Steven Y.K Aw, Wilhelm W.H. Eng, Han Ming Gan, Sui Mae Lee, Cheryl Ong, Kuan Shion Ong, Chin Chin Too and Alex Keller

PEATLANDS IN HARMONY

A-144 Peatland Restoration in Russia for Fire Prevention and Climate Change Mitigation: The Experience of a Large Scale Rewetting Project…………….. 94
Andrey Sirin, Gennady Suvorov, Aleksandr Maslov, Maria Medvedeva, Anastasiya Markina, Dmitry Makarov, Anna Vozbrannaya, Natalya Valyaeva, Olga Tsyganova, Tamara Glukhova, Tatiana Minayeva, Marcel Silvius, Jozef Bednar, Arina Schrier, Hans Joosten, John Couwenberg, Inga Gummert and Jan Peters

A-256 Peatland Utilization with Secure and Sustainable Management: Case Study in Oil Palm and Timber Forest Plantations in Sumatra………………………. 95
Supiandi Sabiham, Winarna, Heru Bagus Pulunggono, Dian Novarina and Bandung Sahari

A-466 Plantations: Friend or Foe? …………………………………………………... N/A
Henry Lau Lee Kong

A-373 Root Respiration Drives Patterns of Total Soil CO_2 from Cultivated Tropical Peatlands……………………………………………………………………… 97
F.C. Manning, L.K. Kho, T. Hill, Mohd. Haniff Harun, Zulkifli Hashim and Y.A.Teh

A-365 Sarawak's Approach to Sustainable Development………………….............. 101
Sudarsono Osman

A-334 The Co-Firing Experience: The Use of Peat and Biomass for Electricity Generation in Ireland…... 102
Charles Shier

A-187 Towards Attaining High Yields and Long Term Sustainability of Second Generation Oil Palm Replants on Peat in North Sumatera, Indonesia – The Asian Agri Experience………………………………………………………. 107
Manjit Sidhu, Mukesh Sharma, Abdul Aziz, Arusman Limbong, Simon Sihotang and Bukit Sanjaya

A-388 Vulnerability of CO_2 Exchange in Tropical Peat Ecosystems: A Case Study from Sarawak, Malaysian Borneo……………………............................... 111
Angela C. I. Tang, Paul C. Stoy, Kevin K. Musin, Edward B. Aeries, Joseph Wenceslaus, Ryuichi Hirata and Lulie Melling

1.1: PEAT CHARACTERISTICS

A-072 Britain's Highest Bog: Can We Unlock Its Secrets? 118
Olivia M. Bragg, Philip J. Basford, Andrew R. Black, Graeme M. Bragg, Jane K. Hart and Kirk Martinez

A-246 Development of Analysis Methodology of Technical Indicators of Peat and Relationship between these Indicators, Peat Properties and Fields of Use….. 123
Mall Orru, Ingo Valgma, Vivika Väizene and Fred Rusanov

A-044 Effects of Carbon Substrate Lability on Tropical Peat Mineralization under Aerobic and Anaerobic Conditions……………………………………………….. 127
Jyrki Jauhiainen, Hanna Silvennoinen, Mari Könönen, Suwido Limin and Harri Vasander

A-223 Heterogeneity in Peat Decomposition Evaluated by Fourier Transform Infrared Micro-Spectroscopy …………….…………………………………….. 132
Mizuki Morishita and Masayuki Kawahigashi

A-109 Vulnerability of Soil Organic Matter in Anthropogenically Disturbed Organic Soils………………………………………………………………… 136
Annelie Säurich, Bärbel Tiemeyer, Michel Bechtold, Axel Don and Annette Freibauer

1.2: GEOCHEMISTRY, HYDROCHEMISTRY & HYDROLOGY

A-181 Changes of Water Chemistry (Dissolved Organic Carbon) with Frequent Peat Fires in Indonesian Peatland…………………………………………… 143
Masayuki Itoh, Hiroshi Nishimura, Satomi Shiodera, Takashi Hirano, Osamu Kozan and Haris Gunawan

A-074 Coastal Peat Mass Movement and its Effect on the Terrestrial Carbon Discharge to the Ocean in Bengkalis Island, Indonesia…………………….. 147
Koichi Yamamoto, Muhammad Haidar, Ariyo Kanno, Motoyuki Suzuki, Yoshihisa Akamatsu, Noerdin Bashir, Sigit Sutikno, Mu Hardi and Syawal Satibi

A-358 Dissolved Greenhouse Gases in Peat-Draining Rivers in Sarawak, Malaysia 151
M. Müller, D. Müller, T. Warneke, T. Rixen, J. Notholt, N. Denis, E. Sia and A. Mujahid

A-029 Effects of Water Table Fluctuations on Dissolved Organic Carbon Concentrations in an Oil Palm Plantation In Tropical Peatlands…………… 152
Wendy Lim, Adesiji Richard Adeolu, Fitriah Azizan, Alexander Kiew Sayok, Thamer Ahmed Mohammad, Nik Norsyahariati Nik Daud, Rory Padfield, Stephanie Evers and Zuriati Zakaria

A-084 Landscape Heterogeneity of Dissolved Organic Carbon (DOC) Concentrations within Tropical Peat Landscapes and Links to Heavy Metal Mobilisation………………………………………………………………. 153
Stephanie Evers, Paul Williams, Rory Padfield and Alexander Kiew Sayok

A-094 Methane Fluxes from a Tropical Peatland in Brunei Darussalam………….. 154
A. Hoyt, S. Pangala, L. Gandois, A. Cobb, F. M. Kai, X. Xu, V. Gauci, Y. Mahmud, A. S. Kamariah, J. A. Eri and C. F. Harvey

A-193 Once the Trees Have Gone: Evaluating Changes in Water Quality in Restored Blanket Bog of the Flow Country, Scotland……………………… 159
Roxane Andersen, Richard Taylor, Paul Gaffney, Neil Cowie and Alan Youngson

A-289 Profiling Water Table Depth and Soil Moisture in a Drained Peat Swamp Hosting Oil Palm…………………………………………………………. 164
Susan Waldron, Stephanie Evers, Ralph Burton and Rory Padfield

A-081 The Impact of Land Cover Change on the Hydraulic Conductivity in Tropical Peatlands……………………………………………………….. 165
Sofyan Kurnianto , James Peterson, John Selker, Boone Kauffman and Daniel Murdiyarso

A-192 Using Lake Sediments in Estimating Possible Environmental Impacts of Peat Production: Case Studies from Finland………………………………. 169
Tuija Vähäkuopus, Tommi Kauppila, Jari E. Mäkinen, Antti E. K. Ojala and Samu E. Valpola

1.3: PEATLAND REMOTE SENSING, AERIAL & SATELLITE IMAGERY

A-021 Biomass Situation of Mawas Region in Central Kalimantan between 2007 and 2015 Using LiDAR- and TerraSAR-X Data………………………….. 173
Viktor Boehm, Michael Schlund, Veraldo Liesenberg and Steffen Kuntz

A-177 Combination of PALSAR-2 and SPOT-6 Images for Estimating Aboveground Biomass of Peat Swamp Ecosystem in Malaysia…………... 179
Hamdan Omar, Norsheilla Johan Chuah, Ismail Parlan, Abd Rahman Kassim and Samsudin Musa

A-140 Locating and Delineating Peatlands and Other Organic Soils in the Tropics………………………………………………………………….. 185
Alexandra Barthelmes, Uwe Ballhorn and John Couwenberg

A-197 Remote Sensing as a Tool for Mapping and Evaluating Peatlands and Peatland Carbon Stock in Northern Finland……………………………….. 191
Janne Kivilompolo, Eija Hyvönen, Maarit Middleton, Jukka Turunen, Samu E. Valpola and Tuija Vähäkuopus

A-204 Utilization of Discrete-Return Airborne LiDAR for Identification of Small Canals in the Closed-Canopy of Peat Swamp Forest in Central Kalimantan Indonesia…………………………………………………… 196
Solichin Manuri, Baba Barkah, Hans-Erik Andersen, Bruce Doran and Cris Brack

1.4: PEATLAND CONSERVATION & MANAGEMENT

A-269 History and Future of Scientific Research on Ozegahara Mire, Central Japan 202
Toshio Iwakuma, Kazuyuki Inubushi and Mitsuru Sakamoto

A-404 Observations on Biomass and Biogeochemistry of Rain-Fed Peat Dome Pole Forest, Riau, Sumatra ………………………………………………….. 203
J. Bathgate, D. Probosaputro and M. Iqbal

A-027 Restoring Pig Damaged Peat Ecosystems in the Walpole Wilderness Western Australia………………………………………….……………… 207
Karlene Bain, Elizabeth J. Edmonds and David M. Edmonds

A-284 The Spruce and Peatlands Responses Under Climatic and Environmental Change (SPRUCE) Experiment……………………………………………... 212
R.K. Kolka and P.J. Hanson

1.5: PEATLAND BIODIVERSITY

A-101 N_2O Emitters from Different Habitats, Boreal Peats and Tropical Peats and Comparison of their Physiological Traits…………………………….. 214
Yasuyuki Hashidoko, Yanxia Nie and Sharon Y. L. Lau

A-448 Comparison of Macrofungal Diversity between Peat Swamp Forest and Oil Palm Smallholding in Peninsular Malaysia……………………………. 219
Shuhada Rajihan, Sabiha Salim, Frisco Nobilly and Badrul Azhar

A-422 Exploring Novel Microbial Lignocellulosic Enzymes from Indonesia Peatland and Herbivores for Conversion of Oil Palm Empty Fruit Bunch to Biofuel……………………………………………………………….. 224
Amadeus Pribowo, Irnayuli Sitepu, Ezra Wijaya, Victor De Vries and Kyria Boundy-Mills

A-374 Impact of Fire on Microbial Diversity and Community Structure in Malaysian Peatlands……………………………………………………….. 229
Catherine M. Yule, Stephanie Evers, Thomas Smith, Han Ming Gan, Chin Chin Too and Wilhelm W. H. Eng

A-330 Species Composition and Environmental Factors of Grasslands Developing on the Burnt Peatlands in Sumatra, Indonesia……………….. 230
Satomi Shiodera, Kazuo Yabe, Masayuki Ito, Osamu Kozan, Tika Dewi Atikah and Joeni S. Rahajoe

1.6: CONSERVATION OF PEATLAND FOREST & WILDLIFE

A-341 Conservation in the Production Areas: An Opportunity to Conserve Wild Cat Species in Kampar Peninsular, Riau Province, Indonesia…………… 234
Donny Gunaryadi, Petrus Gunarso, Ryan Avriandy, Irene Margareth Romaria Pinondang, Andi Arya Fajar Art Christ, Safrina Ayu Trisnawati, Nugraha Putra Maulana, Husnul Fikri, Ahmad Dani and Muhammad Iqbal

A-394 Orangutan Conservation in Sarawak, Malaysia………………………….. 238
Oswald Braken Tisen and Sundai Silang

A-051 The Terrestrial Fauna Composition of the Peat Swamp Forest of Ulu Sebuyau National Park, Sarawak, Malaysia…………………………….... 243
Sundai Silang, Oswald Braken Tisen, Wong Ting Chung and Kalyana Sundram

A-171 Wetlands as Keystone Ecosystems: Conservation Cornerstones in Dynamically-Changing Landscapes…………………………………….... 248
David Alexander Locky

2.1: PEATLAND CARBON BALANCE, STOCKS, STORAGE & LOSSES

A-328 Calculation of Carbon Balance in *Acacia crassicarpa* Plantation on Tropical Peatland in Indonesia…………………………………………… 255
Muhajir Utomo, Basuki Sumawinata, Suwardi, Darmawan, Gunawan Djajakirana and Dian Novarina

A-136 Carbon Cycle in Sago Palm Cultivation System in Tropical Peatland…... 256
Akira Watanabe, Shuhei Makabe, Ho Ando, Ken-ichi Kakuda, Sudid Donny, Zulhilmy Abdullah Mohd and Lulie Melling

A-053 Carbon Stocks and Emissions from Degradation and Conversion of Tropical Peat Swamp Forests in West Kalimantan, Indonesia…………... 260
Imam Basuki, J. B. Kauffman, Daniel Murdiyarso and Gusti Anshari

A-315 Contribution from Root Respiration and Litter Decomposition to Carbon Flux in Tropical Peatland……………………………………………… 264
Marissa Permatasari Jayaputra, Darmawan, Basuki Sumawinata and Gunawan Djajakirana

A-049 Effect of Drainage on the Carbon Loss from Soil Ecosystems in Tropical Peatlands of Central Kalimantan………………………………………. 269
Siti Sundari, Takashi Hirano and Hiroyuki Yamada

A-222 Exact Measurement of Photosynthetic Carbon Accumulation Rate in *Sphagnum Community*………………………………………………… 274
Akira Haraguchi

A-071 Fluvial Organic Carbon Losses from Oil Palm Plantations on Tropical Peat, Sarawak, Southeast Asia………………………………………… 275
Sarah Cook, Susan E. Page, Mick Whelan, Chris D. Evans, Vincent Gauci and Kho Lip Khoon

A-379 Mapping the Depth and Carbon Stock for Peatland in Meranti, Riau Indonesia……………………………………………………………. 279
Dian Novarina, Rudiyanto, Budi Indra Setiawan and Muhajir Utomo

A-019 Sensitivity of High Altitude Peatlands to Changes and their Sustainable Management in the Hindu-Kush Himalayan Region…………………….. 280
Wu Ning

A-207 The Effect of Land Uses on Selected Peat Properties that Control Carbon Storage in a Massively Drained Tropical Peat Dome……………………. 281
Gusti Z. Anshari, Evi Gusmayanti and M. Afifudin

2.2: GHG EMISSION FROM NATURAL & MANAGED PEATLANDS

A-178 Challenges and Opportunities for Eddy-Flux Measurements of CO$_2$ Emissions of Oil Palm on Peat……………………………………………….. 287
M. Y. Leclerc, G. Zhang, H. Nahrawi, J. Nur Maisarah, H. Mos, M. Law, M.H. Haniff, K. Norman, Y.M. Choo

A-194 Characterizing Peat Palm Forest Degradation in the Peruvian Amazon from Space and on the Ground………………….……………………….… 288
K. Hergoualc'h , V.H. Gutierrez-Velez , J. van Lent and L.V. Verchot

A-276 Comparison of the Carbon Dioxides Fluxes from Peat Soil between Temperate and Tropical Region under Intensive Agriculture Production… 289
Ahmad Suhaizi Mat Su, Ahmad Husni Mohd. Hanif and Viacheslav I. Adamchuk

A-105 Effects of Forest Type on Decomposition Rate and Greenhouse Gas Fluxes of Tropical Peat Soil after Conversion into an Oil Palm Plantation.. 292
Faustina E. Sangok, Nagamitsu Maie, Lulie Melling and Akira Watanabe

A-102 Estimating CO^2 Flux from Bare Land in a Peat Island Using an Artificial Neural Network Model ……………………..……………………….………….. 296
Yudi Chadirin, Satyanto K. Saptomo, Rudiyanto, Budi I. Setiawan, Kazutoshi Osawa,Dian Novarina and Muhajir Utomo

A-118 Greenhouse Gas (GHG) Balance of Biomass Grown for Biogas Production on Rewetted Agricultural Fen Peatland……………………….. 300
Poul Erik Lærke, Tanka P. Kandel, Sandhya Karki and Lars Elsgaard

A-273 Greenhouse Gas Emissions Factors for Drained and Rewetted Boreal, Temperate and Tropical Peatlands…………………….…………………… 301
J. O. Rieley, D. Wilson, D. Blain, J. Couwenberg, C. D. Evans, D. Murdiyarso, S. E. Page, F. Renou-Wilson, A. Sirin, M. Strack and E-S Tuittila

A-123 Root Exudates and Carbon Emissions from Tropical Peatlands…………... 307
Nick Girkin, Nick Ostle, Benjamin L. Turner and Sofie Sjogersten

A-046 Spatial Distribution of GHG Sinks and Sources in Forestry-Drained Boreal Peatlands…………………………………………….…………….... 312
Mari Parkkari, Miia Parviainen, Paavo Ojanen and Anne Tolvanen

A-372 Surface-Atmosphere Exchange in Tropical Peat Forests Versus other Tropical Forests: A FLUXNET Synthesis…………………….…………… 317
Paul C. Stoy, Tobias Gerken, Rong Yu, Benjamin Ruddell and FLUXNET contributors

2.3: PEAT FOREST-WILDFIRE-IMPACT ON ENVIRONMENT & SOCIETY

A-421 2015 Severe Peat Fires and Air Pollution Near the Former Mega Rice Project Area in Central Kalimantan, Indonesia…….……………….………….. 323
Hiroshi Hayasaka and Alpon Sepriando

A-278 Degraded Peatlands, Ground Water Level and Severe Peat Fire Occurrences………………………………………………………………… 327
Erianto Indra Putra, Mark A. Cochrane, Yenni Vetrita, Laura Graham and Bambang Hero Saharjo

A-259 Detailed Analyses of Emissions from Peat Combustion Across Biomes….. 332
Adam C. Watts, Hans Moosmüller, Vera Samburova, Andrey Y. Khlystov, Madhu Gyawali, Deep Sengupta, Chiranjivi Bhattarai, Reddy L. N. Yatavelli, Rajan K. Chakrabarty, Ian J. Arnold, Barbara Zielinska, Joe D. Knue, Judith Chow, John G. Watson, Xiaoliang Wang, L.-W. Anthony Chen, Anna Tsibart and Guenter Engling

A-114 Detection and Characterization of Low Temperature Peat Fires During the 2015 Fire Catastrophe in Indonesia Using a New High-Sensitivity Fire Monitoring Satellite Sensor (Firebird)…………………………………….. 337
Elizabeth C. Atwood, Sandra Englhart, Eckehard Lorenz, Werner Wiedemann and Florian Siegert

A-361 Drivers of Recurrent Peat Fire in Riau and South Sumatera, Indonesia…. 342
Oka Karyanto, Ismail, Ari Susanti, Satyawan Pudyatmoko and Trias Aditya

A-427 Fire Prevention through Community Engagement - The Fire Free Village Program……………………………………………………………...... 348
Craig Tribolet and Sailal Arimi

A-112 Fire-Climate Ecosystem Interactions Related to Carbon Accumulation Rates of Peatlands in Jambi, Sumatra (Indonesia) During the Past 12, 000 Years……………………………………………………………………. 352
Siria Biagioni, Kartika Hapsari, Valentyna Krashevska, Marife D. Corre, Peter M. Reimer, Yudhi Achnopha, Asmadi Saad, Tim C. Jennerjahn, Supiandi Sabiham, Edzo Veldkamp and Hermann Behling

A-132 First *In* Situ Measurements of Tropical Peatland Fire Emissions: New Emission Factors for Greenhouse Gas Reporting and Haze Forecasting….. 353
Thomas E. L. Smith, Catherine M. Yule, Stephanie Evers, Clare Paton-Walsh, and Jing Ye Gan

A-031 Flaming Peat: Synergistic Effects of Fire and Forest Clearance on Tropical Peat Swamp Forests…….……….……….……….……….………………. 355
Lydia E.S. Cole, Shonil A. Bhagwat and Katherine J. Willis

A-317 Is Peatland Utilization the Main Cause of Land Fire in Indonesia? ………. 361
Moch. Reza Kasfari, Yudha Asmara Adhi, Basuki Sumawinata and

2.3: PEAT FOREST-WILDFIRE-IMPACT ON ENVIRONMENT & SOCIETY

Bandung Sahari

A-057 Haze And Peatlands: the Top Three Challenges of Tackling Smouldering Megafires………………………………………………………………… 365
Guillermo Rein

A-170 Mutual Interdependence between Rewetting, Afforestation and Fire Protection in Tropical Peatlands……………………………………………… 366
Hidenori Takahashi, Bambang Setiadi and Mitsuru Osaki

A-180 National Responses in the Context of ASEAN Developments over Peat Fires and Haze…………………………………………………………… 370
Helena Muhammad Varkkey

A-357 Peat Fire Economy and Actor Network in Sumatra: An Analytical Approach…………………………………………………………………… 375
Herry Purnomo, Bayuni Shantiko and Harris Gunawan

A-351 Peat Fire Susceptibility in Sarawak, Malaysia in the Context of Climate Change………………………………………………………………………… 380
Zulfaqar Sa'adi and Shamsuddin Shahid

A-138 Peatland Fires In Riau, Sumatra: Stakeholders' Perceptions of a "Wicked Problem"……………………………………………………………………. 383
Rachel Carmenta, Aiora Zabala and Jacob Phelps

A-119 Quantification and Characterization of Peat Fires and Related Fire-Emission Factors from Tropical Peatlands……………………………… 384
Grahame Applegate, Bambang H. Saharjo, Bob Yokelson, Kevin Ryan, Andrew P.Vayda, Tim Jessup, Sulistyo, Erianto Indra Putra, Laura Graham and Mark Cochrane

A-239 Recurrent Burnt Peat: Potential Positive Feedback for Peat Fires………… 390
Ahmad Ainuddin Nuruddin, Dayang Nur Sakinah Musa and Luqman Chua

A-147 Sources of Anthropogenic Fire Ignitions on the Peat Swamp Landscape in Kalimantan, Indonesia…………………………………………………... 393
Megan E. Cattau, Mark E. Harrison, Iwan Shinyo, Sady Tungau, María Uriarte and Ruth DeFries

3.1: RESTORATION OF BOREAL, TEMPERATE & TROPICAL PEATLANDS

A-168 A Partnership between Two Protected Peatlands: Great Dismal Swamp National Wildlife Refuge, Virginia, USA and Sebangau National Park, Central Kalimantan, Indonesia……………………………………………… 402
Chris Lowie, Frederic C. Wurster, Sean Lawlor, Jason Riley, Adib Gunawan and Noviyanti Nugraheni

A-451 The IUCN-UK Peatland Programme and the Yorkshire Peat Partnership. 407
Rob Stoneman

A-121 Designing Targeted Interdisciplinary Restoration Action Plans for Asia's Degraded Tropical Peat Swamp Forests………………………………… 410
Laura L. B. Graham, Jenny Pickerill and Susan E. Page

A-417 Does Hydrological Restoration Affect Greenhouse Gases Emission and Plant Dynamics in *Sphagnum* Peatlands?……………………………… 416
Laggoun-Défarge, S. Gogo, L. Bernard-Jannin, C.Guimbaud, R. Zocatelli, J. Rousseau, S. Binet, B. D'Angelo, F. Leroy, N. Jozja, F. Le Moing and C. Défarge

A-067 Enhancing Reforestation in Degraded Tropical Peatlands in Central Kalimantan……………………………………………………………….. 420
Maija Lampela, Jyrki Jauhiainen and Harri Vasander

A-066 Greenhouse Gas Flux Heterogeneity Across a Temperate Lowland Fen under Restoration Management……………………………………… 423
Emma Brown, Andrew Smith, David L. Jones and Chris Evans

A-092 Modelling the Impact of Marginal Cutting on Raised Bog Topography and Conservation……………………………………………………….. 428
Alister Best and Raymond Flynn

A-291 Monitoring the Effects of Peatland Restoration in Indonesia Using Insar Time Series Analysis………………………………………………… 433
Zhiwei Zhou, Zhenhong Li, Susan Waldron and Akiko Tanaka

A-386 Peatlands After-Use in the Polish Carpathian Mountains - Geomorphological and Hydrographic Symptoms of their Restoration….. 434
Adam Lajczak

A-137 Peatlands on Permafrost: Options for Management and Restoration from Arctic to Steppe ……………………………………………………… 438
T. Minayeva, A. Sirin, G. Suvorov, O. Cherednichenko, Ch. Dugardjav, D. Bayasgalan, G. Malkovaand R. Bolshakov

3.1: RESTORATION OF BOREAL, TEMPERATE & TROPICAL PEATLANDS

A-376 Response to Fire of Plant Communities in a Restored Ombrotrophic Peatland…………………………………………………………………….. 439
Ariane Blier-Langdeau and Line Rochefort

A-268 Restoration of High Altitude Peatlands in Ruoergai Plateau, China…….. 444
Faizal Parish, K. L. Chen and X. Zhang

A-325 Restoration of Peatland Ecosystems and Biodiversity in U Minh Region of Mekong Delta, Vietnam……………………………………………………… 445
Le Phat Quoi, Nguyen Tan Truyen and Tran Van Thang

A-398 Shade Cloth Trials in South-Eastern Australia as a Method of Restoring Peatlands Damaged by Fire……………………………………………….. 451
Geoffrey Hope, Roger Good, Jennie Whinam and Genevieve Wright

A-447 The Role of Institutions to Prevent Forest Fire and Manage Peatlands in Indonesia…………………………………………………………………….. 454
Parlindungan Purba

3.2: REWETTING & RE-VEGETATION TECHNIQUES

A-148 Identifying the Available Revitalisation Potential of Drained Bogs ……… 456
Karin Keßler, Andreas Wahren and Ingo Dittrich

A-228 Nutrients in Drained and Re-Wetted Peatlands in NE Poland….…………… 460
Barbara Kalisz and Andrzej Łachacz

A-164 Sphagnum Farming in Germany: How to Maximize Peatmoss Yields…………….……….……….……….……….……….………... 461
Greta Gaudig, Matthias Krebs and Susanne Abel

A-255 Reintroduction of Fen Plant Communities on Minerotrophic Remnant Surfaces After Peat Extraction….……….……….……….…………………. 462
Marie-Claire LeBlanc, Line Rochefort and Sandrine Hugron

A-065 Rewetting of Degraded Tropical Peatland by Canal Blocking Technique in Sebangau National Park, Central Kalimantan, Indonesia…………………. 467
Rosenda Chandra Kasih, Okta Simon, Ma'mun Ansori, Muhammad Porkab Pratama and Fenky Wirada

4.1: PEAT USE, PEATLANDS TECHNOLOGY & AGRO-TECHNOLOGY

A-354 Characterization and Classification of Peat Soils in Malaysia…………….. 474
As'ari bin Hassan, Ngab Dollah Salam, Roslan bin Mahali, Frederick Haili Teck, Elizabeth Malangkig and Noranizam Mohd Sahil

A-331 Consolidation of Information – A Myth for Peatland Database System?..... 476
Frederick Haili Teck, Ngab Dollah Salam, Thomas Chai Ching Siong, Richard Kho Shu Yuan, Sim Hui Chin and Alexander Chu Kah Choi

A-163 Initiating A Global Database for Peatland Deposits………………………… 480
Vera Luthardt, Hans Joosten, Corinna Schulz and Jorinna Prinz

A-082 Mapping the Depth of Peatlands Using Neural Networks Spatial Models…………………………………………………………………... 485
Rudiyanto, Budi Indra Setiawan, Chusnul Arif, Satyanto Krido Saptomo, Yudi Chadirin and Budiman Minas

A-329 Utilizing Remote Sensing Technology for Land Cover Mapping in Peat Land Area………………………………………………………………… 486
Frederick Haili Teck, Ngap Dollah Salam, Richard Kho Shu Yuan, Lim Chun Wee, Sim Hui Chin and Alexander Chu Kah Choi

5.1: AGRICULTURE & FOREST PLANTATIONS ON PEATLAND

A-115 Changes in the Physicochemical Properties of Tropical Peat during Its Early Decomposition under Oil Palm Plantations Environments…………. 493
Masahiro Maeda, Nagamitsu Maie, Lulie Melling, Hajime Tanji, Zulhilmy Abdullah Mohd and Akira Watanabe

A-104 Effective Water Management for Oil Palm in Peatland: For Peat Conservation and Yield Optimization….………….……….….……….. 497
Eko Naviandi Ginting, Nuzul Hidjri Darlan and Winarna

A-316 Ground Water Level, Rainfall and Subsidence: Key Factors Analysis Affecting Peatland Management System for Oil Palm Plantations in Indonesia….………………………………………………………………... 502
Rovy Roland, Hardy Mulia, Faisal Firmansyah and Bandung Sahari

A-415 Increased CO_2 Emissions Due to Rewetting of Degraded Tropical Peatlands under Oil Palm Plantations…….………………….…………….. 503
Shailendra Mishra, Romy Chakraborty, Jyrki Jauhiainen, Hanna Silvennoinen, Umashankar Shivshankar, Peter I Benke, Aswandi Idris and Sanjay Swarup

A-201 Introducing a Revised Approach to Peatland Development on a Large Scale Multi-Stakeholder Landscape, Riau Province, Sumatra, Indonesia… 508
Anthony Greer, Yogi Suardiwerianto, Nardi, John Bathgate and Muhammed Fikky Hidayat

A-408 Sustainable Oil Palm Planting on Peat Soils in Sarawak………………….. 511
Galau Melayong and Sylvester Fong

A-355 The Effect of Nitrogen Fertiliser on Nitrous Oxide Emission in Oil Palm Plantation………………………………………………………………………. 515
Norliyana Zin Zawawi, Yit Arn Teh, Kho Lip Khoon, Timothy Hill, Zulkifli Hashim and Mohd Haniff Harun

A-210 The Effect Of Nitrogen Fertilization on Soil N_2O Emissions from Oil Palm Cultivation on Deep Peat….……………….………….………………. 519
Satria Oktarita, Kristell Hergoualc'h and Louis V.Verchot

A-368 Water Management Approaches in Peatlands Based on Comprehensive Field Surveys and Analysis in West Kalimantan….…………………………. 520
Asep Andi Yusup, Tsuyoshi Kato, Bong Suhandi, Nana Suparna and Michael Allen Brady

5.2: PEATLAND FORESTRY

A-185 Ash Fertilization in Old Drained Swedish Peatland Forests………….. 522
Tord Magnusson and Björn Hånell

A-215 Development of Finnish Peatland Area and Carbon Storage 1950-2015: Review and Update….…………….……….……….……….…… 528
Jukka Turunen and Samu Valpola

A-412 Peatland Simulator Connecting Drainage, Nutrient Cycling, Forest Growth, Economy and GHG Efflux in Boreal and Tropical Peatlands.. 529
Ari Laurén, Hannu Hökkä, Samuli Launiainen, Marjo Palviaine, Aleksi Lehtonen and Anssi Ahtikoski

A-279 Sufficiency of Potassium (K) for Wood Production – Long-Term Effects of Forest Management on the K-Balance of Drained Boreal Peatlands……………………………………………………………….. 533
Sakari Sarkkola, Raija Laiho, Liisa Ukonmaanaho, Tiina Nieminen, Ari Laurén, Leena Finér, Timo Penttilä and Mika Nieminen

5.3: PEATLAND MANAGEMENT: LEGISLATIONS, REGULATIONS & POLICY

A-083 Challenges for Southeast Asian Tropical Peat Swamps: A Review of Existing Management and Policy………………………………………… 539
Stephanie Evers, Catherine Yule, Rory Padfield, Patrick O'Reilly and Helena Varkkey

A-389 Driving Sustainability Objectives on National Level…………………….. 540
Rosediana Suharto

A-240 Implementation of Integrated Management Plan for North Selangor Peat Swamp Forest 2014-2023 (IMP-NSPSF 2014-2023) ……………………… 542
Mohd Puat Dahalan, Mohd Basri Abdul Manaf, Badrol Hisam Abdul Rahman, Syed 6.1 Mohd Adzha Syed Khalid, Azuan Mohd Sukri, Mangsor Mohd Yusoff, Yusoff Muda, Hamdan Napiah, Azid Adam, Faizal,Parish Nagarajan Rengasamy, S.Y. Lew, and Julia Lo

A-360 Not Wastelands, Let's Manage Our Peat Swamps Properly through a Systematic Conservation Planning Approach…………………………….... 546
Jason Hon, Jayasilan Mohd Azlan, Stephanie Alau Apui and Belinda Lip

6.1: CULTURAL & SOCIO-ECONOMIC ASPECTS OF PEATLAND

A-156 Anthropogenic Disturbances and Resilience: A Message from the Past……. 553
Kartika A. Hapsari, Siria Biagioni, Tim Jennerjahn, Peter Reimer, Asmadi Saad, Supiandi Sabiham and Hermann Behling

A-292 Economic Values of Peat Forest to Local Communities in Mukah, Sarawak 558
Sulaiman Hj Husaini, Ahmad Shuib, Sridar Ramachandran, Syamsul Herman Mohd Afandi, Shazali Johari and Mohamad Ibrani Shahrimin Bin Adam Assim

A-294 Eco-Tourism Potentials of Peat Soil Forest in Mukah, Sarawak……………. 563
Sridar Ramachandran, Ahmad Shuib, Sulaiman Hj Husaini, Shazali Johari and Syamsul Herman Mohd Afandi

A-350 Rehabilitation of Degraded Peat Swamp Ecosystem Services and Construction of an Implementation System on REDD+ Safeguard…………. 567
Shigeo Kobayashi

A-311 Socio-Cultural-Economic Impacts of Peat Soil Ecosystem in Mukah, Sarawak…….……….…………….………….………….……….……….……….. 572
Shazali Johari, Mohd Ibrani Shahriman, Sulaiman Hj Husaini, Ahmad Shuib Sridar Ramachandran, Puvaneswaran Kunasekaran and Poh Yee Thoo

6.2: PEATLAND & LOCAL PEOPLE

A-096 Local Peoples' Appreciation on and Contribution to Conservation of Peatland Swamp Forests: Experience from Peninsular Malaysia………………………….. 577
Tapan Kumar Nath, Mohd Puat Bin Dahalan, Faizal Parish and Nagarajan Rengasamy

A-097 Participatory Approach in the Peat Swamp Forest Management of Two Different Forest Statuses in Central Kalimantan, Indonesia…………………….. 582
Hesti Lestari Tata and Agustinus P. Tampubolon

A-173 Strategy to Control Forest and Peatland Fires after the Central Kalimantan Fire in 2015……………………………………………………………………….. 587
Cakra Birawa, Adi Jaya, Nina Yulianti, Fengky F. Adji, Yanarita and Suwido H. Limin

A-241 Using Peat Shrub for Agriculture Likely Reduces CO_2 Emissions and Improves Local Livelihood…………………………………………………….. 590
Fahmuddin Agus, Neneng Laela Nurida, Maswar, Wahyunto, I. GM Subiksa, Husnain, and Dedi Nursyamsi

SPECIAL SESSION 1: SOFT SOIL ENGINEERING

A-111 Case Studies on Design and Construction of Deep Foundation in Sarawak Soft Soil………………………………………………………………………… 596
Frydolin Siahaan and Junaidi Sahadan

A-364 Effects of Compressibility and Permeability of Peaty Soil on the Design and Construction of Infrastructure…………………………………………… 602
Dominic E. L. Ong

A-327 Microstructure of Solidified Peat at Different Decomposition Levels…….. 607
Junita Abd Rahman, Radin Maya Saphira and Chan Chee Ming

A-306 Peat and Organic Soils Challenges in Road Construction in Sarawak: JKR Sarawak Experience……………………………………………………… 613
Vincent Tang Chok Khing

A-403 Peatland Flood Protection Engineering – APRIL Experience in Coastal Riau………………………………………………………………………… 619
J. Bathgate, L. Maranan and A. Purwoko

A-326 Recommendation on Pre-Solidification Procedure for Highly Organic Soils at Various Decomposition Levels…………………………………… 623
Junita Abd Rahman, Radin Maya Saphira and Chan Chee Ming

A-203 Sarawak Hemic Peat Consolidation Settlement and Shear Strength Behaviour……………………………………………………………… 630
N. M. Sa'don, A. R. Abdul Karim, Z. Ahamad and A. Mariappan

SPECIAL SESSION 2: PEAT FOR HORTICULTURE & ENERGY

A-158 DPPP -A Worldwide Search for Paludiculture Plants and their Potential to Stop Peat Degradation……………………………………………………………….. 636
Susanne Abel, Christian Schröder and Hans Joosten

A-183 A Carbon Footprint for the Peat and Substrate Industry……………………….. 641
Moritz Boecking

A-025 Fen Peat Properties and Metal Accumulation in It……………………………... 646
Janis Krumins, Maris Klavins and Valdis Seglins

A-407 From Conversion of Waste to Production of Growing Media Constituents: Change of Focus………………………………………………………………... 652
Hein Boon

A-242 Opportunities and Challenges Surrounding the Farming Sphagnum as a Growing Media Constituent in Germany……………………………………….. 654
Gerald Schmilewski and Jan Felix Köbbing

A-396 Planning for the End of Energy Peat Production in Bord na Mona…………… 658
Cathal Byrne

SPECIAL SESSION 3: PUBLICALLY MANAGED PEATLAND CARBON STORAGE, ECOSYSTEM SERVICES, AND MANAGEMENT

A-167 Carbon Storage and Ecosystem Services by Publically Managed Wetlands 663
Zhiliang Zhu and Chris Lowie

A-231 Forested Peatland Management in Southeast Virginia and Northeast North Carolina, USA…………. 664
Frederic C. Wurster, Sara Ward, and Christine Pickens

A-254 Management Implications Associated with Consideration of Carbon Storage and Ecosystem Services in Peatland and Blue Carbon Ecosystems of National Wildlife Refuges (USA) 669
Kurt A Johnson and John Schmerfeld

A-155 *Modeling, Assessing, and Valuing Peatland Ecosystem Services.………..* 670
Dianna Hogan, Emily Pindilli, Rachel Sleeter, Bryan Parthum and Brianna Williams

A-169 Quantifying Above and Belowground Carbon Loss Following Wildfire in Peatlands Using Repeated LiDAR Measurements……………………… 676
Todd J. Hawbaker, Ashwan D. Reddy, Zhiliang Zhu, Fredric C. Wurster and Jamie A. Duberstein

A-205 Quantifying Aboveground Biomass and its Rate of Change in Great Dismal Swamp, Virginia, USA………………… 681
Jamie A Duberstein , Todd J Hawbaker, Gary Speiran and Zhilang Zhu , Nicole Cormier, Chris Lowie and Fred Wurster

A-150 Spatial Differences in Hydrologic and Geochemical Characteristics Across a Temperate Coastal Plain Peatland: The Great Dismal Swamp, USA… 686
Gary K. Speiran, Frederic C. Wurster and Jack Eggleston

A-252 The Carbon Sequestration and Climate Adaptation Benefits of Rewetting Pocosin Peatlands in Pocosin Lakes National Wildlife Refuge, North Carolina, USA…… 691
Sara Ward, Jamie Eaton, Christine Pickens, Scott Settelmyer, and John Schmerfeld

A-253 The United States' National Wildlife Refuge System: A Natural Laboratory for Studying Peatland Carbon Storage, Ecosystem Services and Impacts of Management………………………………………………. 696
Kurt A Johnson and John Schmerfeld

A-196 The Use of Long-Term and Interdisciplinary Data to Plan the Sustainable Use of Peatlands ………………………………………………………. 701
Anne Tolvanen and Miia Parviainen

SPECIAL SESSION 3: PUBLICALLY MANAGED PEATLAND CARBON STORAGE, ECOSYSTEM SERVICES, AND MANAGEMENT

A-122 Valuing and Mapping Ecosystem Services Hotspot and Trade-Offs to Support Sustainable Peatland Management……………………………. 702
Saritha Kittie Uda and Garika Pristiwati

SPECIAL SESSION 4: TROPICAL PEATLAND BIODIVERSITY & CONSERVATION IN SOUTHEAST ASIA

A-213 Biodiversity of Tropical Peatland in Southeast Asia……………………… 707
John Rieley

A-349 Diversity and Characteristics of *Cryptocoryne* (*Araceae*) Species of Peat Swamp Ecosystem in Borneo…………………………………………… 712
I.B. Ipor, C.S. Tawan, S. Wongso, N. Jacobsen, J.D. Bastmeijer and H. Budianto

A-040 Impacts of the 2015 Fire Season on Peat Swamp Forest Biodiversity in Indonesian Borneo…………………………………………………… 713
Mark E. Harrison, Bernat Ripoll Capilla, Sara A.Thornton, Megan E. Cattau and Susan E. Page

A-226 Mangrove Peat of Botum Sakor in Cambodia……………………………… 718
Julia Lo, Le Phat Quoi and Sun Visal

A-348 Peat Swamp Flora And Conservation Of Maludam National Park, Sarawak……………………………………………………………………… 722
C.S. Tawan, A.M Nadia, I.B. Ipor and K. Meekiong

A-055 Peatland Fish of Sabangau, Borneo: Ecology and Implications for Future Monitoring and Conservation……………………………………………. 723
Sara A. Thornton, Dudin, Suwido H. Limin, Susan E. Page, Caroline Upton and Mark E. Harrison

A-441 Protection and Restoration of Peat Areas for Orangutans………………… 728
Doug Cress, Johannes Refisch, Julien Simery and Serge Wich

A-061 Southeast Asian Peat Swamp Forest Biodiversity Lost Before Even Being Recognized……………………………………………………………… 729
Marcel Silvius

A-199 Unique Southeast Asian Peat Swamp Habitats Have Relatively Few Distinct Plant Species.………………………………………………………... 730
Wim Giesen and Susan Page

Special Session 5: PEATLAND RESTORATION: THE WAY FORWARD

A-460 Restoring Indonesia's Degraded and Post-Fire Peatlands: Policy Framework, Strategic Actions and Techniques………………………….. 736
Alue Dohong

A-461 Restoring Peat Swamp Ecosystem in the Village Areas…………………. 737
Haris Gunawan

A-468 Socio-Economic Parameters for Peat Restoration Policy Makers ………. N/A
Khor Yu Leng

SPECIAL SESSION 6: ASIA FLUX

A-420 Advanced Estimation of Tropical Peatland/Wetland Ecosystems Using Innovative Technologies……………………………………………………….. 741
Mitsuru Osaki, Kazuyo Hirose, Hidenori Takahashi, Nobuyuki Tsuji and Bambang Setiadi

A-293 Carbon Dioxide Balance of a Secondary Tropical Peat Swamp Forest in Sarawak, Malaysia…………………………………………………………………. 745
Frankie Kiew, Ryuichi Hirata, Takashi Hirano, Wong Guan Xhuan, Edward Baran Aries, Kevin Kemudang , Joseph Wenceslaus and Lulie Melling

A-410 Comparison of Several Studies on Greenhouse Gas (GHG) Emissions from Peat Soil…………………………………………………………………. 746
Helena Lina Susilawati, Yuichiro Furukawa, Abdul Hadi, Hironori Arai, Rosnaeni Sakata and Kazuyuki Inubushi

A-369 Continuous Measurements of Soil CO_2 and CH_4 Fluxes in Two Tropical Peat Forests with High and Low Ground Water Level in Sarawak, Malaysia, by Using an Automated Multi-Chamber Systems……………… 751
Ryuichi Hirata, Yosuke Okimoto, Takashi Hirano, Frankie Kiew and Lulie Melling

A-047 Evaluation of Carbon Emission from Tropical Peatland in Central Kalimantan, Indonesia and Technology Transfer of the Evaluation Method……………………………………………………………………….. 752
M. Y. Hamada, N. Tsuji, , H. Takahashi, , Y. Shigenaga, , E.N.N. Sari, , R. Naito, , G.G. Hidayat, , H. Kobayashi, , S. Takahara, N. Yulianti, , Y. Jagau, and M. Osaki

A-298 Factors Controlling the Contribution of Net Carbon Loss and Total Subsidence in a Water-Managed Tropical Peatland………………………. 755
Kiwamu Ishikura, John Bathgate and Ryusuke Hatano

A-043 Greenhouse Gas (GHG) Emissions in Relation to Water Table and Soil Amelioration from Tropical Peat Soil……………………………………… 759
H. L. Susilawati, P. Setyanto, A. Miranti and K. Inubushi

A-402 Greenhouse Gas Fluxes in Boreal and Arctic Wetland in Alaska……….. 764
Masahito Ueyama, Hiroki Iwata, Hirohiko Nagano, Kazuhito Ichii and *Yoshinobu Harazono*

A-233 Soil Greenhouse Gas Emissions in Tropical Peat Swamp Forests and Oil Palm Plantations in Central Kalimantan, Indonesia………………………… 769
Nisa Novita, Dede Hendry Tryanto, Kristell Hergoualc'h and J. Boone Kauffman

SPECIAL SESSION 6: ASIA FLUX

A-078 Spatial Distribution of N_2O Flux from an Agricultural Field in a Tropical Peatland, Kalimantan, Indonesia…………………………………………….. 770
Yo Toma, Fumiaki Takakai, Untung Darung, Kanta Kuramochi, Suwido H. Limin and Ryusuke Hatano

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TABLE OF CONTENTS

THEME 1 INVENTORY, BIODIVERSITY, CONSERVATION & FUNCTIONS OF PEATLANDS **3**

1.1 Peat Characteristics 4

1.2 Geochemistry, Hydrochemistry & Hydrology of Peatland 49

1.3 Peatland Remote Sensing, Aerial & Satellite Imagery 85

1.4 Peatland Conservation & Management 117

1.5 Peatland Biodiversity 154

1.6 Conservation of Peatland Forest & Wildlife 222

THEME 2 PEATLANDS & ECOSYSTEM MANAGEMENT **251**

2.1 Peatland Carbon Balance, Stocks, Storage & Losses 252

2.2 GHG Emission from Natural & Managed Peatlands 281

2.3 Peat Forest-Wildfire-Impacts on Environment & Society 364

THEME 3 PEATLANDS AFTER-USE, RESTORATION & REHABILITATION OF EX- PRODUCTION PEATLANDS **407**

3.1 Restoration of Boreal, Temperate & Tropical Peatlands 408

3.2 Rewetting & Re-Vegetation Techniques -

THEME 4 PEAT USE, PEATLANDS TECHNOLOGY & AGROTECHNOLOGY **424**

4.1 Peat Use, Peatland Technology & Agro-Technology 425

TABLE OF CONTENTS

THEME 5 RESPONSIBLE UTILIZATION & MANAGEMENT OF PEATLANDS 439

5.1 Agriculture & Forest Plantations on Peatland 440

5.2 Peatland Forestry -

5.3 Peatland Management: Legislations, Regulations & Policies -

THEME 6 CULTURAL,EDUCATIONAL,MEDICINAL & SOCIO-ECONOMIC ASPECTS OF PEATLANDS, PEAT & SAPROPEL 523

6.1 Cultural & Socio-economic Aspects of Peatland 524

6.2 Peatland & Local People 539

THEME 7 SPECIAL SESSION 560

7.1 Soft Soil Engineering -

7.2 Peat for Horticulture & Energy 561

7.3 Publically Managed Peatland Carbon Storage, Ecosystem Services, & Management -

7.4 Tropical Peatland Biodiversity & Conservation In Southeast Asia 586

7.5 Peatland Restoration: The Way Forward -

7.6 Asia Flux -

1.1: PEAT CHARACTERISTICS

A-107 Accumulation Rate of Tropical Peat Soils Under Different Types of Forest... 6
Faustina E. Sangok, Yuki Sugiura, Nagamitsu Maie, Lulie Melling, and Akira Watanabe

A-100 Cellulose Oxygen Isotopes of Peat as a Tool of Paleoclimate Reconstruction; Applications in Rishiri and Borneo Peats………………….. 10
Masanobu Yamamot, Osamu Seki, Takafumi Kikuchi, Ryoma Hayashi, Abdullah Sulaiman, Hasrizal Shaari and Lulie Melling

A-166 Change of Physical and Chemical Properties of Peat after Fire in Drained Tropical Peat Swamp Forest………………………………………………. 12
Y. Sulistiyanto, O.Umar and Jaya A. Lendraand R.Umbing

A-106 Characterization of Organic Carbon Compounds of Tropical Peat From Various Land Management Types………………………………………… 13
Mari Könönen, Jyrki Jauhiainen, Raija Laiho, Peter Spetz, Kitso Kusin, Suwido Limin and Harri Vasander

A-116 Diversity in the Physicochemical Properties of Tropical Peat In Sarawak, Malaysia…………………………………………………………………... 17
Norika Kato, Nagamitsu Maie, Lulie Melling, Sonoko D. Bellingrath-Kimura, Haruo Tanaka, Masahiro Maeda, Zulhilmy Abdullah Mohd and Akira Watanabe

A-381 Gauging Differences between Blanket and Raised Bogs using Legacy Data.. 21
Stephen James Chapman

A-032 Long-Term Disturbance Dynamics and Resilience of Tropical Peat Swamp Forests………………………………………………………………… 24
Lydia E.S. Cole , Shonil A. Bhagwat and Katherine J. Willis

A-244 Mineral Variation Across An Esturine Raised Bog In Wales……………….. 25
Fred M. Slater

A-026 Properties of Peat Humic Substances …………………………………….. 26
Maris Klavins

A-426 Responses of Peat Carbon at Different Depths to Simulated Warming and Oxidization…………………………………………………………... 31
Liangfeng Liu and Huai Chen

A-211 Soil Physical Properties of Tropical Peatland at Three Different Types of Land Use in Kubu Raya District of West Kalimantan, Indonesia…………… 35
Mateus Aba, Urai Edi Suryadi and Sutarman Gafur

1.1: PEAT CHARACTERISTICS

A-232 Subsidence Rate of Drained Peat in Sumatra and Kalimantan Islands, Indonesia……………………………………………………………………... 40
Maswar and F. Agus

A-433 Temporal Changes of Selected Physico-chemical Properties Of Tropical Peat Under Managed Oil Palm Plantation…………………………………… 41
Zulhilmy Abdullah, Nur Azima and Lulie Melling

A-283 The Role of Peat Layer on Nutrient and Metal Concentrations on Peatland With a Substratum of Sulphidic Materials ………………………………….. 46
Arifin Fahmi and Siti Nurzakiah

1.2: GEOCHEMISTRY, HYDROCHEMISTRY & HYDROLOGY

A-312 Comparison of Chemical Characteristics of Dissolved Organic Matter in River Water Flowing through Peatlands in Sarawak, Malaysia and Eastern Hokkaido, Japan……………………………………………………………… 50
Kiyoshi Tsutsuki, Emi Yoshida, Akira Watanabe, Nagamitsu Maie, and Lulie Melling

A-382 Dissolved Organic Carbon (DOC) in Peat Water Suggests Limit to Decomposition…………………………………………………………….. 54
Muhammad Nuriman, Gunawan Djajakirana, Darmawan and Gusti Z. Anshari

A-263 Dynamics and Distribution of Peat Water Macro Nutrients (N, P, K, Ca, Mg and S) in Oil Palm Plantation based on Season, Peat Thickness, Chanel Distance and Plant Age…………………………………………………….. 58
Heru Bagus Pulunggono, Syaiful Anwar, Budi Mulyanto, and Supiandi Sabiham

A-399 Hydrological Changes of Fens Sites in the Course of Soil Development…….. 62
Uwe Schindler, Lothar Müller and Axel Behrendt

A-465 Hydrological Monitoring at Peat Swamp Forest, Ayer Hitam Forest Reserve, Johor, Malaysia for Forest Conservation………………………………….. 68
Siti Aisah Shamsuddin, Ibrahim Hasim, Mohd Muflif Mohd Rodzi and Hafizi Mohd Jaafar

A-229 Hydrophobicity of Dissolved Organic Carbon in Fen Peatlands …………… 73
Barbara Kalisz and Andrzej Łachacz

A-117 Seasonal and Interannual Variations of Dissolved Organic Matter Composition in the Groundwater of Tropical Peat Under Oil Palm Plantation Management…………………………………………………………….... 77
Nagamitsu Maie, Lulie Melling, Sonoko D. Bellingrath-Kimura, Kosuke Ikeya, Eikichi Shima, Hajime Tanji, Zulhilmy Abdullah Mohd and Akira Watanabe

A-290 The Export of Old DOC Fuels Efflux of Old Carbon Dioxide from Disturbed Tropical Peat Drainage Systems in Malaysia…………………………………. 81
Susan Waldron, Leena Vihermaa, Stephanie Evers, Mark Garnett, Jason Newton and Rory Padfield

A-385 The Role of Local Water Conditions in Distribution of Raised Bogs in Mountainous Areas: Case Study of the Polish Carpathian Mountains……….. 82
Adam Lajczak

1.3: PEATLAND REMOTE SENSING, AERIAL & SATELLITE IMAGERY

A-392 Assessment of Tropical Peatland Map in West Kalimantan, Indonesia….. 86
Kazuyo Hirose, Tomomi Takeda, Gusti Anshari, Muhammad Nuriman, Tesuo Tanimoto, Ronny Christianto, Shigeru Takahara, Hiroshi Kobayashi, and Gun Gun Hidayat

A-159 GIS-Peatland Mapping Based on Discontinuous Data - The Example of Northern Jutland (Denmark)………………………………………………. 91
Cosima Tegetmeyer, Alexandra Barthelmes, Mette Risager and Hans Joosten

A-143 Global Peatland Database @ Greifswald Mire Centre - Integration, Evaluation and Generation of Geospatial Data…………………………….. 92
Alexandra Barthelmes, Cosima Tegetmeyer, Franziska Tanneberger, Reni Barthelmes, Stephan Busse and Hans Joosten

A-318 Historical Development of Industrial Scale Oil Palm Over Peatland in Riau and West Kalimantan Provinces, Indonesia………………………………… 97
Syaiful Anwar, Syed Aziz Ur Rehman, Untung Sudadi, Bandung Sahari and Supiandi Sabiham

A-146 Identification of Tropical Peat Forest Vegetation Using Spectroradiometer and Hyperspectral Imagery in Central Kalimantan, Indonesia……………. 102
Hendrik Segah, Freddy Wijaya, Laju Gandharum and Hiroshi Tani

A-413 Remote Sensing Imagery in Tropical Peatland Mapping: A Review……….. 107
Chloe Brown, Doreen Boyd, Sofie Sjögersten and Paul Aplin

A-444 Tropical Peatlands Characterization using Temporal PALSAR/PALSAR-2 Mosaic Data: A Case Study in Siak Regency, Riau, Indonesia……………. 112
Dandy Aditya Novresiandi and Ryota Nagasawa

1.4: PEATLAND CONSERVATION AND MANAGEMENT

A-272 25 Years of Tropical Peatland Research: A Review…………………….. 118
John O. Rieley

A-411 A Field Study of the Tripa Peat Swamps………………………………… 123
G. Usher, M.G. Nowak and I. Singleton

A-141 Location, Extent And Drainage Status Of Peatlands And Organic Soils In East Africa……………………………………………………………… 128
Reni Barthelmes, Alexandra Barthelmes, René Dommain and Hans Joosten

A-464 Forest Management in the Peat Swamp Forests of Sarawak……………… 133
Abdul Rani Jaili

A-436 Montane Peatlands Conservation: An Insight on Nutrient Characteristics and Carbon Dating………………………………………………………. 138
Jeyanny Vijayanathan, Wan Rasidah Wan Abdul Kadir, Ahmad Husni, Mohd. Hanif and Suhaimi Wan Chik

A-195 Quantification and Valuation of Ecosystem Services to Optimize Sustainable Re-Use for Low-Productive Drained Peatlands…………….. 141
Anne Tolvanen and Miia Parviainen

A-224 Regional Approach to Peatland Conservation in Southeast Asia………… 145
Faizal Parish, S.Y. Lew and Noor Azura Ahmad

A-285 Sustainable Wetlands Adaptation and Mitigation Program (SWAMP)….. 148
R.K. Kolka and D. Murdiyarso

A-064 Trophic Status of the Mires in Changbai Mountains, Northeast China)….. 149
Na Xu, Yanmin Dong, Hongyan Zhao, Shasha Liu, Hongkai Li, Ming Wang, Yiwen Cao, Shengzhong Wang, Xianmin Meng

1.5: PEATLAND BIODIVERSITY

A-189 Assessing the Diversity of Viruses in Soils Obtained from Limestone Caves………………………………………………………………………. 156
Hasina Mkwata, Lee Tung Tan and Peter Morin Nissom

A-346 Assessment of Microbial Diversity in an Undisturbed Tropical Peat-Draining River Using 16S rRNA Pyrosequencing, With a Particular Focus on Methanotrophs and Methanogens …………………………. 161
N. Denis, D. Müller, T. Warneke, A. Mujahid, D. Tan and M. Müller

A-431 Biocontrol Assessment of Actinobacteria from Tropical Peatland against *Ganoderma Spp*……………………………………………………… 162
Frazer Midot, Sharon Yu Ling Lau and Lulie Melling

A-437 Carabid Beetle and Ant Assemblages in the Western Balkans Peat Bog 168
Andreja Brigić, Jelena Bujan, Antun Alegro, Ivančica Ternjej and Mladen Kerovec

A-430 Characterization of Nitrous Oxide Emitters from Tropical Peatlands of Sarawak………………………………………………………………. 173
Sharon Yu Ling Lau, Frazer Midot, Yasuyuki Hashidoko and Lulie Melling

A-323 Combined Assessment of Archaeal and Bacterial Communities in Soil Samples from Hornsund, Spitsbergen using Illumina Mi-Seq………….. 180
Sia, Edwin, Denis, Nastassia, Mujahid, Aazani, Zhang, Jing, Alias, Siti Aisyah, Ali, Siti Hafizah, Samah, Azizan Abu and Mueller, Moritz

A-302 Eukaryotic Biodiversity Under Oil Palm on Peat at Sarawak Determined Using 454 Next Generation Sequencing………………………………. 181
Siti Ramlah Ahmad Ali, Mohd Noor Mat Isa, Mohd Shawal Thakib Maidin, Sakinah Safari, Nur Aziemah Abu Ghani, Hassriana Sapri, Sharifah Azura Syed Ibrahim and Norman Kamarudin

A-091 Fungi of Interest Isolated from Loagan Bunut National Park, Miri, Sarawak……………………………………………………………………. 187
Jamilah Hassan, Elaine Remi, Chia Hwa Chuan and Noreha Mahidi

A-458 Microsatellite Marker Inferred Genetic Diversity of *Ganoderma Boninense* in Tropical Peatland, Sarawak………………………………. 192
Wei Chee Wong, Hung Jiat Tung, Kah King Tan, Mei Lieng Lo and Sharon Yu Ling Lau

A-300 Molecular Assessment of Culturable Bacteria in Sarawak's Deep Peat Forest Converted to Oil Palm Plantation………………………………… 198
Mohd Shawal Thakib Maidin , Sakinah Safari, Sharifah Azura Syed Ibrahim, Shamsilawani Ahamed Bakeri and Siti Ramlah Ahmad Ali

1.5: PEATLAND BIODIVERSITY

A-299	Prokaryotic Diversity Study in Different Oil Palm Development Site Using PCR-DGGE Assessment in Sarawak……………………………. *Mohd Shawal Thakib Maidin, Nur Aziemah Ab Ghani, Sakinah Safari, Shamsilawani Ahmed Bakeri and Siti Ramlah Ahmad Ali*	203
A-424	Soil Microbial Communities and Associated GHG emissions at Different Land Use Types in Malaysian peatlands: An Implication on Climate Change………………………………………………………………… *Selvakumar Dhandapani, Sofie Sjogersten, Stephanie Evers and Karl Ritz*	207
A-337	Study of Functional Microbes Population in Peat Soil Treated with Two Pesticides…………………………………………………………………………… *Syaiful Anwar, Maipa Dia Pati, Rahayu Widyastuti and Dadang*	211
A-088	Study of Peat Soil Microbial Communities of Loagan Bunut National Park………………………………………………………………………. *Barbara Ngikoh, Hii Mei Mei and Ng Lee Tze*	217

1.6: CONSERVATION OF PEATLAND FOREST & WILDLIFE

A-214 Allometric Relations of the Trees in the Tropical Peat Swamp Forests of Sarawak: Influence of Hollow Stems on Tree Biomass………………. 223
Yukako Monda, Yoshiyuki Kiyono, Lulie Melling, Christopher Damian and Auldry Chaddy

A-340 Biodiversity and its Distribution, Kampar Peninsular, Riau Province Indonesia………………………………………………………………. 227
Petrus Gunarso and Anthony Greer

A-186 Birds In Peat Swamp Forest of the Maludam National Park, Sarawak. 228
Bettycopa Amit, Andrew Alek Tuen, Khalid Haron and Mohd Haniff Harun

A-439 Efforts to Conserve *Gonystylus bancanus* (Ramin) in the Peat Swamp Forests of Gunung Mulu National Park………………………………… 231
*Aurelia Dulce Chung, Mohizah Mohamad and Runi Sylvester Pungg*a

A-450 Ground-dwelling Mammals And Birds in a Peat Swamp Forest In Sumatra and the Impact of Industrial Tree Plantation…………………… 235
Hiromitsu Samejima, Motoko S. Fujita, Ahmad Muhammad, Jason Hon and Gono Semiadi

A-343 MyCITES: A Database for *Gonystyslus bancanus*……………………… 236
Siti Yasmin Yaakub, Mohd Azahari Faidi, Abd Rahman Kassim and Muhamad Afizzul bin Misman

A-035 Population Mapping of Gibbons in Kalimantan, Indonesia: Correlates of Gibbon Density and Vegetation Across the Species Range…………… 241
Susan M. Cheyne, Bernat Ripoll Capilla and Mark E. Harrison

A-042 Trees Composition of Ulu Sebuyau National Park, Sarawak……………. 245
Malcom Demies, Jacqualine Henry, Ling Chea Yiing, Sundai Silang and Julaihi Abdullah

2.1: PEATLAND CARBON BALANCE, STOCKS, STORAGE & LOSSES

A-070 A Preliminary Assessment of Carbon Storage and Productivity of Peat Swamp Forest in Katingan, Central Kalimantan, Indonesia…………….. 253
Meli Fitriani Saragi , Sigit Deni Sasmito and Daniel Murdiyarso

A-023 Age and Carbon Accumulation Rate in Selected Peatlands and Marsh of Ancient Ice Caps Along a Mountain Range on the Eastern Tibetan Plateau………………………………………………………………… 256
Dan Zhu, Huai Chen and Ning Wu

A-443 Collecting Original Data on Atmospheric Carbon Balance from a Forested Landscape – Riau, Indonesia……………………………………………. 260
Chandrashekhar Deshmukh, Anthony Greer, John Bathgate

A-418 Effects of Experimental Climate Warming on C Sink Function in a Temperate Peatland…………………………………………………….. 261
F. Laggoun-Defarge, A. Buttler, F. Delarue, D. Epron, A.J. Francez, D. Gilbert, V.E. J. Jassey, L. Grasset, C. Guimbaud, A. Huguet and E.A.D. Mitchell

A-234 Estimation of Organic Carbon Flux from Two Streams in Tropical Peat Swamp Forest of Riau Province, Sumatra, Indonesia…………………… 262
Haiki Mart Yupi, Takashi Inoue, John Bathgate and Rosef Putra

A-397 Potential Carbon Stores in New Guinea Peatlands………………………. 267
Geoffrey Hope

A-209 Soil Carbon Dynamics as the Impact of Change in Tropical Peatland Uses in West Kalimantan, Indonesia………………………………………… 270
Rossie Wiedya Nusantara, Sudarmadji, Tjut S. Djohan and Eko Haryono

A-282 Soil Carbon Stock and Peat Organic Properties in Fresh Water Swampland 276
Siti Nurzakiah, Nur Wakhid and Haris Syahbuddin

2.2: GHG EMISSION FROM NATURAL & MANAGED PEATLANDS

A-089 Biochar Amendment to Improve Soil Fertility and Reduce CO_2 Emissions in Tropical Peatsoil………………………………………………………………. 283
Eni Maftu'ah, Herman Subagio and Dedi Nursyamsi

A-052 Carbon Dioxide Emissions from Cultivated Peat Soil Cropped with Bio-Energy Crops, A RECARE Project…………………………………………… 289
Kerstin Berglund and Örjan Berglund

A-038 CO_2 Emissions from Cultivated Peat Soil with Sand Addition, a CAOS Project………………………………………………………………………… 292
Kerstin Berglund and Örjan Berglund

A-090 CO_2 Emissions from Ground Surface of Oil Palm Plantation in Sarawak, Malaysia………………………………………………………………… 296
Yosuke Okimoto, Takashi Hirano, Ryuichi Hirata , Lulie Melling, Yoshiyuki Ishii, Frankie Kiew and Wong Guan Xhuan

A-218 CO_2 Fluxes from Secondary Forest, Oil Palms, Aloe vera, and Shrub Peatland on Drained Tropical Peat……………………………………………………… 300
Randi Adi Candra, Evi Gusmayanti and Gusti Anshari

A-208 Effect of Acid Mine Drainage on Greenhouse Gas Emissions from Peat Soils in South Kalimantan ………………………………………………………. 305
Abdul Hadi and Bahtiar Rifai

A-086 Estimating Greenhouse Gas Emissions from Peatland in Indonesia: An Annual Time Series Analysis using INCAS Framework…………………….. 309
Haruni Krisnawati, Rinaldi Imanuddin, Wahyu Catur Adinugroho and Silver Hutabarat

A-459 Field Challenges of Eddy Covariance Measurement in Tropical Peat Swamp Ecosystems in Sarawak, Malaysia - The TPRL Experience………………. 315
Edward Baran Aeries, Wong Guan Xhuan, Joseph Wenceslaus Waili, Lo Kim San, Ryuichi Hirata and Lulie Melling

A-345 Measuring CO_2 Flux over Oil Palm Agro-System: Spectral Analysis and Correction Application……………………………………………………………. 319
Bram Hadiwijaya , Bayu Septiwibowo, and Jean-Pierre Caliman

A-400 Measuring Emissions of CO_2 and CH_4 from the Soil using the Li-Cor Li-8100A Together with the LGR UGGA………………………………………… 324
Richard L. Garcia, Jason Hupp and Liukang Xu

A-110 Methane Emissions from Stem Surface of Melaleuca cajuputi Trees in a Peat Swamp Area in Southern Thailand……………………………………… 328
Mariko Norisada, Takashi Yamanoshita, Pisoot Vijarnsorn and Katsumi Kojima

2.2: GHG EMISSION FROM NATURAL & MANAGED PEATLANDS

A-020 Partitioning Carbon Dioxide Emissions and Dissolved Organic Carbon Leaching of a Tropical Peat Cultivated with Pineapple at Saratok, Malaysia……………………………………………………………………….. 332
Liza Nuriati, Lim Kim Choo and Osumanu Haruna Ahmed

A-188 Spatial Evaluation of Greenhouse Gas Budget in a Dwarf Bamboo (Sasa) Invaded Wetland Ecosystem in Central Hokkaido, Japan……….…………… 337
Fumiaki Takakai, Akane Kagemoto, Osamu Nagata, Masayuki Takada and Ryusuke Hatano

A-265 The Effect of Pesticides Application on Phenolic Acid Changes and CO2 And CH4 Production of Peat Soil……………………………………………… 342
Syaiful Anwar, Dadang and Fuzi Suciati

A-216 The Relation between Water Contents and CO2 Fluxes from Drained Tropical Peats……………………………………………………………………….. 348
Randi Adi Candra, Evi Gusmayanti and Gusti Anshari

A-039 Tropical Peat GHG Emissions from Oil Palm Plantation Microsites under Compression……………………………………………………………… 353
Samuel, Marshall K. and Evers, Stephanie

A-267 Utilization of Ameliorants and the Effect on GHG Emissions in Peatlands for Corn……………………………………………………………………….. 358
Eni Maftuah and Dedi Nursyamsi

2.3: PEAT FOREST-WILDFIRE-IMPACT ON ENVIRONMENT & SOCIETY

A-099 Demonstration of a Cost-Effective UAV System to Measure Depth of Burn for Emissions Estimates from Peat Fires in Indonesia…………… 365
Jake E. Simpson, Thomas E. L. Smith, Mandar Trivedi and Prof Martin Wooster

A-113 Estimation of Fire Affected Areas and Carbon Emissions on the Basis of Sentinel-1 ……………………………………………………………. 370
Sandra Englhart, Matthias Staengel and Florian Siegert

A-120 Field Research Methodologies for Collecting Peat Fire Data to Enhance Understanding of Tropical Peat Fire Events……………………………. 375
Laura Graham, Grahame Applegate, Erianto Indra Putra, Kevin Ryan and Mark Cochrane

A-453 Managing Peat Fire Risks in Tanjung Jabung Barat District, Jambi, Indonesia………………………………………………………………… 381
Hesti Lestari Tata, Niken Sakuntaladewi, Lukas R. Wibowo, Bastoni and Agustinus P. Tampubolon

A-429 Chemical, Physical and Microbial Characteristics of Peat Soil Cultivated with Sago Palm in Tebing Tinggi Island, Riau Islands During and One Year After Land and Forest Fire……………………………………… 385
Iskandar, Albertus Fajar Irawan and Mochamad Suwarno

A-077 Surface Elevation Changes of Tropical Peatlands under Different Land Covers: A Preliminary Account Following 2015 Fires in Central Kalimantan, Indonesia……………………………………………… 389
Adi Jaya, Daniel Murdiyarso, Sigit Sasmito and Nyahu Rumbang

A-227 The ASEAN Fire Alert Tool, A Smartphone Application for Hotspot and Fire Risk Alerts…………………………………………………………… 394
Faizal Parish, S.Y. Lew, Mohd Faiz M.P. and Noor Azura Ahmad

A-098 The Reduced Complexity of the Termite Community Structure in Tropical Fire-Impacted Peatlands: A Case Study from Sumatra Indonesia……………………………………………………………………… 398
Kok-Boon Neoh, Masayuki Itoh and Osamu Kozan

A-445 Tube Well Constructions and Peat Management to Combat and Prevent Peat Fires at Kuala Baram, Miri, Sarawak, Malaysia…………………… 402
Roslan Rajali

3.1: RESTORATION OF BOREAL, TEMPERATE & TROPICAL PEATLANDS

A-142 Peatlands in Sub Humid Regions under Changing Climate and Human Activities……………………………………………………………... 409
Andrey Sirin, Tatiana Minayeva, Danil Ilyasov, Gennady Suvorov, Vasily Martynenko, Yury Fedotov, Tamara Glukhova, Natalya Valuayeva, Olga Tsuganova, Aleksandr Maslov, Albert Muldashev, Pavel Shirokikh and Evgeny Kuznetsov

A-225 Peatland Rehabilitation Efforts in North Selangor Peat Swamp Forests 414
Faizal Parish, S.Y. Lew, Nagarajan R. and Noor Azura Ahmad

A-463 Soil Management for Indonesian Peatland Restoration………………… 418
Samantha Grover, Budiman Minasny and Ewen Silvester

A-434 The Use of Native Tree Species to Rehabilitate Degraded Heath Forests at Lumut, Brunei Darussalam………………………………… 419
Wardah Haji Tuah, Faizah Metali and Rahayu Sukmaria Sukri

4.1: PEAT USE, PEATLANDS TECHNOLOGY & AGRO-TECHNOLOGY

A-401 A Review of Advance Analytical Instruments for Peat Soil Characterization………………………………………………………… 426
Sathrugnan Karthikeyan

A-261 Field Data Transmission System, SESAME-II, by Universal Mobile Telecommunication Network………………………………………… 429
Yukihisa Shigenaga, Hideyuki Saito, Hidenori Takahashi, Wisnu Kencana, Rony Teguh, Adi Jaya and Bambang Setiadi

A-258 Spectral Characteristics of Oil Palm Leaves Using Spectroradiometer in Indonesia……………………………………………………………… 433
Takane Ogino, Sawahiko Shimada, Ayako Sekiyama and Hiromichi Toyoda

A-335 A Review of the Research on the Anti-tumor Pharmacology of Peat Fulvic Humic Acid…………………………………………………… 435
Min Li

5.1: AGRICULTURE & FOREST PLANTATIONS ON PEATLANDS

A-423 Achieving Climate-Smart Agriculture in Drained Peatlands through Canal Blocking and Agroforestry: A Multi-Agent Systems Based Case Study in Central Kalimantan……………………………………………….. 442
Yohana Maria Indrawati, Hakyoung Kim, Takashi Hirano and Joon Kim

A-377 Can We Scan Oil Palm Roots in Tropical Peat Soil? ……………………… 447
Elisa Rumpang, Mizue Ohashi, Tomonori Kume, Kho Lip Khoon and Mohd Haniff Harun

A-277 Carbon Isotope Discrimination and Leaf Gas Exchange of Oil Palm Planted on Peat in Teluk Intan, Perak……………………………………….. 452
A.R. A'fifah, M.H. Haniff, N.S. Amanina, N.J. Maisarah, M. Hasimah, R. Syamsul Kamal, R. Izzati, N.M.Z and B.B Saiful

A-462 Effects of Controlled Release Nitrogen Fertilizer on Vegetative Growth and Leaf N of Immature Oil Palm Planted on Tropical………………… 457
Auldry Chaddy, Lulie Melling and Hiroshi Aoki

A-093 Effect of Different Combination of Organic and Chemical Fertilizers Application on Growth and Yield of Hybrimas Sweet Corn on Peat… 461
K. Mohamad Hafis, A. Izham, and M. S. Halimi.

A-435 Effect of Drainage in *Acacia Crassicarpa* Plantation Forest Towards the Maturity Level of Peat Soil…………………………………………… 462
Yunita Lisnawati and Chairil Anwar Siregar

A-432 Effects of Environmental Factors on Soil N_2O Fluxes from Oil Palm Plantation on Tropical Peatland………………………………………. 467
Auldry Chaddy and Lulie Melling

A-041 Effect of Soil and Fertilizer Types on Greenhouse Gas Emissions and Plant Growth in Oil Palm Plantations…………………………………. 471
Hiroshi Aoki, Rosnaeni Sakata, Shuzoh Shimada, Hironori Arai, Naho Yoshioka, Ryo Yoshioka, Narutoshi Kimoto, Atsushi Sakamoto, Shew Ngie Wong, Lulie Melling and Kazuyuki Inubushi

A-179 Effect of Water Table on Greenhouse Gas Emissions from a Mineral Soil-Dressed Peatland in Central Hokkaido, Japan……………………… 477
Shimizu Mariko, Ishida Tetsuya and Takeuchi Hideo

A-073 Effects of Biological and Chemical Control on Population of Bunch Moth, Tirathaba in Oil Palm Planted on Peat in Sarawak…………….. 481
Zulkefli Masijan, Saharul Abillah Mohamad, Ramle Moslim, Mohamad Rosman Sulaiman, Su Chong Ming, Norman Kamarudin, Siti Ramlah Ahmad Ali and Siti Nurulhidayah Ahmad

5.1: AGRICULTURE & FOREST PLANTATIONS ON PEATLANDS

A-352 Fertiliser Response of Oil Palm in a Logged Over, Degraded and Drained Peat in Riau, Indonesia……….……………….……….………… 485
Arif Sugandi and Goh Kah Joo

A-131 Fruit Yield, Fruit Quality and Seed Yield Of Four Chilli Varieties Grown in Open-Field As Affected by Conventional System in Peat Soil Area and Fertigation System….……..……………..……….…….……….. 490
Nurul Atilia Shafienaz binti Hanifah, Mohd Aziz bin Rashid and Amat Jupri bin Ahmat

A-442 Oil Palm Sustainability Standards in Malaysia and Peatland Management…………………………………………………………... 495
Sanath Kumaran, Harnarinder Singh

A-245 Peat Soil Reclamation for Maize (zea Mays L.) ….…….……………… 500
F. B. Arief , S. W. Atmojo, S. Sagiman , J. Sutrisno and T. Onishi

A-075 Performance of Biological Agents and Chemical to Control Subterranean Termite, Coptotermes Curvignathus in Oil Palm Planted on Peat in Sarawak………………………………………………………… 504
Saharul Abillah Mohamad, Mohamad Rosman Sulaiman, Ramle Moslim, Zulkefli Masijan, Siaw Ting Chuan and Norman Kamarudin

A-220 Responses of Onion to *Arbuscula*r *Mycorrhizal Fungi* and to Water Stress in Tropical Peat Soil of West Kalimantan, Indonesia…………… 507
Rini Suryani, Sutarman Gafur and Tatang Abdurrahman

A-063 Tirathaba Control and Treatment Management in a Plantation Group: TH Plantations Berhad's Experience……….……………..……..………… 511
Muhammad Pilus Zambri, Khairul Ismadi Ismail, Rafiyudin Abd Rashid and Mohamad Azim Hazny Abd Hafiz

A-139 Towards More Productive and Sustainable Use of Peatland for Acacia Plantations in Riau, Indonesia……….……………..…………..………… 514
Budi Indra Setiawan, Sabar T. Siregar, Nawari, Agung Nugroho and Mukesh Sharma

A-036 Which Policy Instrument for a More Sustainable Management of Organic Soils in Switzerland? – A Computerized Framed Experiment… 518
Marie Ferré, Stefanie Engel and Elisabeth Gsottbauer

6.1: CULTURAL & SOCIO-ECONOMIC ASPECTS OF PEATLAND

A-359 Farming on Undrained Peatland in Riau, Indonesia: Implication for Sustainability……………………………………………………………………….. 525
Oka Karyanto, Rohman, Teguh Yuwono, Slamet Riyanto, Wahyu Tri Widayanti, Ari Susanti and Satyawan Pudyatmoko

A-428 Peatland Development: A Viable Option to Uplift the Socio-Economic Well-Being of Rural Communities in Sarawak, Malaysia…………………... 531
Jiram Sidu

A-387 Rational Choice of Farmers in The Peat Land Conversion of the Gambut Sub-District, South Kalimantan……………………………………………... 536
Budi Suryadi

6.2: PEATLAND & LOCAL PEOPLE

A-363 Communication, Education and Public Awareness at Loagan Bunut National Park, Sarawak…………………………………………………….. 540
Kamal Abdullah, Anthony Chong, Bistari Mahmood, Abang Arabi B. Abang Aimran, Karen Beverly Seem and Baei Hassan

A-056 Fishing Communities of Sabangau, Borneo: Knowledges, Practices and Values………………………………………………………………………. 544
Sara A. Thornton, Erna Setiana, Krisyoyo, Susan E. Page, Caroline Upton and Mark Harrison

A-145 Recreation Impact on the Soil of Tropical Rain Forest in Maliau Basin Conservation Area (Mbca), Sabah, Malaysia…………………………… 550
Wilter A. Malandi, Ian D. Rotherham and Siti Rahayu M.Hashim

A-191 Sustainability Edu-Campaign for the Peatland: An Early Prevention Action of Indonesia's Future …………………………………………… 551
Nina Yulianti, Betrixia Barbara, Rony Teguh, Eritha Kristiana Firdara and Muliatie

A-165 Useful Plants from the Peat Swamp Forest: Documenting Traditional Knowledge of the Melanau Community of Kampong Jemoreng Matu, Sarawak……………………………………………………………………… 555
Jovita Elderson Ripen, Arlene Alicia and Tu Chu Lee

SPECIAL SESSION 2: PEAT FOR HORTICULTURE & ENERGY

A-045 Development of Biological Substrate and Industrial Exploitation……….. 562
Xia Jiang Ping

A-260 Effect of Horticulture and Floriculture Bionic Peat on the Atmospheric Environment……………………………………………………………......... 565
Lina Wang, Ping Zhouxia, Jie Wang, Fang Dongdong

A-264 Effects of Peat Application as an Organic Soil Conditioner to Promote Fertilization Efficiency on Korean Thistle and Chinese Cabbage Cultivation... 566
Se-Won Kim, Yong-Bok Kim, Byoung-Gon Choi, Dong-Geun Shin, Dae-Jin Kim, Young-Ho Seo, Soo-Jeong Lim, Seung-Chul Choi, Dae-Ki Hong, In-Jong Kim and Chang-Su Park

A-050 Heavy Metal Content in Fuel Peat………………………………………. 573
Niklas Vähä-Savo , Minna Salonen and Jaakko Lehtovaara

A-087 Tropical Peat Granulation and Laboratory Testing………………………. 579
Aleksandr Mikhailov

SPECIAL SESSION 4: TROPICAL PEATLAND BIODIVERSITY & CONSERVATION IN SOUTHEAST ASIA

A-314 Diversity and Population Density of Mesofauna in *Acacia Plantation* vs. Conservation Forest in Peatland of Teluk Meranti Area…………… 587
Gunawan Djajakirana, Angga Imansyah, and Marissa Permatasari Jayaputra

A-190 Macroinvertebrates of Tropical Peat Swamp Forest: A Case Study from Maludam National Park…………………………………………………….. 592
Ella Michael Dosi, Lee Nyanti, Jongkar Grinang, Khalid Haron and Mohd Haniff Harun

A-438 Microdistribution and Community Structure of Aquatic Macroinvertebrates in the Largest Peat Bog in Croatia………………….. 596
Sanja Gottstein, Andreja Brigić, Ana Previšić, Marina Vilenica, Mladen Kerovec and Ivančica Ternjej

Abstract No: A-415

INCREASED CO_2 EMISSIONS DUE TO REWETTING OF DEGRADED TROPICAL PEATLANDS UNDER OIL PALM PLANTATIONS

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SUMMARY

Peatlands occupy 44.1 Mha worldwide, of which nearly 15% have been drained and deforested mainly for commercial agriculture. This degradation has resulted in emissions of 1.3 Gt CO_2 yr^{-1}, which excludes the considerable source of emissions arising from peat fires. From the global area under degraded peatlands, nearly 3.1 Mha is present in Southeast Asia, mainly drained and deforested for commercial plantations of oil palm and *Acacia*. The current rate of carbon emissions from these peatlands under commercial plantations is estimated at 230-310 Mt CO_{2e} yr^{-1}. This degradation has led to physical loss of peat resulting in its subsidence, which is a proxy for CO_2 emissions. As drainage of these peatlands has been associated with significant increase in greenhouse gas (GHG) emissions, hydrological restoration by rewetting to bring back the water table levels near to the peat surfaces, is increasingly being considered as an option to reduce peat degradation and GHG emissions. In this study, we have aimed to understand the mechanistic basis of CO_2 emissions in the tropical peatlands, and the effect of rewetting on these processes. We have conducted laboratory-based microcosm studies and have shown that large CO_2 emissions results due to direct CO_2 emissions from different oxic and anoxic state of peat associated with water saturations, and not linked to methane oxidation to CO_2. We also report here metabolic pathways from directly measured metabolites involved in carbon mineralization that are associated with CO_2 emissions and their changes resulting from controlled rewetting. Our findings from the microcosm study corroborate with our field-based monitoring study of peat subsidence that undergo drying-rewetting and subsiding at a rate of 4.4 cm/yr. Finally, we provide field-based GHG emission from different oxic and anoxic state of peat associated with water saturation that corroborates with our microcosm study.

Keywords: *Greenhouse gas emissions, peat oxidation, microcosm study, metabolomics, peat subsidence*

INTRODUCTION

Peatlands are formed by the accumulation of partially decayed vegetation matter in low-lying areas under water-logged conditions. Peatlands occupy 44.1 Mha worldwide, of which nearly 15% have been drained and deforested mainly for commercial agriculture (Page *et al.,* 2011). This degradation is resulting in emissions of 1.3 Gt CO_2 yr^{-1}, which excludes the considerable source of emissions arising from peat fires (Joosten *et al.,* 2010). The current rate of carbon emissions from these peatlands under commercial plantations is estimated at 230-310 Mt CO_{2e} yr^{-1}.This degradation leads to physical loss of peat resulting in subsidence of its surface, which is a proxy for CO_2 emissions (Couwenberg and Hooijer, 2013; Hooijer *et al.,* 2012).

Hydrological restoration by rewetting is increasingly being considered as an option to reduce peat degradation and GHG emissions. The effectiveness of rewetting in reducing emissions has been evaluated mainly by two approaches: (i) direct hydrological interventions in the field and mesocosms and (ii) extrapolation of correlations of water table depth with GHG emissions. In a recent study from temperate peatlands, methane emissions were higher, where peat surface was rewetted till the top when compared to those, which were rewetted till 20 cm below peat surface. However, CO_2 levels were only marginally affected compared to CH_4 levels (Karki *et al.,* 2015). In case of tropical peatlands, hydrological restoration did not reduce emissions from the degraded sites upon rewetting (Jauhiainen *et al.,* 2008). In contrast to field- and mesocosm-based studies, extrapolations based on correlations of water table and GHG emissions have shown that rewetting is associated with reduction in CO_2 emissions. Sites that have relatively low water table have marginally high subsidence, when compared to sites that have relatively high water table (Couwenberg and Hooijer, 2013). Similarly, a trend of low CO_2 emissions has been reported from sites in tropical peatlands with high water table, when compared to low water table sites (Jauhiainen *et al.,* 2005, 2012). Based on these studies, it has been predicted that rewetting in SE Asian peatlands can lead to substantial reductions of net greenhouse gas emissions (Couwenberg *et al.,* 2010). Hence, based on the different reports on the outcomes of the effects of hydrological interventions on GHG emissions using experimental approaches and from modelling studies, it still remains to be established whether rewetting indeed can reduce GHG emissions.

Relationships between water table and GHG emissions can be explained, if the basis of microbial oxidation of peat biomass can be better understood. We have previously shown that fluctuations in water table in low water table sites is linked with changes in bacterial community structure through oxygen and nutrient availability on the one hand and selection of bacteria that can withstand drying–wetting cycles on the other hand (Mishra *et al.,* 2014). The mechanism of large amounts of CO_2 emission and how rewetting affects peat oxidation in the hot tropics leading to these emissions, needs to be better understood. In order to understand the mechanistic basis of CO_2 emissions in the tropics, and the effect of rewetting on these processes, we have conducted microcosm studies and corroborated our findings with the field studies.

MATERIALS AND METHODS

Study site description and sample collection

The study area is located in peatlands of the eastern part of Jambi province, Sumatra, Indonesia (Site map is described in Mishra *et al.,* 2014). The land-use type from where samples were collected was oil palm plantation, having mostly low water table (82±3 cm below peat surface). Peat samples were collected from three depths, (i) 20-30 cm below peat surface- referred as *oxic zone*; (ii) 20-30 cm above water table- referred as *partial oxic zone* and (iii) 20-30 cm below water table- referred as *anoxic zone* (based on dissolved oxygen data). Peat water samples were collected in sterile falcon tubes to conduct rewetting perturbation. These samples were then shipped to Lawrence Berkeley National Laboratory (LBNL), USA, where part of this study (microcosm set-up, measurements of CO_2 and CH_4 emissions using respirometer) was performed.

Microcosm set-up, sampling design and monitoring

In order to understand the microbial physiological responses leading to gas emissions (CO_2 and CH_4) before and after rewetting, a microcosm experimental set-up was designed and samples for microbial and metabolic changes were collected before and after rewetting. Three replicates of sample from respective zone (1. Oxic, 2. Partial oxic, 3. Anoxic) were bottled-up in serum bottles and were then installed in Micro-Oxymax respirometer (Columbus Instruments). A perturbation of rewetting was generated in the middle of the experimental period.

Peat microbial metabolomics and environmental traits

In order to understand the microbial metabolic profiling and predictive functional potential before and after rewetting, samples from each time points were run through in-house developed metabolomics workflow, described in (Benke *et al.,* 2015). In order to monitor the hydrological parameters and subsidence rates, same methodology was adopted as described in Couwenberg and Hooijer, (2013). Physicochemical analysis for anions and cations was also performed based on the methodology described in Mishra *et al.,* (2014).

RESULTS

Effect of oxygen availability and rewetting on microbial CO_2 emissions (Microcosm study)

CO_2 emissions were significantly higher than CH_4 emissions in all the measured zones at all different time–points measured (Figure1). CO_2 emissions were at baseline levels in the autoclaved samples (controls) compared to high levels of emissions in the non-autoclaved samples (Figure 1, Left panel). Thus, establishing that CO_2 emissions are due to microbial respirations only. CO_2 emissions were similar for the first 6 days from the start of microcosm study, indicating an adaptation time of approximately 144 hrs (6 days) for the microbial communities to adapt to the set up. The rates of CO_2 emitted were highest in the anoxic zones (increased 65% after 6 days), followed by –oxic and then partial –oxic zones (35% and 30% after 6 days, respectively), indicating anaerobic CO_2 production dominates such emissions from tropical peatlands. These rates were further increased in the anoxic zones. In the –oxic and partial –oxic zones, the rates at which CO_2 was released increased by 22% and 25%, respectively, upon rewetting. Methane emissions, on the other hand, did not have a clear trend for the emissions patterns from the –oxic, partial –oxic or the anoxic zones (Figure 1, Right panel).

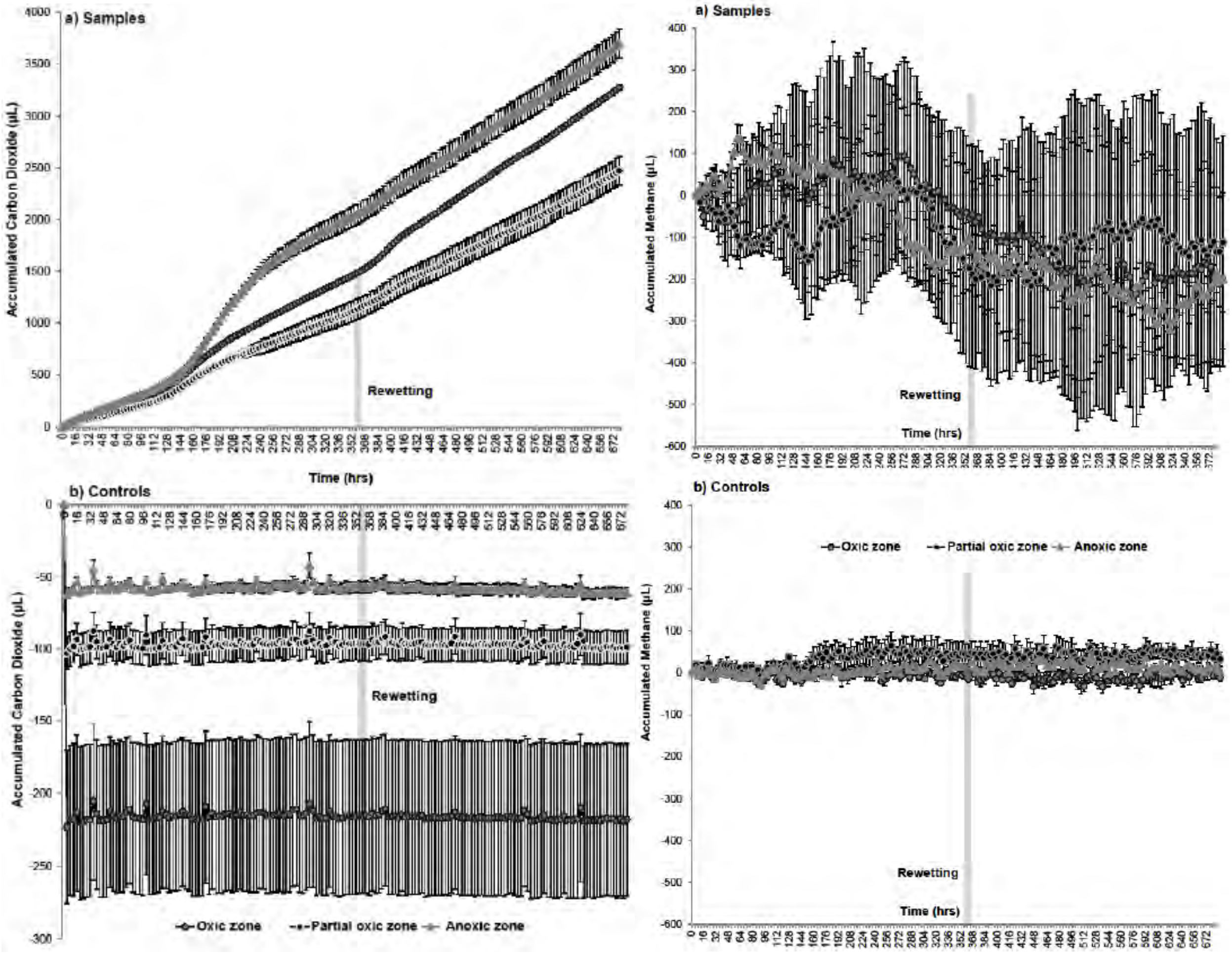


Figure 1: Left Panel- Accumulated carbon dioxide from -oxic, partial-oxic and anoxic zones of peatlands under oil palm plantations, over time before and after rewetting for samples (a) and controls (b). **Right Panel:** Accumulated Methane from -oxic, partial-oxic and anoxic zones of peatlands under oil palm plantations over time before and after rewetting for samples (a) and controls (b).

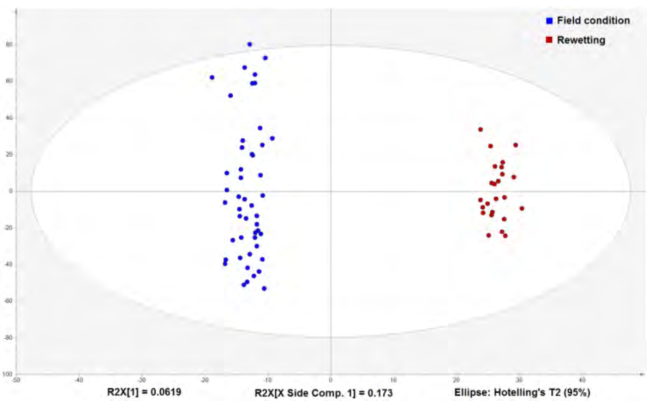
Effect of rewetting (rainfall inundation and hydrological management) and oxygen availability on subsidence rates (proxy for carbon emissions) and GHG emissions, respectively (Field studies)

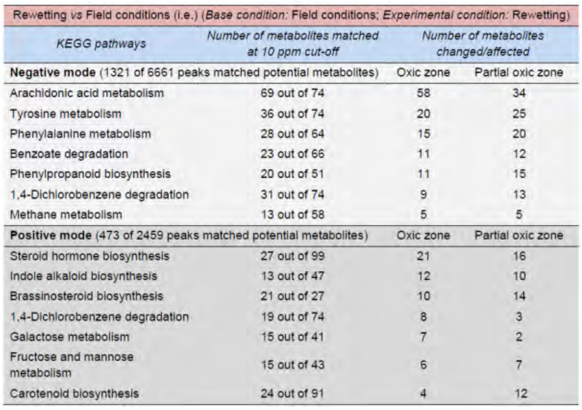
Following similar trend as of CO_2 emissions in the microcosm study, its proxy trait *(i.e.)* subsidence from same sites showed that peat oxidation did not slowed down upon inundation due to rainfall. The average annual subsidence rate based on data monitored for 3.5 years was 4.4 cm/yr. During low water table times, peat oxidized at the subsidence rate of 5.7 cm/yr and did not stop during high water table times (continued subsidence rate: 5.4 cm/yr). Based on this field data, it is clearly evident that during rewetting due to rainfall inundation and hydrological management, peat oxidation do not stop. This is similar to findings reported in Couwenberg and Hooijer (2013).

Similarly, peat mean GHG concentrations were lower at depths that were close to the peat surface. On the other hand, GHG concentrations was generally highest from peat profiles at the depth of 100 cm and 150 cm depth, i.e. in water logged conditions (anaerobic conditions). This corroborates to our findings obtained in microcosm study, where anaerobic CO_2 dominates the gas emissions from degraded tropical peatlands under oil palm plantations.

Metabolic functions of the microbial communities

OPLS–DA analysis showed that the metabolic profiles between field conditions and rewetting were slightly different at variation of 17% (Figure 2, Left panel). Selected pathways, which got annotated in KEGG and had highest number of metabolites being shifted are shown in Figure 2 (Right panel). The changes during rewetting when compared to field conditions, shows that more than 3-fold of predicted metabolites (1321 of 6661 peaks – negative mode *vs* 473 of 2459 peaks – positive mode) was identified in negative mode when compared to positive (Figure 2, Right panel). Most of these pathways belonged to secondary metabolism.





Rewetting *vs* Field conditions (i.e.) (*Base condition:* Field conditions; *Experimental condition:* Rewetting)			
KEGG pathways	*Number of metabolites matched at 10 ppm cut-off*	*Number of metabolites changed/affected*	
Negative mode (1321 of 6661 peaks matched potential metabolites)		Oxic zone	Partial oxic zone
Arachidonic acid metabolism	69 out of 74	58	34
Tyrosine metabolism	36 out of 74	20	25
Phenylalanine metabolism	28 out of 64	15	20
Benzoate degradation	23 out of 66	11	12
Phenylpropanoid biosynthesis	20 out of 51	11	15
1,4-Dichlorobenzene degradation	31 out of 74	9	13
Methane metabolism	13 out of 58	5	5
Positive mode (473 of 2459 peaks matched potential metabolites)		Oxic zone	Partial oxic zone
Steroid hormone biosynthesis	27 out of 99	21	16
Indole alkaloid biosynthesis	13 out of 47	12	10
Brassinosteroid biosynthesis	21 out of 27	10	14
1,4-Dichlorobenzene degradation	19 out of 74	8	3
Galactose metabolism	15 out of 41	7	2
Fructose and mannose metabolism	15 out of 43	6	7
Carotenoid biosynthesis	24 out of 91	4	12

Figure 2: Left Panel- OPLS-DA analysis of the microbial metabolic features excluding blanks to estimate the variations between metabolic changes during field conditions (blue) and after rewetting (red). Variation in X-and Y- axis are 17.3% and 6.2%, respectively. **Right Panel:** Functional metabolic potential of microbial communities between field and rewetting conditions based on annotation using KEGG pathways. The second columns show the number of metabolites present in our data that were matched in respective pathways showing potential metabolites. The third and fourth column depicts the number of metabolites that got affected due to rewetting.

DISCUSSION

Microorganisms have a variety of evolutionary adaptations and physiological acclimation mechanisms that allow them to survive and remain active in the face of environmental stress. The stress in our study could be rewetting. Microbes acclimatize to immediate stress by altering their allocation of resources from growth to survival pathways. These microbes may use the material to support growth and survival [1. Cryptic growth (Chapman and Gray 1986)], to enable attack on recalcitrant soil organic matter [2. Priming (Fontaine *et al.,* 2004; Battin *et al.,* 2008)], or to fuel processes such as 3. Denitrification (Sharma *et al.,* 2006) under stress conditions. During rewetting, microbes generally dispose osmolytes rapidly, either by respiring, polymerizing, or transporting them across the cell membrane (Wood *et al*., 2001). The consequence of disposing of osmolytes could lead to enhanced production of CO_2, DOC, and nutrients released on rewetting (Schimel *et al.,* 2007), as found in this study.

The top 5 metabolic pathways that are affected by rewetting, as identified from microcosm study (Figure 2, right panel), are also highly abundant in the field-based peat metagenome analysis (data not shown). The metabolic changes associated with aromatic aminoacid, xenobiotics and carbohydrate metabolism after rewetting were affected in our study. In the study about rewetting in organic soils, it is demonstrated that aromatic ring compound, amino-acids, glucose, and acetate metabolism decreased after rewetting (Tate, 1979) with aromatic ring compound metabolism to be highly affected upon rewetting. Upon rewetting, compounds, such as, arachidonic acid, linoleic acid and other lipid metabolism were found to be affected in the current microcosm study. The changes in metabolite concentration in phenylalanine metabolism upon rewetting are linked with adaption of tropical peat microbial communities to degrade recalcitrant lignocellulosic materials.

Drying-wetting mainly occur owing to low water table depths and high rainfall patterns, such as, in tropical peatlands. In our microcosm study which demonstrated that there was no effect on CO_2 emissions upon rewetting, shows linkage of fluctuations of water table with peat oxidation. In a study from farmed organic soils in temperate region, it is shown that CO_2 emission rates increased up to 5-fold following wetting (Prieme and Christensen, 2001). In a field study from Kalimantan, it is reported that there was CO_2 emission were not lowered pre- and post-hydrological restoration (Jauhiainen *et al.,* 2008). From our data both on laboratory-based microcosm and field-based study, shows that it is the direct anaerobic and aerobic CO_2 that dominates the large CO_2 production from this part of the world, rather than methane oxidation to CO_2. Hence, a combined approach of hydrological and microbial-based solution is needed to lower the peat oxidation in this region.

CONCLUSION

From this study, we conclude that elevated carbon dioxide emissions and negligible amount of methane emissions are attributed to low water table depths. At such low depth, there would be higher frequency of rewetting during rainfall events. We also show here that large amount of CO_2 emissions from this region is attributed to high amount CO2 production from both aerobic and anaerobic zones of peat, rather than CH_4 oxidation to CO_2. Lastly, it can be concluded that metabolic functions, such as, metabolism of aromatic compounds, amino acids, xenobiotics and carbohydrate metabolism that are distributed among diverse taxa are likely to govern the changes (non-reduced CO_2 emissions) upon rewetting.

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REFERENCES

1. Battin, T. J., Kaplan, L. A., Findlay, S., Hopkinson, C. S., Marti, E., Packman, A. I., Newbold, J. D., and Sabater, F.: Biophysical controls on organic carbon fluxes in fluvial networks, *Nature Geoscience*, 1, 95 – 100, 2008.
2. Benke, P. I., Vinay Kumar, M. C. S., Pan, D., and Swarup, S.: A mass spectrometry-based unique fragment approach for the identification of microcystins, *The Analyst*, 140, 1198-206, 2015.
3. Chapman, S. J. and Gray, T. R. G.: Importance of cryptic growth, yield factors and maintenance energy in models of microbial growth in soil, *Soil Biology and Biochemistry*, 18(1), 1–4, 1986.
4. Couwenberg, J. and Hooijer, A.: Towards robust subsidence-based soil carbon emission factors for peat soils in south-east Asia, with special reference to oil palm plantations, *Mires and Peat*, 12, 1–13, 2013.
5. Couwenberg, J., Dommain, R., and Joosten, H.: Greenhouse gas fluxes from tropical peatlands in south-east Asia, *Global Change Biology*, 16, 1715–1732, 2010.
6. Fontaine, S., Bardoux, G., Abbadie, L. and Mariotti, A.: Carbon input to soil may decrease soil carbon content: Carbon input in soil carbon sequestration, *Ecology Letters*, 7(4), 314–320, 2004.
7. Hooijer, A., Page, S. E., Jauhiainen, J., Lee, W. A., Lu, X. X., Idris, A., and Anshari, G.: Subsidence and carbon loss in drained tropical peatlands, *Biogeosciences*, 9, 1053–1071, 2012.
8. Jauhiainen, J., Hooijer, A., and Page, S. E.: Carbon dioxide emissions from an Acacia plantation on peatland in Sumatra, Indonesia, *Biogeosciences*, 9, 617-630, 2012.
9. Jauhiainen, J., Limin, S., Silvennoinen, H. and Vasander, H.: Carbon dioxide and methane fluxes in drained tropical peat before and after hydrological restoration, *Ecology*, 89(12), 3503–3514, 2008.
10. Jauhiainen, J., Takahashi, H., Heikkinen, J. E. P., Martikainen, P. J., and Vasander, H.: Carbon fluxes from a tropical peat swamp forest floor, *Global Change Biology*, 11, 1788–1797, 2005.
11. Joosten H.: The Global Peatland CO_2 Picture: Peatland status and drainage related emissions in all countries of the world, *Wetlands International Ede*, August 2010.
12. Karki, S., Elsgaard, L., and Lærke, P. E.: Effect of reed canary grass cultivation on greenhouse gas emission from peat soil at controlled rewetting, *Biogeosciences*, 12, 595–606, 2015
13. Mishra, S., Lee, W. A., Hooijer, A., Reuben, S., Sudiana, I. M., Idris, A., and Swarup, S: Microbial and metabolic profiling reveal strong influence of water table and land-use patterns on classification of degraded tropical peatlands, *Biogeosciences*, 11, 1727-1741, 2014.
14. Page, S. E., Rieley, J. O., and Banks, C. J.: Global and regional importance of the tropical peatland carbon pool, *Global Change Biology*, 17, 798–818, 2011.
15. Prieme, A., and Christensen, S.: Natural perturbations, drying-wetting and freezing-thawing cycles, and the emission of nitrous oxide, carbon dioxide and methane from farmed organic soils, *Soil Biology & Biochemistry*, 33, 2083-2091, 2001
16. Schimel, J., Balser, T. C. and Wallenstein, M.: Microbial stress-response physiology and its implications for ecosystem function, *Ecology*, 88(6), 1386–1394, 2007.
17. Sharma, S., Szele, Z., Schilling, R., Munch, J. C. and Schloter, M.: Influence of Freeze-Thaw Stress on the Structure and Function of Microbial Communities and Denitrifying Populations in Soil, *Applied and Environmental Microbiology*, 72(3), 2148–2154, 2006.
18. Tate, R. L.: Effect of flooding on microbial activities in organic soils: Carbon metabolism, *Soil Science*, 128, 267 – 273, 1979.
19. Wood, J. M., Bremer, E., Csonka, L. N., Kraemer, R., Poolman, B., Heide, T., and Smith, L. T.: Osmosensing and osmoregulatory compatible solute accumulation by bacteria, *Comparative Biochemistry and Physiology Part A*, 130, 437-460, 2001.