Title
Community Interactions In Tropical Forest Restoration And Environmental Governance In The Panama Canal Watershed

Author
Schweizer, Daniella

Publication Date
2012

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA

SANTA CRUZ

COMMUNITY INTERACTIONS IN TROPICAL FOREST RESTORATION AND ENVIRONMENTAL GOVERNANCE IN THE PANAMA CANAL WATERSHED

A dissertation submitted in partial satisfaction
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

In

ENVIRONMENTAL STUDIES

By

Daniella M. Schweizer
August 2012

The Dissertation of Daniella M. Schweizer
is approved:

Professor Karen D. Holl

Professor Gregory S. Gilbert, Chair

Professor Jeffrey T. Bury

Professor Mark S. Ashton

Tyrus Miller
Vice Provost and Dean of Graduate Studies

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

COMMUNITY INTERACTIONS IN TROPICAL FOREST RESTORATION AND ENVIRONMENTAL GOVERNANCE IN THE PANAMA CANAL WATERSHED

Daniella M. Schweizer

ABSTRACT

Increased global awareness of the loss of environmental services that derive from deforestation has triggered calls to promote the recovery of tropical forests. I studied two types of community interactions in tropical forest restoration. The first two chapters present the results of applying tools from phylogenetic ecology to tropical forest restoration. I hypothesized that negative biotic interactions, driven mainly by shared deleterious symbionts, would reduce the natural recruitment of closely related species and the performance of planted seedlings beneath a small monoculture tree canopy. I found non-random phylogenetic structure among coexisting natural recruits, and between them and the overstory trees. The natural recruits beneath legume trees were composed mainly of species further related to each other and to the overstory tree than expected by chance (phylogenetically overdispersed), whereas natural recruits beneath non-legume tree species were more closely related to each other than expected (phylogenetically clustered). This pattern was due to the disproportionate recruitment of Piperaceae, an ancestral clade to all other species, under legume canopies; versus abiotic filters beneath non-legumes leading to dominance of the more recently evolved Asteraceae. In planting experiments, I found the lowest performance on seedlings of the same species as the overstory tree. It was not clear whether the decreased performance of conspecifics was driven by shared pathogens with the overstory because there was no significant

phylogenetic signal in host sharing among pathogens. These results suggest that phylogenetic ecology provides some useful information about community assembly processes during tropical forest succession that can guide selection of which species to plant. Finally, I assessed a multi-stakeholder governance regime implemented by the Panamanian Government aimed at achieving sustainable development of the Panama Canal Watershed. I found the governance regime creates important spaces for environmental education and communication between the communities and government actors led by top-down power dynamics. However, tangible results are still mostly lacking. The local communities expressed frustration with the lack of projects and quality of life improvements to date, and the Panama Canal Authority struggles to achieve greater collaboration from other government institutions to solve pressing social issues in the watershed.
KEY WORDS: Phylogenetic Ecology, Tropical Forest Restoration, Community Assembly, Enrichment Planting, Political Ecology, Environmental Governance, Panama.

ACKNOWLEDGEMENTS

My journey as a doctoral student was filled with great mentors, collaborators, and the support of family and friends without whom I would not be completing this dissertation today. First and foremost, I am deeply grateful to my two advisors, Karen Holl and Gregory Gilbert. I admire Karen and Greg's commitment to their students; they were always available to discuss aspects of my research, to guide me through the writing process, and to respond to innumerable email correspondence. Greg and Karen complimented each other very well. Greg would always push me a little further into owning my research by deepening my understanding of the system of work, the subject area and the data analysis; I deeply cherish his guidance through all aspects of my dissertation. Karen blends very well the depth of academic research with the pragmatism needed to make sure her students complete in a timely manner. I am also thankful to the rest of my Dissertation Committee members. Professor Jeffrey Bury, from the Environmental Studies Department of UCSC, provided me with important guidance and direction for the conduction of the social science chapter. Professor Mark Ashton, from the School of Forestry and Environmental Studies of Yale University, was always available to provide me with important comments and suggestions throughout. I owe special thanks to Professors Pete Raimondi and Andrew Mathews from UCSC for their unconditional guidance and support. I would like to thank the Gilbert and Holl Labs, and the Political Ecology Working Group for countless reviews of my dissertation chapters and for their valuable feedback. The staff in Environmental Studies was always extremely helpful to me. Overall, my experience in an Interdisciplinary Graduate Program has been truly enriching thanks to the commitment to interdisciplinary teaching of the entire Faculty.

The conduction of my work in Panama was made possible by Jefferson Hall from the Smithsonian Tropical Research Institute, who not only allowed me to conduct my research in one of the field sites of the PRORENA Native Species Reforestation Project, but also supported my research with the project's nursery facilities and field maintenance staff. Smithsonian Scientist, Joseph Wright, provided me with important logistic and academic advise. The Smithsonian Tropical Research Institute was instrumental for my research thanks to their short-term funding and research facilities. I am grateful to my outstanding Panamanian field assistants, Isis Lopez and Natalia Sarco, who endured numerous hours of work in the field never loosing their energy and spirit. Professor Gregory Gilbert and Justin Cummings were also of immense help in the field, providing key research-based conversations at the site. The social science aspect of this dissertation was possible thanks to the support of the staff from the Panama Canal Authority. I am deeply thankful to the communities in the Canal Watershed who were willing to participate in my interviews.

To my friends at the Environmental Studies Department, especially my "Cohort Awesome", thanks for being there for me and for all the great times shared. Last but not least, immense thanks to my family for their unconditional love and support. My husband Carlos showed me what true love means with his never ending patience, understanding, and the great advice that only he could provide me. My family in Venezuela, despite the long physical distance, felt very close to me all these years.

The financial support to conduct this research came from various sources. The former STEPS Institute for Innovation in Environmental Research at UCSC made the vast majority of my research possible by supporting me since the beginning of my Graduate Studies. The Environmental Studies Department, The Center for Tropical Research in Ecology, Agriculture and Development (CenTREAD) and the Smithsonian Tropical Research Institute all financially contributed to this effort.

INTRODUCTION

Loss of tropical forest cover due to anthropogenic causes such as cattle ranching, agriculture, and logging has been well documented (e.g., Laurance *et al.*, 2004; Laurance, 2007; Rodriguez *et al.*, 2012; Sangermano *et al.*, 2012). Increased global awareness of the loss of environmental services due to deforestation has triggered calls to promote the recovery of tropical forests; placing great importance on the science and practice of restoration ecology (Chazdon, 2008a; Palmer and Filoso, 2009). Currently, forest restoration is still conducted at small scale and mostly by governments or for scientific purposes. To achieve the wider adoption of forest restoration required for recovering some of the forest cover lost, increased scientific research of forest restoration ecology must be paired with the study of socio-economic and political conditions conducive to forest restoration (Holl and Howarth, 2000; Chazdon, 2008a). In my dissertation I studied two types of community interactions in forest restoration: the phylogenetic (evolutionary) relationships among tree species in a restoration setting and the interactions among community and government actors within the multi-stakeholder governance regime of the Panama Canal Watershed.

Once tropical forests are cut down, aggressive pasture grasses are either planted for forage or colonize naturally, leading to a grass-dominated ecosystem where grasses persist mainly due to low dispersal of forest seeds (Holl, 1999; Suding *et al.*, 2004). The predominant method employed to restore tropical forests on grass-dominated areas consists of planting native tree seedlings, also known as nurse-based restoration, and managing them until they develop a closed canopy (Verdu *et al.*, 2012). The initial tree canopy eliminates light-demanding pasture grasses that compete with tree seedlings, and promotes seed dispersal, which can facilitate the establishment of forest species (Kuusipalo *et al.*, 1995; Parrota *et al.*, 1997; Holl *et al.*, 2000). However, some old-growth forests species, with large, animal-dispersed seeds, are very slow to recruit or do not arrive in plantations due to lack of dispersal (Aide *et al.*, 2000). In these cases, direct seeding or planting seedlings can be employed to introduce the missing species (Bonilla-Moheno and Holl, 2010; Cole *et al.*, 2011).

The goal of tropical forest ecological restoration is to aid the succession of the forest system toward a reference old growth forest. However, the identity of the initially planted tree species can alter the direction of succession by affecting natural recruitment rates, species composition, and survival of enrichment planted seedlings (e.g., Powers *et al.*, 1997; Paquette *et al.*, 2006; Keefe *et al.*, 2009). Traditionally, researchers have evaluated the effects of planted species using a species-by-species approach (e.g., Guariguata *et al.*, 1995; Carnevale and Montagnini, 2002). This approach has been very useful, but inferences are limited to the species studied.

Recent advances in phylogenetic (evolutionary) ecology may provide useful tools to develop a general framework of species performance in restoration sites. In addition, the study of the phylogenetic diversity in restored sites can be a better measure of functional diversity than species richness (Cadotte *et al.*, 2009). Higher phylogenetic and thus functional diversity is desired in restored areas, since it may confer increased provision of ecosystem services, such as productivity and resilience in the face of climate change (Forest *et al.*, 2007; Cadotte *et al.*, 2009; Cavender-Bares *et al.*, 2009).

Closely related species are phenotypically similar, and thus possess similar ecological requirements (Darwin, 1859; Gomez *et al.*, 2010; Burns and Strauss, 2011).

Similarities among closely related plants are due to the evolutionary conservatism of functional traits (Blomberg *et al.*, 2003; Chazdon *et al.*, 2003; Gilbert and Webb, 2007). This similarity allows the use of evolutionary relationships among species as a proxy to infer species shared traits and likely expected performance, and as a guide to understanding the process of community assembly. A phylogenetic ecology approach allows inferences about species niches without evaluating the whole suite of relevant functional traits (Lawing and Polly, 2011; Baraloto *et al.*, 2012; Stevens *et al.*, 2012).

If species in a community are more closely related than what chance recruitment from the regional species pool would predict, the community is referred to as "phylogenetically clustered" This pattern can arise when environmental filters act upon conserved traits (e.g., Green *et al.*, 2011; Fine and Kembel, 2011; Baraloto *et al.*, 2012; Merwin *et al.*, 2012). On the other hand, negative biotic interactions (*e.g.,* competition and diseases) among close relatives are expected to lead to "phylogenetically overdispersed" communities comprised of distant relatives (e.g., Cavender-Bares *et al.*, 2004; Losos, 2008). Empirical findings range from communities with no phylogenetic signal (e.g., Swenson *et al.*, 2012) to communities showing strong phylogenetic structure (e.g*.,* Anderson *et al.*, 2004; Cavender-Bares *et al.*, 2004; Lovette and Hochachka, 2006; Kraft *et al.*, 2007; Kraft *et al.*, 2008; Gotzenberger *et al.*, 2012). This range can be due to variation in the processes that govern community assembly in space and scale, and the possibility of both, environmental filtering and negative biotic interactions, acting in parallel on a community (Helmus *et al.*, 2007).

Phylogenetic approaches have been employed mostly in old-growth forests with growing research on phylogenetic structure and diversity in disturbed forests (Letcher, 2010; Arroyo-Rodriguez *et al.*, 2012; Swenson *et al.*, 2012). Letcher, (2010) studied the changes in phylogenetic structure of tropical forests during succession after disturbance and found a tendency toward overdispersion that points to the prevalence of abiotic factors driving community assembly during succession. A recent meta-analysis showed the importance of phylogenetic relatedness in the performance of seedlings growing in nurse-plant restoration projects; restoration projects benefited from planting far relatives that facilitate each other. My dissertation adds to these results by assessing the phylogenetic structure of naturally recruiting species beneath small monoculture plantations (Chapter 1), and represents the first attempt to explicitly incorporate phylogenetic distance as a predictor of the performance and pest damage of tree seedlings planted beneath the plantation trees (Chapter 2).

The restoration ecology component of my dissertation was conducted in a deforested area of Soberania National Park in the Panama Canal Watershed, which had been recently reforested. This area had been used by "The Native Species Reforestation Project" (PRORENA) (research.yale.edu/prorena/) to assess the forestry potential of several native tree species and promote their use in forestry and reforestation (Wishnie *et al.*, 2007). I assessed which species had naturally recruited beneath the selected tree species and then enrichment planted the understories with a wide variety of tree seedling species that spanned across the range of evolutionary distances to the overstory trees.

In addition to scientifically based methodologies, tropical forest restoration requires a socio-political environment conducive to implementing restoration projects (i.e., government support and the participation of a variety of stakeholders). In the Panama Canal Watershed, funding from the Panamanian Government for water conservation, plus the development of a multi-stakeholder watershed governance regime are creating opportunities and spaces for interaction among actors that can promote the protection and restoration of forests.

The Panama Canal Watershed is an important feature of the global landscape, since it provides the water for a key component of the world's economy: the Panama Canal. A single Panamanian Government institution: The Panama Canal Authority, is in charge of overseeing the functioning of the canal and guaranteeing continuous water supply via the conservation of critical areas in the Watershed (Morris Carrera and Mendoza, 2002). To achieve its conservation mandate, the Panama Canal Authority developed a watershed governance regime, called the Integrated Watershed Management Plan that includes local communities that inhabit the watershed, non-governmental organizations, and local branches of government institutions. The plan aims to promote the interaction among all of these actors for more efficient policies and environmental outcomes around water conservation. In Chapter 3, I critically analyze the governance regime in place using a post-structural political ecology framework that focuses on the power dynamics among the different actors. I studied the positive aspects and challenges of the regime and the power dynamics at play.

My dissertation research involved in-depth study of two types of community interactions aimed at increasing forest cover and tree diversity in the Panama Canal Watershed. The intersection between the two community interactions lies in the application of novel ecologically based methods for forest restoration facilitated by socio-political spaces. The findings from my dissertation will be useful for both academic and applied audiences, which is the ultimate goal of the interdisciplinary graduate program in Environmental Studies at the University of California, Santa Cruz.

LITERATURE CITED

Aide, T. M., J. K. Zimmerman, J. B. Pascarella, L. Rivera, and H. Marcano-Vega. 2000. Forest regeneration in a chronosequence of tropical abandoned pastures: Implications for restoration ecology. Restoration Ecology **8**:328-338.

Anderson, M. T., M. Lachance, and W. T. Starmer. 2004. The relationship of phylogeny to community structure: the cactus yeast community. The American Naturalist **164**:709-721.

Arroyo-Rodriguez, V., J. Cavender-Bares, F. Escobar, F. P. L. Melo, M. Tabarelli, and B. A. Santos. 2012. Maintenance of tree phylogenetic diversity in a highly fragmented rain forest. Journal of Ecology **100**:702-711.

Baraloto, C., O. J. Hardy, C. E. T. Paine, K. G. Dexter, C. Cruaud, L. T. Dunning, M. A. Gonzalez, J. F. Molino, D. Sabatier, V. Savolainen, and J. Chave. 2012. Using functional traits and phylogenetic trees to examine the assembly of tropical tree communities. Journal of Ecology **100**:690-701.

Blomberg, S. P., T. , J. Garland, and A. R. Ives. 2003. Testing for phylogenetic signal in comparative data: behavioral traits are more labile. . Evolution **57**:717–745.

Bonilla-Moheno, M. and K. D. Holl. 2010. Direct seeding to restore tropical mature-forest species in areas of slash-and-burn agriculture. Restoration Ecology **18**:438-445.

Burns, J. H. and S. Y. Strauss. 2011. More closely related species are more ecologically similar in an experimental test. Proceedings of the National Academy of Sciences of the United States of America **108**:5302-5307.

Cadotte, M. W., J. Cavender-Bares, D. Tilman, and T. H. Oakley. 2009. Using phylogenetic, functional and trait diversity to understand patterns of plant community productivity. Plos One **4**.

Carnevale, N. J. and F. Montagnini. 2002. Facilitating regeneration of secondary forests with the use of mixed and pure plantations of indigenous tree species. Forest Ecology and Management **163**:217-227.

Cavender-Bares, J., D. D. Ackerly, D. A. Baum, and F. A. Bazzaz. 2004. Phylogenetic overdispersion in Floridian Oak communities. The American Naturalist **163**:823-843.

Cavender-Bares, J., K. Kozak, P. Fine, and S. W. Kembel. 2009. The merging of community ecology and phylogenetic biology. Ecology Letters **12**:693-715.

Chazdon, R. L. 2008a. Beyond deforestation: Restoring forests and ecosystem services on degraded lands. Science **320**:1458-1460.

Chazdon, R. L., S. Careaga, C. Webb, and O. Vargas. 2003. Community and phylogenetic structure of reproductive traits of woody species in wet tropical forests. Ecological Monographs **73**:331-348.

Cole, R. J., K. D. Holl, C. L. Keene, and R. A. Zahawi. 2011. Direct seeding of late-successional trees to restore tropical montane forest. Forest Ecology and Management **261**:1590-1597.

Darwin, C. 1859. The origin of species. Barnes and Noble Classics, New York. 480 pp.

Fine, P. V. A. and S. W. Kembel. 2011. Phylogenetic community structure and phylogenetic turnover across space and edaphic gradients in western Amazonian tree communities. Ecography **34**:552-565.

Forest, F., R. Grenyer, M. Rouget, T. J. Davies, R. M. Cowling, D. P. Faith, A. Balmford, J. C. Manning, S. Proches, M. van der Bank, G. Reeves, T. A. J. Hedderson, and V. Savolainen. 2007. Preserving the evolutionary potential of floras in biodiversity hotspots. Nature **445**:757-760.

Gilbert, G. S. and C. O. Webb. 2007. Phylogenetic signal in plant pathogen-host range. Proceedings of the National Academy of Sciences of the United States of America **104**:4979-4983.

Gomez, J. M., M. Verdu, and F. Perfectti. 2010. Ecological interactions are evolutionarily conserved across the entire tree of life. Nature **465**:918-921.

Gotzenberger, L., F. de Bello, K. A. Brathen, J. Davison, A. Dubuis, A. Guisan, J. Leps, R. Lindborg, M. Moora, M. Partel, L. Pellissier, J. Pottier, P. Vittoz, K. Zobel, and M. Zobel. 2012. Ecological assembly rules in plant communities-approaches, patterns and prospects. Biological Reviews **87**:111-127.

Green, W. A., G. Hunt, S. L. Wing, and W. A. DiMichele. 2011. Does extinction wield an axe or pruning shears? How interactions between phylogeny and ecology affect patterns of extinction. Paleobiology **37**:72-91.

Guariguata, M. R., R. Rheingans, and F. Montagnini. 1995. Early woody invasion under tree plantations in Costa Rica: Implications for forest restoration. Restoration Ecology **3**:252-260.

Helmus, M. R., K. Savage, M. W. Diebel, J. T. Maxted, and A. R. Ives. 2007. Separating the determinants of phylogenetic community structure. Ecology Letters **10**:917-925.

Holl, K. D. 1999. Factors limiting tropical rain forest regeneration in abandoned pasture: Seed rain, seed germination, microclimate, and soil. Biotropica **31**:229-242.

Holl, K. D. and R. B. Howarth. 2000. Paying for restoration. Restoration Ecology **8**:260-267.

Holl, K. D., M. E. Loik, E. H. V. Lin, and I. A. Samuels. 2000. Tropical montane forest restoration in Costa Rica: Overcoming barriers to dispersal and establishment. Restoration Ecology **8**:339-349.

Keefe, K., M. D. Schulze, C. Pinheiro, J. C. Zweede, and D. Zarin. 2009. Enrichment planting as a silvicultural option in the eastern Amazon: Case study of *Fazenda Cauaxi*. Forest Ecology and Management **258**:1950-1959.

Kraft, N. J. B., W. K. Cornwell, C. Webb, and D. Ackerly. 2007. Trait evolution. community assembly, and the phylogenetic structure of ecological communities. The American Naturalist **170**:271-283.

Kraft, N. J. B., R. Valencia, and D. D. Ackerly. 2008. Functional traits and niche-based tree community assembly in an amazonian forest. Science **322**:580-582.

Kuusipalo, J., G. Adjers, Y. Jafarsidik, A. Otsamo, K. Tuomela, and R. Vuokko. 1995. Restoration of natural vegetation in degraded *Imperata cylindrica* grassland - understorey development in forest plantations. Journal of Vegetation Science **6**:205-210.

Laurance, W. F. 2007. Forest destruction in tropical Asia. Current Science **93**:1544-1550.

Laurance, W. F., A. K. M. Albernaz, P. M. Fearnside, H. L. Vasconcelos, and L. V. Ferreira. 2004. Deforestation in Amazonia. Science **304**:1109-1109.

Lawing, A. M. and P. D. Polly. 2011. Pleistocene Climate, Phylogeny, and Climate Envelope Models: An Integrative Approach to Better Understand Species' Response to Climate Change. Plos One **6**:e28554.

Letcher, S. G. 2010. Phylogenetic structure of angiosperm communities during tropical forest succession. Proceedings of the Royal Society B-Biological Sciences **277**:97-104.

Losos, J. B. 2008. Phylogenetic niche conservatism, phylogenetic signal and the relationship between phylogenetic relatedness and ecological similarity among species. Ecology Letters **11**:995-1003.

Lovette, I. J. and W. M. Hochachka. 2006. Simultaneous effects of phylogenetic niche conservatism and competition on avian community structure. Ecology **87**:S14-S28.

Merwin, L., T. H. He, and B. B. Lamont. 2012. Phylogenetic and phenotypic structure among Banksia communities in south-western Australia. Journal of Biogeography **39**:397-407.

Morris Carrera, J. A. and J. D. Q. Mendoza. 2002. Los actores sociales en el proyecto de ampliacion del canal y el desarrollo economico social en la llamada cuenca occidental. Tesis. Universidad de Panama. Facultad de Humanidades. Escuela de Sociologia. 162 pp.

Palmer, M. A. and S. Filoso. 2009. Restoration of ecosystems services for environmental markets. Science **325**:575-576.

Paquette, A., A. Bouchard, and A. Cogliastro. 2006. Survival and growth of under-planted trees: A meta-analysis across four biomes. Ecological Applications **16**:1575-1589.

Parrota, J. A., J. w. Turnbull, and N. Jones. 1997. Catalyzing native forest regeneration on degraded tropical lands. Forest Ecology and Management **99**:1-7.

Powers, J. S., J. P. Haggar, and R. F. Fisher. 1997. The effect of overstory composition on understory woody regeneration and species richness in 7-year-old plantations in Costa Rica. Forest Ecology and Management **99**:43-54.

Rodriguez, N., D. Armenteras, R. Molowny-Horas, and J. Retana. 2012. Patterns and trends of forest loss in the Colombian Guyana. Biotropica **44**:123-132.

Sangermano, F., J. Toledano, and J. R. Eastman. 2012. Land cover change in the Bolivian Amazon and its implications for REDD plus and endemic biodiversity. Landscape Ecology **27**:571-584.

Stevens, R. D., M. M. Gavilanez, J. S. Tello, and D. A. Ray. 2012. Phylogenetic structure illuminates the mechanistic role of environmental heterogeneity in community organization. Journal of Animal Ecology **81**:455-462.

Suding, K. N., K. L. Gross, and G. R. Houseman. 2004. Alternative states and positive feedbacks in restoration ecology. Trends in Ecology & Evolution **19**:46-53.

Swenson, N. G., J. C. Stegen, S. J. Davies, D. L. Erickson, J. Forero-Montana, A. H. Hurlbert, W. J. Kress, J. Thompson, M. Uriarte, S. J. Wright, and J. K. Zimmerman. 2012. Temporal turnover in the composition of tropical tree communities: functional determinism and phylogenetic stochasticity. Ecology **93**:490-499.

Verdu, M., L. Gomez-Aparicio, and A. Valiente-Banuet. 2012. Phylogenetic relatedness as a tool in restoration ecology: a meta-analysis. Proceedings of the Royal Society Biological Sciences **279**.

Wishnie, M. H., D. H. Dent, E. Mariscal, J. Deago, N. Cedeno, D. Ibarra, R. Condit, and P. M. S. Ashton. 2007. Initial performance and reforestation potential of 24 tropical tree species planted across a precipitation gradient in the Republic of Panama. Forest Ecology and Management **243**:39-49.

CHAPTER 1

The phylogenetic ecology of natural regeneration beneath tropical tree plantations

ABSTRACT

Trees are often planted to establish an initial canopy and promote tropical forest recovery. Traditionally, research on how those planted trees impact later forest succession has taken a species-by-species approach. However, phylogenetic ecology can provide the tools to evaluate whether those findings can be extended to closely related species, given the evolutionary conservatism of species interactions. We assessed the evolutionary relations among different tree species planted in small monocultures and the species naturally recruiting beneath them. Our objectives were to ask 1) if closely related planted tree species resulted in similar species composition of naturally recruiting species, and 2) if the phylogenetic structure of coexisting species reflected a prevalence of negative species interactions among close relatives. We found that naturally recruiting communities under closely related overstory tree species in the Fabaceae were more similar to each other than expected by chance. It was not clear, however, whether the similarity was driven by broad phylogenetically conserved effects or was a specific effect of legumes. We predicted that negative biotic interactions would result in lower than random coexistence of close relatives, but the phylogenetic distance between most overstory tree species and the species recruiting beneath them did not show a significant deviation from randomly assembled communities. On the other hand, the phylogenetic structure among naturally recruiting species showed two non-random tendencies; species under legume overstory trees were more distantly related to each other than expected, whereas the species recruiting under non-legumes where more closely related. These non-random patterns were likely an effect of the preferential recruitment of the evolutionarily distant *Piper* clade under legumes, and of environmental filters under non-legumes, such as greater density of the invasive grass, *Saccharum spontaneum*. Our results show a weak, yet informative phylogenetic signal in the assemblage of communities under trees planted for restoration. This suggests that consideration of phylogenetic relationships in tropical forest restoration and succession studies is useful to shed light on community assembly processes.

KEY WORDS: phylogenetic ecology, restoration, species interaction, community assembly, tropical rain forest.

INTRODUCTION

In many areas of the tropics, forest recovery on deforested lands is hindered by competition with aggressive grasses and limited dispersal of forest species (Nepstad *et al.*, 1996; Holl *et al.*, 2000). One method that is often employed to restore tropical forests consists of planting tree species to establish canopies that will shade invasive grasses and create suitable conditions for the dispersal and natural recruitment of forest species (Kuusipalo *et al.*, 1995; Parrotta *et al.*, 1997; Holl *et al.*, 2000; Carnevale and Montagnini, 2002). When the goal is to direct succession toward a desired reference forest community, careful selection of which species to plant becomes important given that the identity of initially planted species affects the species composition of subsequent naturally recruiting species (Kuusipalo *et al.*, 1995; Parrotta, 1995; Haggar *et al.*, 1997). For example, in a reforestation trial in Costa Rica, more woody species recruited naturally under plantations of tree species in the genera *Vochysia* and *Leucaena* than under other planted species (Parrotta, 1995; Powers *et al.*, 1997). Typically, researchers studying how planting one or more species would affect subsequent succession assess the species composition, species richness, and abundance of naturally recruiting species under the planted species (e.g., Guariguata *et al.*, 1995; Powers *et al.*, 1997; Carnevale and Montagnini, 2002; Jones *et al.*, 2004). This approach has provided useful information on the successional impacts of a number of tested tree species, but it is difficult to use that information to create broadly applicable rules for species selection.

Recent advances in phylogenetic (evolutionary) ecology may provide useful tools for generalization. Closely related species are expected to interact with their environment in similar ways (Gomez *et al.*, 2010; Burns and Strauss, 2011); which are governed by evolutionarily conserved functional traits . This similarity among close relatives is called "phylogenetic signal" and forms the basis of phylogenetic ecology research (Webb, 2000; review by Emerson and Gillespie, 2008). Blomberg *et al.*, (2003) showed that a phylogenetic signal is ubiquitous among species for a wide range of morphological, physiological, behavioral, ecological and life history traits. In addition, a phylogenetic signal has been shown for plant reproductive traits (Chazdon *et al.*, 2003), pest susceptibility and defense mechanisms (Futuyma and Mitter, 1996; Farrell, 2001; Gilbert and Webb, 2007; Gossner *et al.*, 2009; Hill and Kotanen, 2009; Hill and Kotanen, 2011; Ness *et al.*, 2011), parasites host specificity (Mouillot *et al.*, 2006), and mycorrhizal functional traits (Maherali and Klironomos, 2007). The presence of a ubiquitous phylogenetic signal may allow predicting communities' assembly processes based on the phylogenetic structure of coexisting species, without data-intensive measurements of functional traits (Kraft and Ackerly, 2010).

Assuming the conservatism of ecologically important functional traits, communities can show two distinctive phylogenetic patterns, clustering and overdispersion. If coexisting species are closer together in the evolutionary tree than expected at random, they show "phylogenetic clustering"; if species in a community are less related than expected by chance, the pattern is called "phylogenetic overdispersion" (Webb, 2000). Various ecological and evolutionary mechanisms can lead to a given phylogenetic pattern (Losos, 2008; Cavender-Bares *et al.*, 2009). Conservation of traits important in niche preference (e.g., drought tolerance) should lead to phylogenetic clustering through habitat filtering (e.g., Tilman, 1994; Weiher *et al.*, 1998, Cavender-Bares *et al.*, 2006; Merwin *et al.*, 2012). In contrast, phylogenetic overdispersion can result from negative biotic interactions among close relatives such as competitive exclusion or limiting similarity (e.g., Lovette and Hochachka, 2006; Helmus *et al.*, 2007; Wilson and Stubbs, 2012) or the sharing of pests and pathogens (Webb *et al.*, 2006). Research has shown facilitative interactions occur among closely related species, but negative interactions tend to prevail (Valiente-Banuet and Verdu, 2007; Valiente-Banuet and Verdu, 2008; Verdu *et al.*, 2009; Sargent *et al.*, 2011).

Negative species interactions are important drivers of species composition in tropical forests. Negative interactions among conspecific seedlings, mediated by shared species-specific pests and pathogens, led to the Janzen-Connell hypothesis of seedlings density-dependent mortality at high densities and in close proximity to a parent tree (Janzen, 1970; Connell, 1971). Several studies have found evidence of this hypothesis operating in tropical forests, and have suggested this mechanism can be important in explaining the high species diversity found in these ecosystems (e.g., Clark and Clark, 1984; Gilbert *et al.*, 1994; Bell *et al.*, 2006; Bagchi *et al.*, 2010; Metz *et al.*, 2010; Swamy and Terborgh, 2010; Paine *et al.*, 2012). Recent findings by Gilbert and Webb, (2007) of high evolutionary conservatism in disease susceptibility among tropical plant species suggests diseases could further structure species composition by affecting not only conspecifics, but other closely related species as well. Most of the evidence, however, comes from old-growth forests where processes of recruitment and survival are different than in secondary forests. The tools and concepts of phylogenetic ecology have not been applied in a restoration or reforestation context, despite calls to do so (Naeem, 2011). We aimed to fill this gap with the current study and to stimulate additional research on phylogenetic structure in restored communities. Our approach may provide a useful framework to predict how a broad range of species is likely to influence subsequent succession based on information from well-tested species.

In this research, we studied natural recruitment under a suite of small monocultures of tree species planted as trials for native trees reforestation of grass-invaded tropical lands. We wanted to test (1) if closely related planted tree species fostered similar communities of naturally recruiting species, and (2) if the phylogenetic structure of coexisting species reflected a prevalence of negative species interactions among close relatives. We expected that the evolutionary conservatism of traits that determine species interactions (Gomez *et al.*, 2010) would lead closely related overstory tree species to develop similar communities of naturally recruiting species. For the second question, we expected to find fewer closely related species compared to a completely random community, due to negative biotic interactions among closely related species (Figure 1-1). We tested the second question at two levels. First, we looked at the phylogenetic distances between planted overstory tree species and the species recruiting beneath them (OS-NR analysis). Secondly, we looked at the phylogenetic structure of naturally recruiting species under each tree species (NR-NR analysis). This two level approach allowed us to assess negative interactions at two different yet related scales: that of the overstory tree on the naturally recruiting species, and that of naturally recruiting species on each other.

METHODS:

RESEARCH SITE — This project was conducted at the Smithsonian Tropical Research Institute and the Yale School of Forestry and Environmental Studies led

PRORENA project (The Native Species Reforestation Project) (http://research.yale.edu/prorena/) located in the Soberania National Park, in the watershed of the Panama Canal, Republic of Panama. Soberania National Park has a mean annual rainfall of 2226 mm and 4.1 dry months annually (defined as months with <100 mm rainfall) (Wishnie *et al.*, 2007). Soberania National Park overlies tropical ultisols that are predominantly clay or silty clays (Park *et al.*, 2010).

Most of Soberania National Park is covered by secondary tropical rain forest. The study site, however, had been deforested before the 1960s and then farmed for several decades. In 2003, when the PRORENA project began, the site had not been farmed for at least 10 years, during which time it was invaded by the exotic grass *Saccharum spontaneum* L. subsp. *spontaneum* (Wishnie *et al.*, 2007). This grass has invaded extensive deforested areas along the Panama Canal and significantly arrests forest recovery unless trees that can provide shade to the grass are planted and cared for (Hooper *et al.*, 2002, Hooper, 2008).

NATURALLY RECRUITING SPECIES CENSUS — The PRORENA plots consist of 9 × 12-m single-species plots with three replicates per species randomly placed across the planting area. Plots were established to assess the reforestation and forestry potential of 22 native tree species and two exotic tree species (Wishnie *et al.*, 2007). The trees in each plot were planted in 2003 at an initial density of 20 trees, spaced at 3 m. For two years following planting, the understory was cleared of competing vegetation with machetes and the trees were sprayed with insecticide. After two years, the plots were thinned 50% so that a total of ten trees at 6-m spacing remained in each plot (Wishnie *et al.*, 2007). Subsequent mortality meant that by the time of the present experiment some of the plots, mainly of the species *Ochroma pyramidale,* had fewer than ten trees. We chose 12 species that showed good growth and/or an almost closed canopy during the rainy season (over 80% canopy cover) (Figure 1-2). Our selected species span the phylogenetic age ranges from confamilial (85 million years (MY) of independent evolution) to extra-ordinal (over 200 MY of independent evolution from the most closely related).

During July and August 2008, three years after understory clearing ceased and the canopy was thinned, we surveyed all plant species (except *Saccharum spontaneum*) that had naturally colonized the understory. We ran one 15-m long transect diagonally across each plot, and at every meter counted and identified all individuals that touched a 1.5-m tall stick at that meter. Most species were identified in the field, but some were collected for identification and to deposit voucher specimens at the University of Panama herbarium. To better characterize the naturally recruiting community, we gathered published information on growth form and dispersal syndrome for each species. The main source was a database compiled by the Smithsonian Tropical Research Institute (Wright, 2007; Wright *et al.*, 2010); other sources of trait data are listed in Appendix 1-1. Growth forms were classified following Wright (2007) and Wright *et* al., (2010), as: palms, grasses, climber, herb, and freestanding woody species. The latter were categorized based oon maximum adulthood heights of 5, 10, 20 and $\geq$30 m, respectively. Dispersal syndromes were classified as: bird, bats and birds, birds and insects, birds and terrestrial mammals, explosive seeds, gravity, and wind.

DATA ANALYSIS — Because the overstory species is the unit of interest for analysis, and because the density of naturally recruiting plants was often quite low, we combined the data from the three plots per overstory species. Despite the low density of natural recruits beneath some overstory species, we believe this to be mainly an outcome of the identity of the overstory tree species, and not simply a result of random seed dispersal; thus a factor of interest for us. Before combining we determined there was no correlation between similarity of species composition and distance between two plots (Mantel test, Z= 1629.7, P= 0.166). Individual-based rarefaction curves (Gotelli and Colwell, 2001) per overstory species did not reach an asymptotic number of naturally recruiting species. Analyses were conducted separately on all naturally recruiting species and including only those with over five individuals encountered per overstory species (all replicate plots combined, 18 of 63 species), to assess the extent to which results were driven by uncommon versus common species. Abundance data were square root transformed to reduce the weight of the most abundant species in all the analyses (Beals, 1984).

ANALYSIS OF NATURAL RECRUIT COMPOSITION SIMILARITY AMONG OVERSTORY TREE SPECIES — We conducted hierarchical clustering and non-metric multidimensional scaling (NMDS) ordination based on the Bray-Curtis dissimilarity matrices, on both the square root-transformed number of stems per plot and species presence/absence. These two analytical approaches are complementary for the analysis of community composition patterns (Brazner and Beals, 1997; Tonn *et al.*, 1990). We conducted the NMDS on two dimensions, with a stress value of 10.64. We chose the complete linkage algorithm for clustering, since it has been recommended for ecological communities when one needs to find clear separation of clusters (Legendre and Legendre, 1983). In our case, we wanted to test whether there were similarities in the vegetation communities recruiting under closely related overstory species. The number of groups was selected based on the reduction in the sums of squares within groups as number of groups increased (Pollard, 1981). The number of groups in which the within-samples difference stabilized (reached an asymptote) was chosen. The number of groups varied between three and four in all cases. Permutation Manovas (ADONIS) were conducted to test the significance of overstory species groupings. The ADONIS function partitions distance matrices into sources of variation and allows relating this variation to fixed or random sources (Legendre and Anderson, 1999; McArdle and Anderson, 2001).

We conducted indicator species analysis (Dufrene and Legendre, 1997) on the groups that resulted from the cluster analysis to determine whether there were naturally recruiting species that characterized each of the different groups. The indicator species index developed by Dufrene and Legendre (1997) takes the groups derived from hierarchical or non-hierarchical procedures and finds the species that characterize the groups by comparing their abundance and occurrence within groups. This index maximizes when a species is observed in all sites of a group and only in that group. For species presence/absence data, the index uses the number of species presences instead of the number of individuals. Univariate t-tests were conducted to evaluate if the characteristic species of each group were present in significantly higher abundance within groups. All data analyses were conducted in the R statistical software. Multivariate analyses were conducted using the Vegan package, version 1.17, and the indicator species analysis was conducted using the Labdsv package, version 1.6 (R-Development-Core-Team, 2009).

ANALYSIS OF COMMUNITY PHYLOGENETIC STRUCTURE — A phylogenetic tree (Figure 1-3) (see Newick file in Appendix 1-2) of all the naturally recruiting and overstory species was estimated using the Phylomatic tool implemented in the Phylocom program, version 4.2 (Webb and Donoghue, 2005 ,Webb et al. 2009, http://www.phylodiversity.net/phylocom/). Phylomatic maps the input community onto a resolved phylogenetic "megatree" of the angiosperms, which is a tree assembled by merging smaller phylogenies together. We used the most updated and maximally resolved angiosperm megatree, R20080417.new, based on APG3 phylogenies, which is available online at www.phylodiversity.net (previous trees available at http://svn.phylodiversity.net/tot/trees/). To reduce polytomies in our community phylogenetic tree, we used published phylogenies of all the families with polytomies and included the evolutionary relationships of tribes within those families to the original newick file (Appendix 1-3). We determined the ages of the interior nodes of the phylogeny using the BLADJ algorithm from Phylocom and evolutionary ages published by Wikstrom *et al.*, (2001). Following the construction of the tree, we calculated the phylogenetic distance matrix between all species using the Phylomatic software implemented in Phylocom.

OVERSTORY TO NATURAL RECRUIT PHYLOGENETIC STRUCTURE (OS-NR ANALYSIS) — To evaluate the structure of phylogenetic distances between the overstory species and the natural recruit community (OS-NR analysis), we compared the observed distances with those of a null community created by sampling at random 1000 times from the pool of natural recruit species sampled under all overstory tree species. The total number of individuals observed under a given overstory species was kept constant in the random communities created. The probability of sampling a species was weighted by its relative abundance. We plotted the observed and random quantiles of the cumulative distribution of naturally recruiting individuals against their phylogenetic distances to the overstory tree species. We used 95% confidence intervals of the null distribution to evaluate whether close relatives to the overstory species were observed less frequently than expected by chance (Figure 1-4). The reasoning behind this is that a phylogenetic signal resulting from negative biotic interactions, such as shared disease susceptibility, should have the greatest impact among conspecific, congeners, or confamilials (Gilbert and Webb, 2007).

For the construction of the null communities, we chose as the community pool all the species sampled in all the plots instead of the more common approach of using a regional list of species. Choosing species known to be able to establish in a site should improve the power of phylogenetic tests for detecting phylogenetic structure (Swenson, 2009; Kraft and Ackerly, 2010). Some overstory tree species had conspecific seedlings recruiting under them. Because these conspecific seedlings likely came from the overstory tree dropping seeds, they are skipping the dispersal filter faced by the rest of the species and do not properly form part of the overall pool of natural recruits. Therefore, we report the analysis without conspecifics in the data set.

PHYLOGENETIC STRUCTURE AMONG NATURALLY RECRUITING SPECIES — We evaluated the phylogenetic structure among naturally recruiting species under each overstory tree species (NR-NR analysis) using two phylogenetic indices developed by Webb (2000). These indices are based on the distance (in millions of years) that separates taxa in a phylogenetic tree. The two metrics are the net relatedness index (NRI) and the nearest taxon indexes (NTI), which are the observed Mean Phylogenetic Distance (MPD) and the Mean Nearest Taxon Distance (MNTD) standardized to those measures estimated from 1000 random communities. MPD is the average distance between all pairs of taxa in the phylogenetic tree and is a measure of phylogenetic structure for the community as a whole. MNTD estimates the distance between each taxa and its closest neighbor on the tree; therefore, it is a metric of the relatedness at the tips of the phylogeny (Webb, 2000). The random communities were generated using the species pool explained above, keeping observed plot abundance, and weighting species selection by its abundance. The formulas of each index are:

$$NRI: -1 \times ((MPD_{observedPD} – Mean\ MPD_{nullPD})/sd\ MPD_{nullPD})$$

$$NTI: -1 \times ((MNTD_{observedPD} – Mean\ MNTD_{nullPD})/sd\ MNTD_{nullPD})$$

We estimated these indices using the Picante package version 0.7.2 (R-Development-Core-Team, 2009, Kembel *et al.*, 2010). We multiplied the output by -1 to match the indices created by Webb (2000). A positive index value indicates phylogenetic clustering and a negative value phylogenetic overdispersion. We estimated 95% confidence intervals of the null community to determine the significance of the indices. The NTI is sensitive to tree topology (Letcher, 2010); therefore, interpretations of this index must pay attention to polytomies occurring within families. However, it has greater power to pick up phylogenetic structure than NRI if traits are conserved (Kraft *et al.*, 2007).

RESULTS

GENERAL CHARACTERISTICS OF NATURALLY RECRUITING SPECIES — We found 63 plant species from 29 different families recruiting in the understories of the planted overstory tree species. The most commonly surveyed families were Fabaceae (9 species) and Asteraceae (9 species), followed by Rubiaceae (5 species) and Piperaceae (4 species) (Appendix 1-1). Woody plants over 10 m tall were the most common growth form (34% of all species). Zoochory was the most common dispersal syndrome (66% of all species). Within this dispersal syndrome, most individuals were exclusively bird dispersed (22%). Dispersal by birds and bats was restricted to species of the genus *Piper* (4 species and 14% of all individuals).

NATURAL RECRUIT COMPOSITION SIMILARITIES AMONG OVERSTORY TREE SPECIES — Multivariate analyses showed that the identity of the overstory tree species planted affected the composition of naturally recruiting species. Specifically, naturally recruiting species beneath overstory trees in the Fabaceae family were more similar to each other than to those beneath other tree species (All species, ADONIS, $F_{1,10}$=2.1, P = 0.006; common species, ADONIS, $F_{1,10}$=2.4, P= 0.025) (Figure 1-5). Other closely related overstory tree species (e.g., Bombacaceae species *Ochroma pyramidale* and *Pachira quinata*) did not show comparable groupings of compositional similarity among naturally recruiting species. Appendix 1-4 shows additional variables we looked at which were not significant at explaining naturally recruiting species composition differences.

Three naturally recruiting species were characteristic of Fabaceae plots*, Piper marginatum, Miconia argentea,* and *Desmodium axillare*. Fabaceae species had significantly more individuals of *Piper* species recruiting under them that did other overstory tree species (Mean Fabaceae= 20.5 ± 7.3, mean other overstory species= 3.75 ± 2.8, Welch $t.test_{3.5}$= 4.4, P =0.01613). The other overstory tree species formed three distinct groups based on sharing a specific naturally recruiting species, but not based on phylogenetic proximity. For example, the group formed by *Tectona grandis* and *Ochroma pyramidale* was characterized by recruitment of the understory herb *Mimosa casta*, which appeared exclusively under these two overstory species (Figure 1-5).

COMMUNITY PHYLOGENETIC STRUCTURE — In the analysis of phylogenetic distances between overstory tree species and their naturally recruiting species (OS-NR analysis), we found a tendency toward overdispersion for the overstory tree species: *Acacia mangium, Gliricidia sepium,* and *Inga punctata* (Figure 1-6). This trend was due to the presence and abundance of recruits over 200 million years of independent evolution from the overstory tree species (Figure 1-3). Several species had conspecific seedlings recruiting under them (*Diphysa americana, Spondias mombin, Tectona grandis*, *Cordia alliodora,* and *Terminalia amazonia*), which resulted in significant phylogenetic clustering that disappeared once conspecifics were removed from the dataset (Figure 1-6, Appendix 1-5). All of these species showed a tendency toward fewer recruits over 200 MY than expected by chance. Only *Pachira quinata* showed phylogenetic clustering, driven by recruitment of the heterospecific species, *Helicteres guazumifolia,* located at 76 MY of distance from it.

The phylogenetic structure among naturally recruiting species (NR-NR analysis) showed two distinctive tendencies: 1) overdispersion beneath most overstory tree species in the Fabaceae family, and 2) clustering beneath the other overstory tree species (Figures 1-7A and 1-7B). Overdispersion is a result of the abundant recruitment of individuals of

Piper species, which are distantly related to the rest of the naturally recruiting species. Clustering among naturally recruiting species is a result of the dominance by species of the genus Asteraceae. For some overstory species, analysis of the phylogenetic structure of the whole community (NTI) showed a trend opposite that of the phylogenetic structure at the tips of the phylogeny (NRI). For example, *Ochroma pyramidale* and *Tectona grandis* species showed a strong overdispersion on the NTI and clustering on the NRI. This reflects having few species recruiting under those two overstory tree species and thus few opportunities for the nearest neighbor measure (NRI) to include more closely related pairs of species than expected by chance.

DISCUSSION

GENERAL OVERVIEW — The main objective of the present study was to test whether phylogenetic relationships provide useful information about likely successional trajectories following the planting of trees for restoration of tropical forests. We found similarity in composition of naturally recruiting species with phylogenetic proximity only for those overstory tree species in the Fabaceae family, and similarity did not show a continuous decline with phylogenetic distance. Therefore, we cannot conclude whether the similarities were driven by shared phylogenetic descent beyond the legume versus non-legume comparison. The phylogenetic distance structure between overstory tree species and the species recruiting beneath them (OS-NR analysis) was not different from random for most species. However, the phylogenetic distance structure among naturally recruiting species differed from a completely random assembly of coexisting species for most overstory tree species. Our results show a weak, yet informative phylogenetic signal in the assemblage of communities under trees planted for restoration. This suggests that further work on phylogenetic relationships may be useful in choosing which species to plant for tropical forest restoration.

NATURAL RECRUIT COMPOSITION SIMILARITIES AMONG OVERSTORY TREE SPECIES — The species composition of the natural recruitment communities reflected early successional stages of a forest, with abundant lianas, herbs and shrubs (Guariguata and Ostertag, 2001), and a predominance of zoochorous seeds (Parrotta, 1995; Kuusipalo *et al.*, 1995; Jones *et al.*, 2004; Cole *et al.*, 2010). Communities recruiting under the four legume overstory tree species were notably more similar to each other than to communities developing under other overstory species. A characteristic genus recruiting under Fabaceae trees was *Piper*. A previous study in Costa Rica found *Piper* species were important early recruiters in plantations, although not exclusively found under legume species (Guariguata *et al.*, 1995; Cusack and Montagnini, 2004). In our study site, *Piper* species were nearly absent under non-legume overstory species.

We did not test for mechanisms that would explain the presence and abundance *Piper* species exclusively under legumes. However, research has found that neotropical bats of the genus *Carollia,* which are *Piper* specialists, utilizes human-modified agrarian landscapes where legumes are often employed as live fences or as shade for coffee and cacao (Estrada and Coates-Estrada, 2001; Estrada and Coates-Estrada, 2002). Birds, which are also *Piper* dispersers, visited more and stayed longer in tropical forest restoration sites with legume trees than either scattered plantings or pasture controls (Zahawi and Augspurger, 2006; Fink *et al.*, 2009; Cole *et al.*, 2010; Crampton *et al.*, 2011). Visitation of bats and birds to the exotic *Acacia mangium* has not been reported for neotropical areas. However, literature from Australia and Kenya report use of Acacia trees as roosting sites by bats (Law and Anderson, 2000; Webala *et al.*, 2004). In addition, in a study site close to ours, results show that birds are attracted to high trees, with large and complex crowns, such as all legume trees used in this study (Jones *et al.*, 2004). In addition to dispersal, community interactions among species could be facilitating the recruitment and survival of *Piper* species under legumes and deterring it under non-legumes. *Piper* species do not germinate or survive well in conditions of low light or low red light to far-red light ratios (R:FR) (Vazquez-Yanes and Orozco-Segovia, 1992 Orozco-Segovia *et al.*, 1993), which might explain the absence of *Piper* below overstory trees where *Saccharum spontaneum* had reinvaded (Appendix 1-6), as light dependent species do not germinate well under this grass (Hooper, 2008).

We did not find a clear, continuous, relationship between the phylogenetic distance among overstory tree species and similarities in species naturally recruiting beneath them. Therefore, we cannot confirm whether naturally recruiting composition similarities were driven by phylogenetic proximity among the Fabaceae or were an effect specific to legumes. Studies have shown that in a restoration setting, legumes can affect the direction of succession by facilitating or inhibiting different species (Gosling, 2005; Del Moral and Rozzell, 2005), sometimes by altering nutrient cycling patterns compared to natural secondary forests (Celentano *et al.*, 2011). However, recent studies have provided evidence that closely related species are more ecologically and functionally similar, thus they tend to interact in similar ways with their abiotic and biotic environment (Swenson *et al.*, 2007; Parmentier and Hardy, 2009 Gomez *et al.*, 2010; Burns and Strauss, 2011). These findings and others highlight the role of phylogeny as an important predictor of plant-plant, and plant-disperser interactions (Gomez *et al.*, 2010; Donatti *et al.*, 2011; Verdu and Valiente-Banuet, 2011). Additional research focusing on closely related species pairs (e.g., congeners and confamilials) may provide broader evidence of a phylogenetic conservatism in the effects of trees on the composition of naturally recruiting species beneath them.

COMMUNITY PHYLOGENETIC STRUCTURE — We predicted an overdispersion pattern in the phylogenetic distances among species, based on the predominance of negative biotic interactions among close relatives (e.g., Cavender-Bares *et al.*, 2004; Webb *et al.*, 2006; Verdu *et al.*, 2009), and the importance that shared diseases and herbivores may have in driving the composition of natural forest communities (Gilbert and Webb, 2007; Parmentier and Hardy, 2009 Metz *et al.*, 2010; Ness *et al.*, 2011). In addition, overdispersion has been shown for forest communities in succession (Letcher, 2010).

We observed a tendency toward the expected overdispersion pattern for three legume overstory tree species, *Acacia mangium, Gliricidia sepium*, and *Inga punctata* in the OS-NR analysis, and beneath all legume overstories in the NR-NR analysis. We did not test for causal mechanisms of the overdispersion observed, and thus cannot rule out negative interactions. However, it is unlikely that the pattern observed would be due to negative interactions, because the significant overdispersion on the OS-NR analysis was due to frequent recruitment of far relatives (over 200 MY) to the overstories and not to lower than random presence of close relatives as expected from a negative interactions hypothesis (Figure 1-1). A more likely mechanism is dispersal and recruitment of *Piper* species, which are in a clade distantly related to all other clades in this study. Our natural recruitment communities were 2-years old at the time of the study; thus, the weak effect of negative interactions could be due to the early succession stage. In the early stages of succession, dispersal and abiotic conditions, not biotic interactions, are often stronger determinants of community composition. Biotic interactions become more important during the later stages of succession (Guariguata and Ostertag, 2001; Chazdon, 2008b).

The presence of conspecific recruits under some overstory tree species (OS-NR analysis) led to a significant clustering signal in the closer phylogenetic distances (Appendix 1-5). Once conspecifics were removed, we observed a tendency toward fewer far relatives than expected by chance; likely due to the absence of abundant *Piper* species recruits under the majority of those overstory tree species. Clustering was observed in the phylogenetic structure of natural recruit communities under non-legumes (NR-NR analysis). Filters to species colonization in disturbed areas lead to phylogenetic clustering among coexisting species (Verdu and Pausas, 2007; Dinnage, 2009). In our case, plots of *Ochroma pyramidale, Cordia alliodora,* and *Luehea seemannii* had been reinvaded by *Saccharum spontaneum* (Appendix 1-6), which creates conditions that strongly inhibit species recruitment and growth (Hooper *et al.*, 2004). *Tectona grandis* is known for restricting recruitment of native species in its understory due to allelopathic effects and poor seed disperser visitation (Healey and Gara, 2003). Our non-legume species were mostly colonized by species in the Asteraceae family. Many species from the Asteraceae family share the traits that allow them to overcome strong habitat filters; in particular being wind-dispersed allows them to disperse and colonize disturbed or recently restored habitats (Lavorel *et al.*, 1999; Diaz *et al.*, 2004; Cole *et al.*, 2010).

In this study we employed phylogenetic ecology methods in the context of natural recruitment beneath monoculture plantation trees. Our results show that beyond species-specific effects, there are some phylogenetic trends in the observed community assemblages. Results from the present study add to other studies that have shown that plants community assembly and succession dynamics are not independent of the evolutionary history of the species involved, which leads to deviations of community phylogenetic structures from random expectations (Webb *et al.*, 2002; Dinnage, 2009 Letcher, 2010; Silva and Batalha, 2010). This evidence supports the idea that phylogenetically guided species selection may prove useful in restoration. Future work would entail looking at more comparisons of planted overstory species within the same genus or family, and following natural recruitment communities through time to trace species composition changes to the phylogenetic relations of coexisting species.

FIGURES:

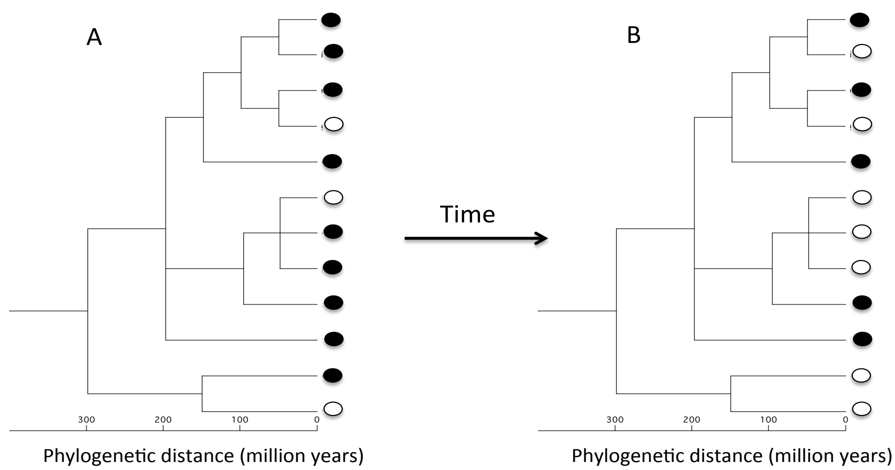


Figure 1-1 Diagram of the expected effect negative species interactions have on the phylogenetic structure of coexisting species. Filled circles are species present in the community, and empty circles are species absent from the community. At time zero, closely related species colonize a habitat and recruit (phylogenetic tree A), but as time passes, negative interactions among closely related species lead to the loss of some species and a resulting phylogenetic tree that lacks close relatives, which means the community is phylogenetically overdispersed (phylogenetic tree B).

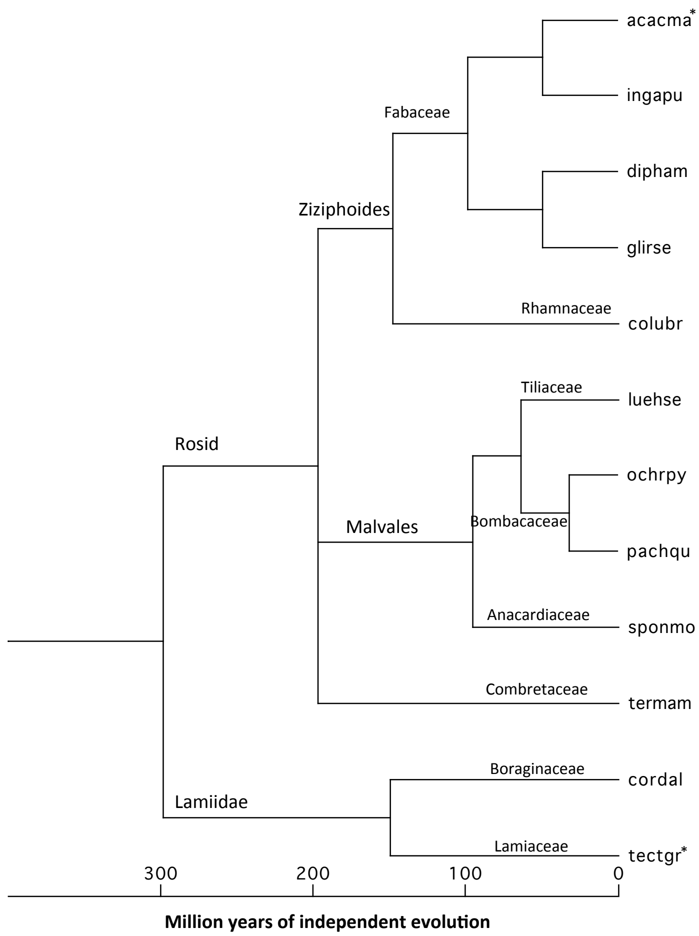


Figure 1-2. Phylogenetic tree of the overstory species selected for this study. Species Codes: Acacma: *Acacia mangium,* ingapu: *Inga punctata*, dipham: *Dyphisa americana*, , glirse: *Gliricidia sepium*, colubr: *Colubrina glandulosa*, luehse: *Luehea semmannii,* ochrpy: *Ochroma pyramidale,* pachqu: *Pachira quinata*, sponmo: *Spondias mombin*, termam: *Terminalia amazonia*, cordal: *Cordia alliodora*, tectgr: *Tectona grandis*. Asterisks denote the two exotic species present in the plantation.

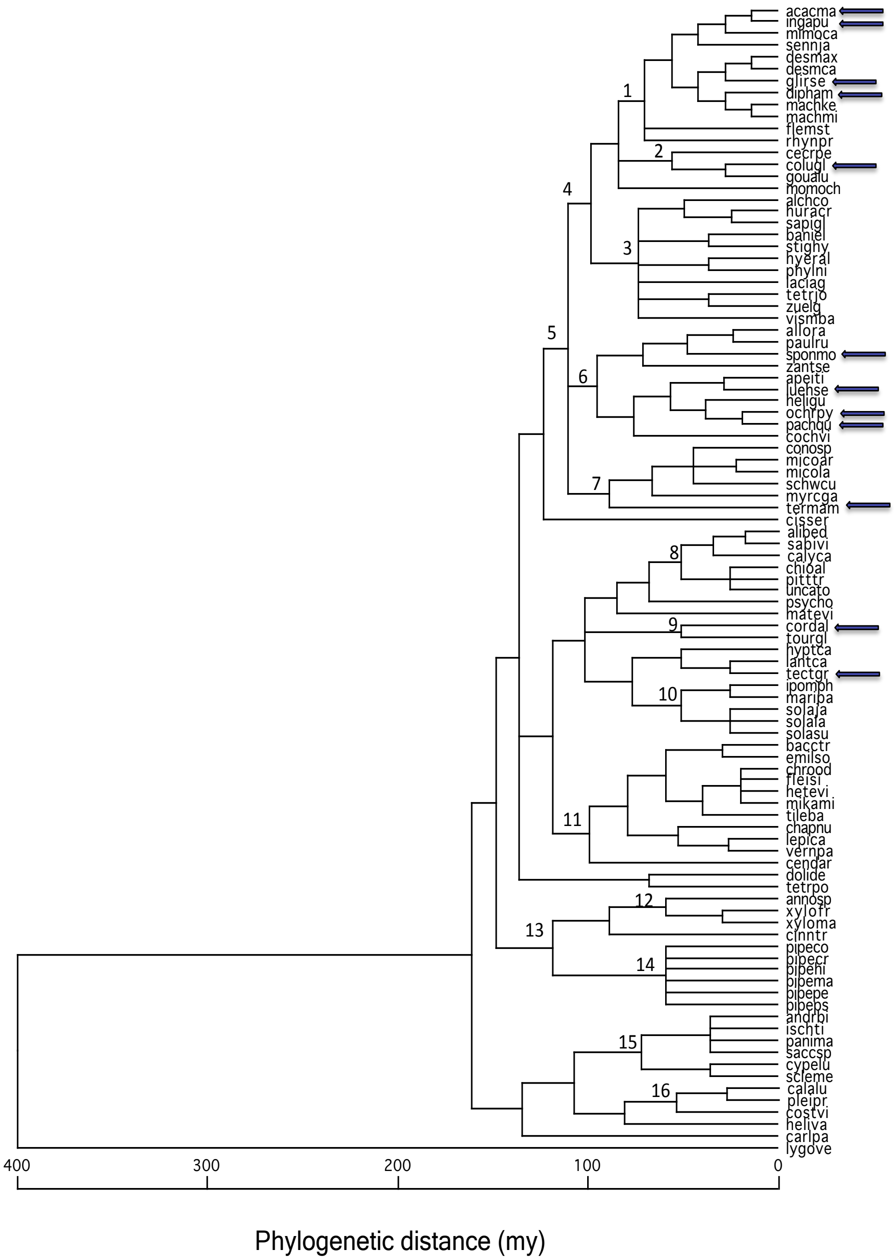


Figure 1-3. Phylogenetic tree of all species sampled. Arrows highlight species of the overstory. Numbers at nodes correspond to: 1: Fabaceae, 2: Ziziphoids; 3: Malpighiales, 4: Eurosids 1, 5: Rosids. 6: Eurosids 2, 7: Myrtales, 8: Rubiaceae, 9: Boraginaceae, 10: Solanales, 11: Asteraceae, 12: Annonaceae, 13: Magnoliid, 14: Piperaceae, 15: Poales, Zingiberales. Species codes are composed of the first four letters of the Genus and the two first letters of the species names.

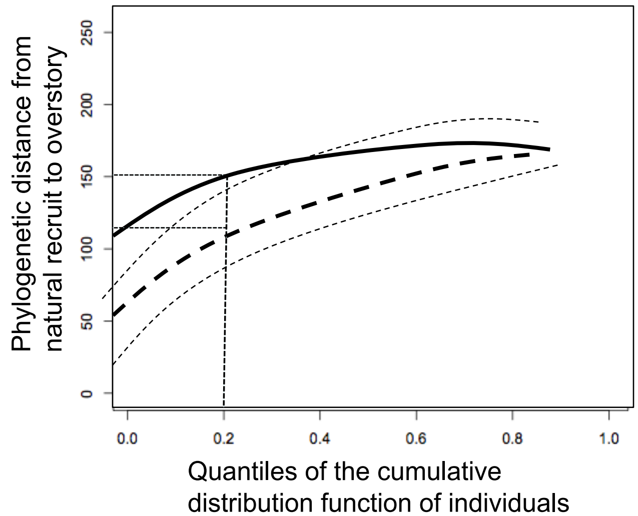


Figure 1-4. Quantile graph obtained from plotting the observed (solid line) vs. the random (thick dotted line) cumulative distribution of phylogenetic distances from naturally recruiting species to their overstory tree species, and the 95 % confidence intervals of the random distribution (thin dotted lines). The expectation is that negative species interaction among close relatives will lead to observing fewer individuals at close phylogenetic distances than expected at random. The graph shows how the observed second quantile is around 150 MY of phylogenetic distance, which is significantly greater than the random phylogenetic distance located around 110 MY.

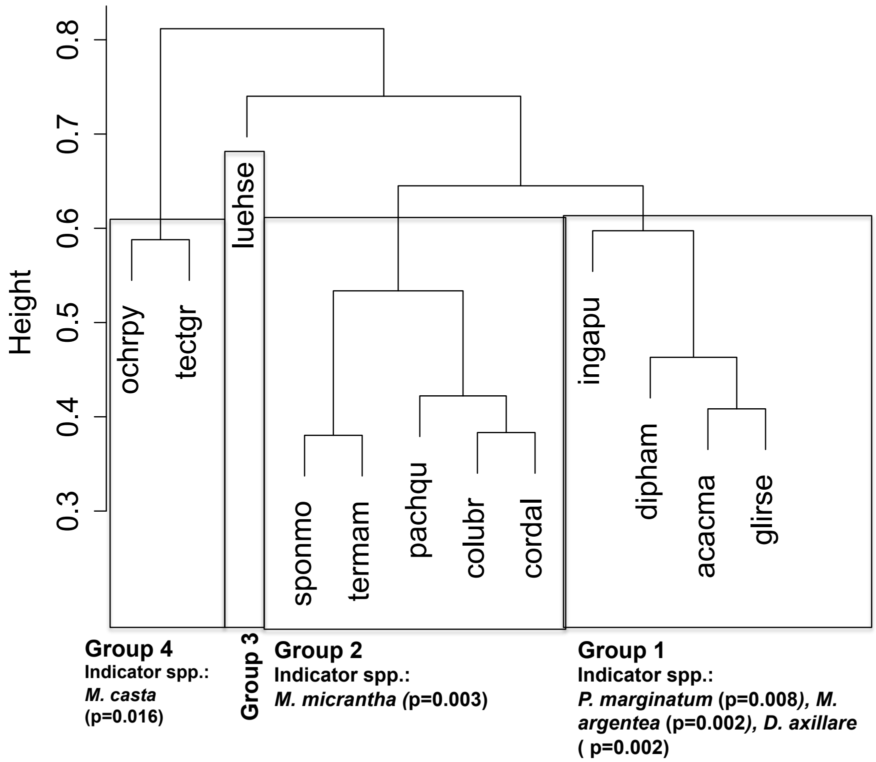


Figure 1-5. Hierarchical cluster diagram grouping overstory tree species by similarities in the composition of naturally recruiting species. Group 1 are legume species, groups 2 through 4 are non legumes. Species Codes: Ochrpy: *Ochroma pyramidale,* tectgr: *Tectona grandis,* luehse: *Luehea semmannii,* sponmo: *Spondias mombin*, termam: *Terminalia amazonia*, pachqu: *Pachira quinata*, colubr: *Colubrina glandulosa*, cordal: *Cordia alliodora*, ingapu: *Inga punctata*, dipham: *Dyphisa americana*, acacma: *Acacia mangium*, glirse: *Gliricidia sepium*. Beneath each group are the significant indicator species, obtained from Dufrene and Legendre, (1997)

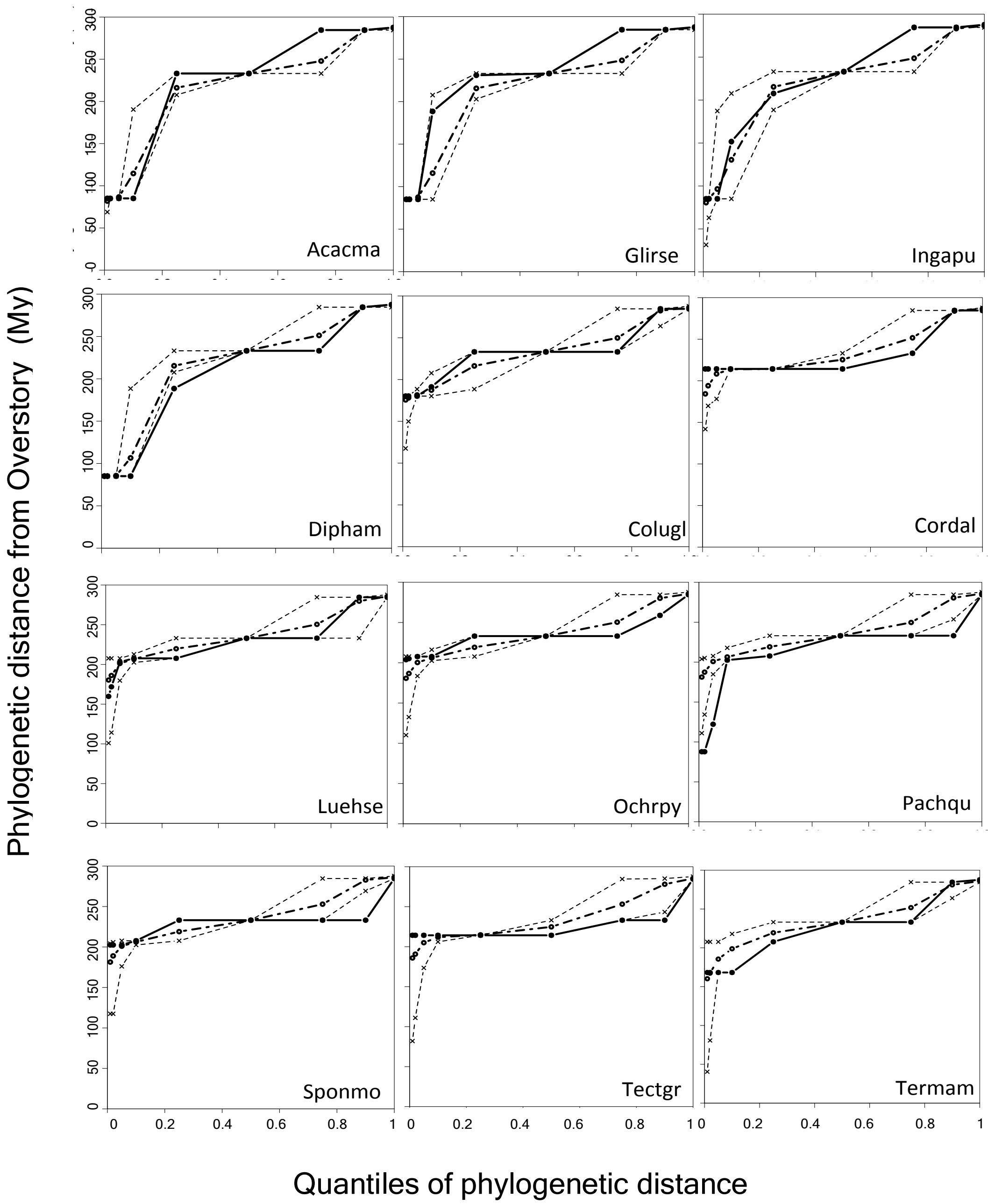


Figure 1-6. Quantiles of phylogenetic distance for each overstory tree species, obtained from plotting the observed vs. the random cumulative distribution of phylogenetic distances. Continuous line represents observed data, dashed line represents the random data; thin fragmented lines are the 95% confidence intervals. Species Codes: Acacma: *Acacia mangium,* ingapu: *Inga punctata*, dipham: *Dyphisa americana*, , glirse: *Gliricidia sepium*, colubr: *Colubrina glandulosa*, luehse: *Luehea semmannii,* ochrpy: *Ochroma pyramidale,* pachqu: *Pachira quinata*, sponmo: *Spondias mombin*, termam: *Terminalia amazonia*, cordal: *Cordia alliodora*, tectgr: *Tectona grandis*.

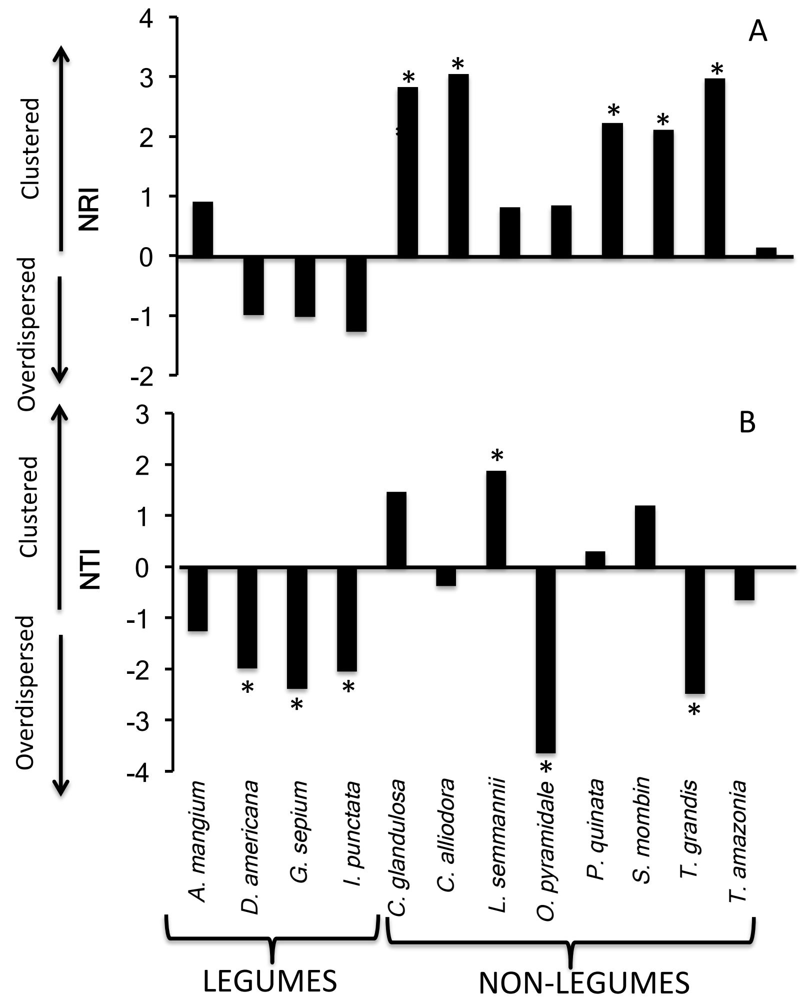


Figure 1-7. Phylogenetic indices of naturally recruiting species per overstory tree. Asterisk denotes significance based on the 95% C.I. A: Measure of phylogenetic structure of the natural recruitment community, as a whole (NRI), B: Measure of phylogenetic structure at the tips of the phylogeny, nearest neighbor metric (NTI).

APPENDICES:

Appendix 1-1. Natural recruit species sampled. Habit codes S, U, M and T are free-standing, species with maximum heights of 5, 10, 20 and ≥ 30 m, respectively. These species are found in the old-growth forest of Barro Colorado Island, Panama. Most habits and dispersal syndromes come from databases provided by Joe Wright and published in Wright, 2007; Wright *et al.*, 2007; Wright *et al.*, 2010. Other sources noted. Species names with an (*) means that those species were observed at frequencies of five stems or more.

Species	APG 6 letter code	Families	Habit	Dispersal mode	Source trait data
Acacia mangium Willd.	Acacma	Fabaceae	T	Birds + Insects	World Agroforestry Centre, n.d.;Forest Ecology and Forest Management Group,
Alchornea costaricensis Pax & K. Hoffm.	Alchco	Euphorbiaceae	T	Birds + Mammals	
Alibertia edulis (rich.) a. Rich. ex DC.	Alibed	Rubiaceae	U	Birds + Mammals	
Allophylus racemosus Sw.	Allora	Sapindaceae	T	Birds + Mammals	
Annona spraguei Saff.	Annosp	Annonaceae	M	Birds + Mammals	
Apeiba tibourbou Aubl.	Apeiti	Malvaceae	M	Birds + Mammals	
Baccharis trinervis Pers.*	Bacctr	Asteraceae	S	Wind	Sugden, 1982
Calathea lutea Schult.	Calalu	Marantaceae	Musoid	Birds + Insects	Levey *et al.,* 2002
Calycophyllum candidissimum (Vahl) DC.	Calyca	Rubiaceae	T	Wind	Smithsonian Tropical Research
Carludovica palmata Ruiz & Pav.	Carlpa	Cyclanthaceae	Palm	Birds + Mammals	
Chaptalia nutans (L.) Pol.	Chapnu	Asteraceae	Herb	Wind	USDA: Plants.usda.gov
Chiococca alba (L.) Hitchc.	Chioal	Rubiaceae	Climber	Birds + Mammals	Smithsonian Tropical Research
Chromolaena odorata (L.) R.M. King & H. Rob.*	Chrood	Asteraceae	S	Wind	Blackmore, n.d.

Appendix 1-1. Continuation.

Species	**APG 6 letter code**	**Families**	**Habit**	**Dispersal mode**	**Source trait data**
Cinnamomum triplinerve (Ruiz & Pav.) Kosterm.	Cinntr	Lauraceae	S	Birds+Mammals	
Cissus erosa Rich.	Cisser	Vitaceae	Climber	Birds	Griz and Machado, 2001
*Cochlospermum vitifolium (*Willd.) Spreng.	Cochvi	Cochlospermaceae	U	Wind	Smithsonian Tropical Research
Conostegia speciosa Naudin	Conosp	Melastomataceae	S	Birds + Mammals	Smithsonian Tropical Research
Cordia alliodora (Ruiz & Pav.) Cham.*	Cordal	Boraginaceae	M	Wind	
Costus villosissimus Jacq.	Costvi	Costaceae	Herb		Bongers *et al.*, 1988
Cyperus luzulae (L.) Rottb. ex Retz.	Cypelu	Cyperaceae	Grass	Wind	
Desmodium axillare (Sw.) DC.*	Desmax	Fabaceae	Climber	Mammals	Smithsonian Tropical Research Institute, n.d.
Desmodium cajanifolium (Kunth) DC.	Desmca	Fabaceae	Climber	Mammals	Croat, 1978
Diphysa americana (Mill.) M. Sousa	Dipham	Fabaceae	T	Birds	
Doliocarpus dentatus (Aubl.) Standl.	Dolide	Dilleniaceae	Climber	Birds	Smithsonian Tropical Research Institute, n.d.
Emilia sonchifolia (L.) DC.	Emilso	Asteraceae	Herb	Wind	Frenedozo, 2004
Fleischmannia sinclairii (Benth. ex Oerst.) R.M.King & H.Rob.*	Fleisi	Asteraceae	Herb	Wind	Croat, 1978
Flemingia strobilifera (L.) R. Br.*	Flemst	Fabaceae	S	Birds	

Appendix 1-1. Continuation.

Species	APG 6 letter code	Families	Habit	Dispersal mode	Source trait data
Gouania lupuloides (L.) Urb.	Goualu	Rhamnaceae	Climber	Wind	Smithsonian Tropical Research Institute, n.d.
Helicteres guazumifolia Kunth	Heligu	Malvaceae	Musoid		
Heterocondylus vitalbae (DC.) R.M. King & H. Rob.*	Hetevi	Asteraceae	Herb	Wind	Holl, 2002; Croat, 1978
Hyeronima alchorneoides Allemão	Hyeral	Phyllanthaceae	T	Birds + Mammals	
Inga punctata Willd.	Ingapu	Fabaceae	U	Birds + Mammals	Smithsonian Tropical Research Institute, n.d.
Ipomoea phyllomega House	Ipomph	Convolvulaceae	Climber	Wind	Smithsonian Tropical Research Institute, n.d.
Lantana camara L.	Lantca	Verbenaceae	S	Birds	Asia-Pacific Forest Invasive Species Network, n.d.
Lepidaploa canescens (Kunth) Cass.*	Lepica	Asteraceae	S	Wind	Smithsonian Tropical Research Institute, n.d.
Luehea seemannii Triana & Planch.	Luehse	Malvaceae	T	Wind	Smithsonian Tropical Research Institute, n.d.
Machaerium milleflorum Pittier*	Machmi	Fabaceae	Climber	Wind	Smithsonian Tropical Research Institute, n.d.
Miconia argentea (Sw.) DC.*	Micoar	Melastomataceae	M	Birds + Mammals	

Appendix 1-1. Continuation

Species	APG 6 letter code	Families	Habit	Dispersal mode	Source trait data
Miconia lacera (Bonpl.) Naudin	Micola	Melastomataceae	M	Birds + Mammals	Smithsonian Tropical Research Institute, n.d.
Mikania micrantha Kunth*	Mikami	Asteraceae	Climber	Wind	Asia-Pacific Forest Invasive Species Network, n.d.
Mimosa casta L.	Mimoca	Fabaceae	Climber		
Momordica charantia L.	Momoch	Cucurbitaceae	Climber	Birds + Mammals	Morellato and Leitao, 1996
Myrcia gatunensis Standl.	Myrcga	Myrtaceae	U	Birds + Mammals	
Paullinia rugosa Benth. ex Radlk.	Paulru	Sapindaceae	Climber	Birds	Smithsonian Tropical Research Institute, n.d.
Phyllanthus niruri L.*	Phylni	Phyllanthaceae	Climber	Gravity	Martinez-Garza and Gonzalez-Montagut, 1999
Piper colonense C. DC.	Pipeco	Piperaceae	S	Bats + Birds	
Piper marginatum Jacq.*	Pipema	Piperaceae	S	Bats + Birds	
Piper peltatum Ruiz & Pav.*	Pipepe	Piperaceae	S	Bats + Birds	
Piper pseudofuligineum C. DC.*	Pipeps	Piperaceae	S	Bats + Birds	
Rhynchosia precatoria (Humb. & Bonpl. ex Willd.) DC.	Rhynpr	Fabaceae	Climber	Birds	Smithsonian Tropical Research Institute, n.d.
Sabicea villosa Ruiz & Pav.	Sabivi	Rubiaceae	Climber		Smithsonian Tropical Research Institute, n.d.

Appendix 1-1. Continuation

Species	APG 6 letter code	Families	Habit	Dispersal mode	Source trait data
Scleria melaleuca Rchb. ex Schltdl. & Cham.*	Scleme	Cyperaceae	Grass	Wind	Martinez-Garza and Gonzalez-Montagut, 1999
Solanum jamaicense Mill.	Solaja	Solanaceae	S	Birds + Mammals	
Solanum subinerme Jacq.	Solasu	Solanaceae	S	Birds + Mammals	
Spondias mombin L.	Sponmo	Anacardiaceae	T	Birds + Mammals	
Stigmaphyllon hypargyreum Triana and Planch.	Stighy	Malpighiaceae	Climber	Wind	Smithsonian Tropical Research Institute, n.d.
Tectona grandis L. f.	Tectgr	Verbenaceae	T	Birds + Mammals	
Uncaria tomentosa (Willd. ex Roem. & Schult.) DC.	Uncato	Rubiaceae	Climber	Wind	Smithsonian Tropical Research Institute, n.d.
Vernonia patens (Kunth) H. Rob.*	Vernopa	Asteraceae	Herb	Wind	Smithsonian Tropical Research Institute, n.d.
Xylopia frutescens Sieb. ex Presl	Xylofr	Annonaceae	U	Birds	Smithsonian Tropical Research Institute, n.d.
Xylopia macrantha Triana & Planch.	Xyloma	Annonaceae	U	Birds	Smithsonian Tropical Research Institute, n.d.
Zuelania guidonia (Sw.) Britton & Millsp.	Zuelgu	Salicaceae	M		Smithsonian Tropical Research Institute, n.d.

Appendix 1-2. Newick file of species of understory natural recruits and overstory species.

(((((((((((((acacma:14.000000,ingapu:14.000000):14.000000,mimoca:28.000000):14.000000,sennja:42.000000):14.000000,(((desmax:14.000000,desmca:14.000000)desmodium:14.000000,glirse:28.000000):14.000000,(dipham:28.000000,(machke:14.000000,machmi:14.000000)machaerium:14.000000):14.000000):14.000000):14.000000,flemst:70.000000,rhynpr:70.000000)fabaceae:14.000000,(cecrpe:56.000000,(colugl:28.000000,goualu:28.000000)ziziphoids:28.000000):28.000000,momoch:84.000000):14.000000,((alchco:49.000000,(huracr:24.500000,sapigl:24.500000)euphorbioideae:24.500000):24.500000,(baniel:36.750000,stighy:36.750000)malpighiaceae:36.750000,(hyeral:36.750000,phylni:36.750000)phyllanthaceae:36.750000,laciag:73.500000,(tetrjo:36.750000,zuelg:36.750000)salicaceae:36.750000,vismba:73.500000)malpighiales:24.500000)eurosid1:12.599998,((((allora:23.750000,paulru:23.750000)sapindaceae:23.750000,sponmo:47.500000):23.750000,zantse:71.250000):23.750000,(((apeiti:28.500000,luehse:28.500000)grewioideae:28.500000,(heligu:38.000000,(ochrpy:19.000000,pachqu:19.000000)bombacoideae:19.000000):19.000000)malvaceae:19.000000,cochvi:76.000000):19.000000)eurosid2:15.599998,(((conosp:44.239998,(micoar:22.119999,micola:22.119999)miconia:22.119999,schwcu:44.239998)melastomataceae:22.120003,myrcga:66.360001):22.119995,termam:88.479996)myrtales:22.120003)rosid:12.599998,cisser:123.199997):12.600006,(((((((alibed:16.975000,sabivi:16.975000):16.975000,calyca:33.950001)ixoroideae:16.975002,(chioal:25.462502,pitttr:25.462502,uncato:25.462502)cinchonoideae:25.462502):16.974998,psycho:67.900002)rubiaceae:16.974998,matevi:84.875000)gentianales:16.975006,(cordal:50.925003,tourgl:50.925003)boraginaceae:50.925003,((hyptca:50.925003,(lantca:25.462502,tectgr:25.462502)verbenaceae:25.462502):25.462502,((ipomph:25.462502,maripa:25.462502)convolvulaceae:25.462502,(solaja:25.462502,solala:25.462502,solasu:25.462502)solanum:25.462502)solanales:25.462502):25.462502):16.974998,((((bacctr:29.706249,emilso:29.706249):29.706249,((chrood:19.804167,fleisi:19.804167,hetevi:19.804167,mikami:19.804167)eupatorieae:19.804167,tileba:39.608334):19.804165)asteroideae:19.804169,(chapnu:52.811111,(lepica:26.405556,vernpa:26.405556)vernonieae:26.405556)cichorioideae:26.405556):19.804169,cendar:99.020836):19.804169)euasterid1n2:16.974998,(dolide:67.900002,tetrpo:67.900002)dilleniaceae:67.900002)ber2ast:12.599991,(((annosp:59.359997,(xylofr:29.679998,xyloma:29.679998)xylopia:29.679998)annonaceae:29.679996,cinntr:89.039993):29.680000,(pipeco:59.359997,pipecr:59.359997,pipehi:59.359997,pipema:59.359997,pipepe:59.359997,pipeps:59.359997)piper:59.359997)magnoliid:29.680000)chl2ast:12.600000,((((andrbi:35.777779,ischti:35.777779,panima:35.777779,saccsp:35.777779)poaceae:35.777779,(cypelu:35.777779,scleme:35.777779)cyperaceae:35.777779)poales:35.777779,(((calalu:26.833334,pleipr:26.833334)marantaceae:26.833334,costvi:53.666668):26.833332,heliva:80.500000)zingiberales:26.833336):26.833336,carlpa:134.166672):26.833334)monocotneudicot:239.000000,lygove:400.000000)euphyllophyte:0.000000;

Appendix 1-3. Phylogeny sources

Family	Phylogeny source
Asteraceae	Bayer and Starr, 1998; Ito *et al.*, 2000
Euphorbiaceae	Wurdack *et al.*, 2005; Tokuoka, 2007
Fabaceae	Lavin *et al.*, 2003; Sulaiman *et al.*, 2003; Brown *et al.*, 2008
Malvaceae	Alverson *et al.*, 1999; Bayer *et al.*, 1999
Rhamnaceae	Richardson *et al.*, 2004
Rubiaceae	Bremer and Eriksson, 2009
Piperaceae	Jaramillo and Manos, 2001; Jaramillo *et al.*, 2008

Appendix 1-4. Analysis of community composition similarities explained by abiotic variables

Microenvironmental variables

We collected information on the canopy openness, soil macronutrients, leaf litter and *Saccharum spontaneum* cover of each plot as these variables are known to impact species recruitment (Aide and Cavelier, 1994; Holl *et al.*, 2000). The light environment in each plot was estimated with overstory hemispherical photos using a fish-eye lens mounted on a digital camera (Nikon Coolpix, model 995). We took the photos with the camera placed on a tripod 1 m above the ground, at three randomly chosen points. The same point locations were used in each of the plots. The program Gap Light Analyzer v.2 (Frazer *et al.*, 1999) was used to calculate the percent canopy openness from each of the photos; estimates were averaged for each of the three photos taken at a given camera height within each of the plots. Photos were taken in both the wet and in the dry seasons (August 2009 and March 2010, respectively) given differences in foliar periodicity among species.

We collected a total of nine 5-cm diameter × 10-cm deep soil cores, three at each three randomly located points in each 9 × 12-m plot and combined the samples for analysis. Soil samples were kept cool (4 °C) until extraction of the nutrients, which was done within 2-5 hours. We extracted P using 25-ml of Mehlich-III extracting solution on 2.5-g of soil. The solution was mixed with the soil and allowed to sit for 10 min, then filtered and stored in the refrigerator. For NH_4 and NO_3 extractions, we used 20-ml of KCl extracting solution for 2-g of soil. The solution was mixed with the soil and allowed to sit overnight, after which the supernatant was separated and stored in the refrigerator (detailed protocols can be found at: https://ctfs.arnarb.harvard.edu/webatlas/datasets/bci/soilmaps/BCIsoil.html or in John *et al.*, 2007). Subsequent estimations of NH_4 and NO_3 were conducted using Lachat Quickchem method 12-107-04-1-B (NH_4) and 10-107-06-1-K (NO_3) (http://www.lachatinstruments.com). KCl solution was employed as the carrier and to make combined standards between 0.5–20-mg N L^{-1} for NH_4 and NO_3. P was determined via ICP spectrometry using standards prepared in Mehlich-III extraction solution. Percent leaf litter and *S. spontaneum* cover were estimated using 1 m^2 plots placed every three meters on a fifteen meters long transect.

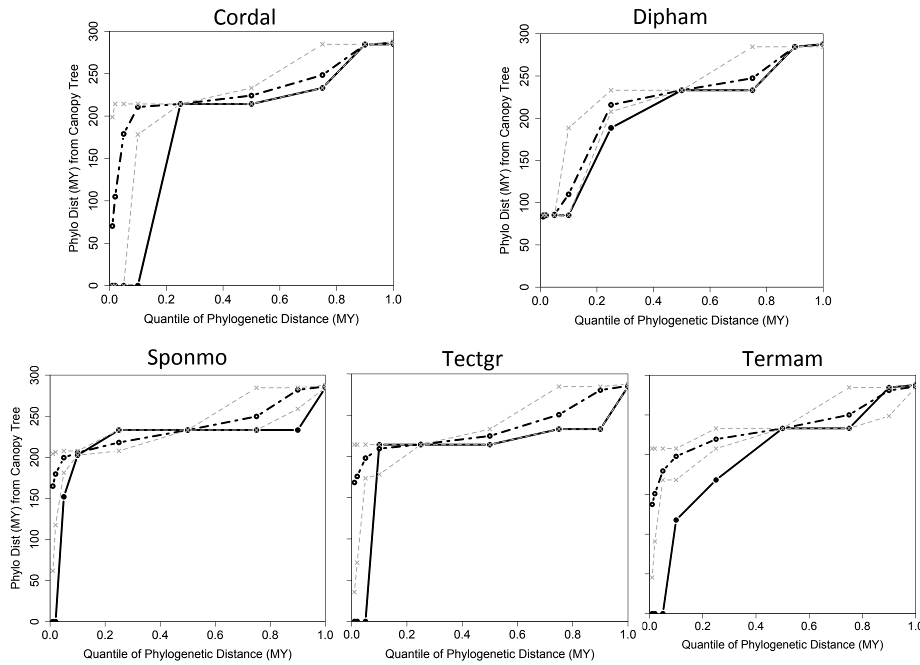
Data analysis

Species composition differences were tested against abiotic factors, leaf litter and grass cover. We regressed the NMDS axis against soil nutrients (NH_4, NO_3, and P), canopy openness, leaf litter and grass cover variables to evaluate whether species composition patterns of the overstory tree species on multivariate space were explained by these factors.

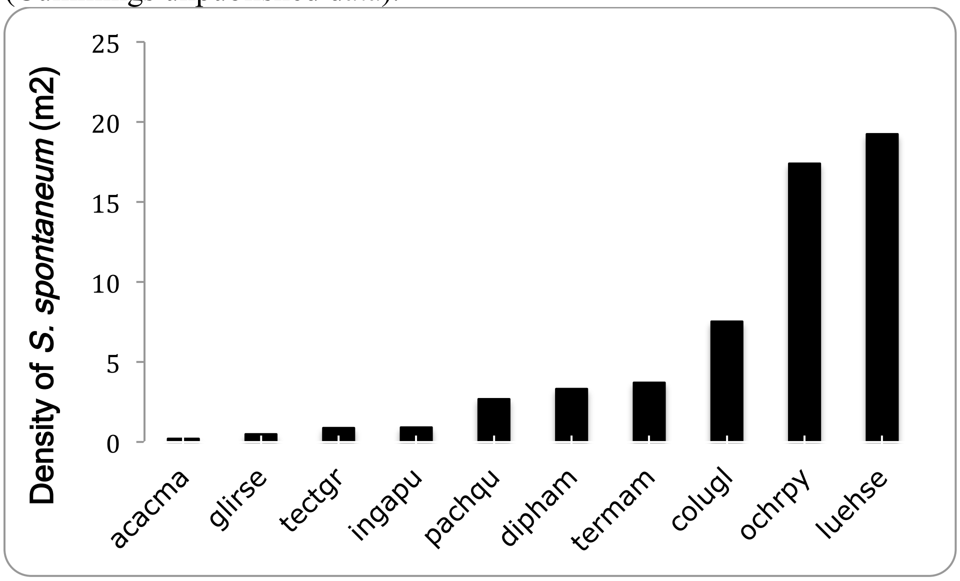
Results

The variables of canopy openness, soil macronutrients, leaf litter and grass cover did not explain overstory species distribution along the two NMDS axes for the abundance and species presence/absence ordinations ($p>0.05$ in all regressions).

Appendix 1-5. Quantile graphs of overstory species with conspecific seedlings recruiting beneath them.



Appendix 1-6. Density of *Saccharum spontaneum* beneath the different overstory species (Cummings unpublished data).



LITERATURE CITED

Aide, T. M. and J. Cavelier. 1994. Barriers to lowland tropical forest restoration in the Sierra Nevada de Santa Marta, Colombia. Restoration Ecology **2**:219-229.

Alverson, W. S., B. A. Whitlock, R. Nyffeler, C. Bayer, and D. A. Baum. 1999. Phylogeny of the core Malvales: evidence from NDHF sequence data. American Journal of Botany **86**:1474-1486.

Asia-Pacific Forest Invasive Species Network. n.d. Lantana Camara. Invasive Pest Fact Sheet. http://www.apfisn.net/.

Bagchi, R., T. Swinfield, R. E. Gallery, O. T. Lewis, S. Gripenberg, L. Narayan, and R. P. Freckleton. 2010. Testing the Janzen-Connell mechanism: Pathogens cause overcompensating density dependence in a tropical tree. Ecology Letters **13**:1262-1269.

Bayer, C., M. F. Fay, P. Y. De Bruijn, V. Savolainen, C. M. Morton, K. Kubitzki, W. S. Alverson, and M. W. Chase. 1999. Support for an expanded family concept of Malvaceae within a recircumscribed order Malvales: a combined analysis of plastid atpB and rbcL DNA sequences. Botanical Journal of the Linnean Society **129**:267-303.

Bayer, R. J. and J. R. Starr. 1998. Tribal phylogeny of the Asteraceae based on two non-coding chloroplast sequences, the trnL intron and trnL/trnF intergenic spacer. Annals of the Missouri Botanical Garden **85**:242-256.

Beals, E. W. 1984. Bray-Curtis ordination: an effective strategy for analysis of multivariate ecological data. Advances in Ecological Research **14**:1-55.

Bell, T., R. P. Freckleton, and O. T. Lewis. 2006. Plant pathogens drive density-dependent seedling mortality in a tropical tree. Ecology Letters **9**:569-574.

Blackmore, A. C. n.d. Seed dispersal of *Chromolaena odorata* reconsidered. Natal Parks Board, St Lucia Research, St Lucia Estuary, KwaZulu-Natal, 3936, South Africa.

Blomberg, S. P., T. , J. Garland, and A. R. Ives. 2003. Testing for phylogenetic signal in comparative data: behavioral traits are more labile. . Evolution **57**:717–745.

Bongers, F., J. Popma, J. M. Delcastillo, and J. Carabias. 1988. Structure and floristic composition of the lowland rain-forest of Los Tuxlas, Mexico. Vegetatio **74**:55-80.

Brazner, J. C. and E. W. Beals. 1997. Patterns in fish assemblages from coastal wetland and beach habitats in Green Bay, Lake Michigan: A multivariate analysis of abiotic and biotic forcing factors. Canadian Journal of Fisheries and Aquatic Sciences **54**:1743-1761.

Bremer, B. and T. Eriksson. 2009. Time tree of Rubiaceae: Phylogeny and dating the family, subfamilies, and tribes. International Journal of Plant Sciences **170**:766-793.

Brown, G. K., D. J. Murphy, J. T. Miller, and P. Y. Ladiges. 2008. *Acacia s.s.* and its relationship among tropical legumes, Tribe Ingeae (Leguminosae: Mimosoideae). Systematic Botany **33**:739-751.

Burns, J. H. and S. Y. Strauss. 2011. More closely related species are more ecologically similar in an experimental test. Proceedings of the National Academy of Sciences of the United States of America **108**:5302-5307.

Carnevale, N. J. and F. Montagnini. 2002. Facilitating regeneration of secondary forests with the use of mixed and pure plantations of indigenous tree species. Forest Ecology and Management **163**:217-227.

Cavender-Bares, J., D. D. Ackerly, D. A. Baum, and F. A. Bazzaz. 2004. Phylogenetic overdispersion in Floridian Oak communities. The American Naturalist **163**:823-843.

Cavender-Bares, J., A. Keen, and B. Miles. 2006. Phylogenetic structure of floridian plant communities depends on taxonomic and spatial scale. Ecology **87**:S109-S122.

Cavender-Bares, J., K. Kozak, P. Fine, and S. W. Kembel. 2009. The merging of community ecology and phylogenetic biology. Ecology Letters **12**:693-715.

Celentano, D., R. A. Zahawi, B. Finegan, R. Ostertag, R. J. Cole, and K. D. Holl. 2011. Litterfall dynamics under different yropical forest restoration strategies in Costa Rica. Biotropica **43**:279-287.

Chazdon, R. L. 2008b. Chance and determinism in tropical forest succession. Pages 384-408 *in* W. P. Carson and S. A. Schnitzer, editors. Tropical forest community ecology. Blackwell Scientific, Oxford, UK.

Chazdon, R. L., S. Careaga, C. Webb, and O. Vargas. 2003. Community and phylogenetic structure of reproductive traits of woody species in wet tropical forests. Ecological Monographs **73**:331-348.

Clark, D. A. and D. B. Clark. 1984. Spacing dynamics of a tropical rain-forest tree - Evaluation of the Janzen-Connell model. American Naturalist **124**:769-788.

Cole, R. J., K. D. Holl, and R. A. Zahawi. 2010. Seed rain under tree islands planted to restore degraded lands in a tropical agricultural landscape. Ecological Applications **20**:1255-1269.

Connell, J. 1971. On the role of natural enemies in preventing competitive exclusion in some marine animals and in rain forest trees. Pages 298–312 *in* G. G. PJ Boer, editor. Dynamics of Numbers in Populations (Proc. Adv. Stud. Inst., Osterbeek 1970), Wageningen: Cent. Agric. Publ. Document.

Crampton, L. H., W. S. Longland, D. D. Murphy, and J. S. Sedinger. 2011. Food abundance determines distribution and density of a frugivorous bird across seasons. Oikos **120**:65-76.

Croat, T. 1978. Flora of Barro Colorado Island. Stanford University Press, Stanford, Calif. 943 pp.

Cusack, D. and F. Montagnini. 2004. The role of native species plantations in recovery of understory woody diversity in degraded pasturelands of Costa Rica. Forest Ecology and Management **188**:1-15.

Del Moral, R. and L. R. Rozzell. 2005. Long-term effects of Lupinus lepidus on vegetation dynamics at Mount St. Helens. Plant Ecology **181**:203-215.

Diaz, S., J. G. Hodgson, K. Thompson, M. Cabido, J. H. C. Cornelissen, A. Jalili, G. Montserrat-Marti, J. P. Grime, F. Zarrinkamar, Y. Asri, S. R. Band, S. Basconcelo, P. Castro-Diez, G. Funes, B. Hamzehee, M. Khoshnevi, N. Perez-Harguindeguy, M. C. Perez-Rontome, F. A. Shirvany, F. Vendramini, S. Yazdani, R. Abbas-Azimi, A. Bogaard, S. Boustani, M. Charles, M. Dehghan, L. de Torres-Espuny, V. Falczuk, J. Guerrero-Campo, A. Hynd, G. Jones, E. Kowsary, F.

Kazemi-Saeed, M. Maestro-Martinez, A. Romo-Diez, S. Shaw, B. Siavash, P. Villar-Salvador, and M. R. Zak. 2004. The plant traits that drive ecosystems: Evidence from three continents. Journal of Vegetation Science **15**:295-304.

Dinnage, R. 2009. Disturbance alters the phylogenetic composition and structure of plant communities in an old field system. Plos One **4**.

Donatti, C. I., P. R. Guimaraes, M. Galetti, M. A. Pizo, F. M. D. Marquitti, and R. Dirzo. 2011. Analysis of a hyper-diverse seed dispersal network: modularity and underlying mechanisms. Ecology Letters **14**:773-781.

Dufrene, M. and P. Legendre. 1997. Species assemblages and indicator species: the need for a flexible assymmetrical approach. Ecological Monographs **67**:345-366.

Emerson, B. C. and R. Gillespie. 2008. Phylogenetic analysis of community assembly and structure over space and time. Trends in Ecology & Evolution **23**:619-630.

Estrada, A. and R. Coates-Estrada. 2001. Bat species richness in live fences and in corridors of residual rain forest vegetation at Los Tuxtlas, Mexico. Ecography **24**:94-102.

Estrada, A. and R. Coates-Estrada. 2002. Bats in continuous forest, forest fragments and in an agricultural mosaic habitat-island at Los Tuxtlas, Mexico. Biological Conservation **103**:237-245.

Farrell, B. D. 2001. Evolutionary assembly of the milkweed fauna: Cytochrome oxidase I and the age of Tetraopes beetles. Molecular Phylogenetics and Evolution **18**:467-478.

Fink, R. D., C. A. Lindell, E. B. Morrison, R. A. Zahawi, and K. D. Holl. 2009. Patch size and tree species influence the number and duration of bird visits in forest restoration plots in southern Costa Rica. Restoration Ecology **17**:479-486.

Forest Ecology and Forest Management Group. *Acacia mangium* Willd. Page 1 Tree factsheet. Wagenigen University, Wagenigen.

Frazer, G. W., C. D. Canham, and K. P. Lertzman. 1999. Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, users manual and program documentation. Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook, New York. pp.

Frenedozo, R. C. 2004. Plant reproductive phenology and dispersal patterns after natural regeneration in a limestone mining spoil bank. Brazilian archives of biology and technology **47**:261-271.

Futuyma, D. J. and C. Mitter. 1996. Insect-plant interactions: The evolution of component communities. Philosophical Transactions of the Royal Society B-Biological Sciences **351**:1361-1366.

Gilbert, G. S., S. P. Hubbell, and R. B. Foster. 1994. Density and distance-to-adult effects of a canker disease of trees in a moist tropical forest. Oecologia **98**:100-108.

Gilbert, G. S. and C. O. Webb. 2007. Phylogenetic signal in plant pathogen-host range. Proceedings of the National Academy of Sciences of the United States of America **104**:4979-4983.

Gomez, J. M., M. Verdu, and F. Perfectti. 2010. Ecological interactions are evolutionarily conserved across the entire tree of life. Nature **465**:918-921.

Gosling, P. 2005. Facilitation of *Urtica dioica* colonisation by Lupinus arboreus on a nutrient-poor mining spoil. Plant Ecology **178**:141-148.

Gossner, M. M., A. Chao, R. I. Bailey, and A. Prinzing. 2009. Native fauna on exotic trees: Phylogenetic conservatism and geographic contingency in two lineages of phytophages on two lineages of trees. American Naturalist **173**:599-614.

Gotelli, N. J. and R. K. Colwell. 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. Ecology Letters **4**.

Griz, L. M. S. and I. C. S. Machado. 2001. Fruiting phenology and seed dispersal syndromes in caatinga, a tropical dry forest in the northeast of Brazil. Journal of Tropical Ecology **17**:303-321.

Guariguata, M. R. and R. Ostertag. 2001. Neotropical secondary forest succession: changes in structural and functional characteristics. Forest Ecology and Management **148**:185-206.

Guariguata, M. R., R. Rheingans, and F. Montagnini. 1995. Early woody invasion under tree plantations in Costa Rica: Implications for forest restoration. Restoration Ecology **3**:252-260.

Haggar, J., K. Wightman, and R. Fisher. 1997. The potential of plantations to foster woody regeneration within a deforested landscape in lowland Costa Rica. Forest Ecology and Management **99**:55-64.

Healey, S. P. and R. I. Gara. 2003. The effect of a teak (*Tectona grandis*) plantation on the establishment of native species in an abandoned pasture in Costa Rica. Forest Ecology and Management **176**:497-507.

Helmus, M. R., K. Savage, M. W. Diebel, J. T. Maxted, and A. R. Ives. 2007. Separating the determinants of phylogenetic community structure. Ecology Letters **10**:917-925.

Hill, S. B. and P. M. Kotanen. 2009. Evidence that phylogenetically novel non-indigenous plants experience less herbivory. Oecologia **161**:581-590.

Hill, S. B. and P. M. Kotanen. 2011. Phylogenetic structure predicts capitular damage to Asteraceae better than origin or phylogenetic distance to natives. Oecologia **166**:843-851.

Holl, K. D. 2002. Effect of shrubs on tree seedling establishment in an abandoned tropical pasture. Journal of Ecology **90**:179-187.

Holl, K. D., M. E. Loik, E. H. V. Lin, and I. A. Samuels. 2000. Tropical montane forest restoration in Costa Rica: Overcoming barriers to dispersal and establishment. Restoration Ecology **8**:339-349.

Hooper, E., R. Condit, and P. Legendre. 2002. Responses of 20 native tree species to reforestation strategies for abandoned farmland in Panama. Ecological Applications **12**:1626-1641.

Hooper, E., P. Legendre, and R. Condit. 2004. Factors affecting community composition of forest regeneration in deforested, abandoned land in Panama. Ecology **85**:3313-3326.

Hooper, E. R. 2008. Factors affecting the species richness and composition of neotropical secondary succession: A case study of abandoned agricultural land in Panama *in*. Pages 141-164 *in* R. W. Myster, editor. Post - Agricultural Succession in the Neotropics. Springer, New York.

Ito, M., Y. Tetsukazu, R. King, K. Watanabe, S. Oshita, J. Yokoyama, and D. Crawford. 2000. Molecular phylogeny of Eupatorieae (Asteraceae) estimated from cpDNA RFLP and its implication for the Polyploid origin of the Tribe. Journal of Plant Research **113**:91-96.

Janzen, D. H. 1970. Herbivores and number of tree species in Tropical forests. American Naturalist **104**:501-528.

Jaramillo, M. A., R. Callejas, C. Davidson, J. Smith, A. C. Stevens, and E. J. Tepe. 2008. A phylogeny of the tropical genus Piper using ITS and the chloroplast Intron psbJ-petA. Systematic Botany **33**:647-660.

Jaramillo, M. A. and P. S. Manos. 2001. Phylogeny and patterns of floral diversity in the genus Piper (Piperaceae). American Journal of Botany **88**:706-716.

John, R., J. W. Dalling, K. E. Harms, J. B. Yavitt, R. F. Stallard, M. Mirabello, S. P. Hubbell, R. Valencia, H. Navarrete, M. Vallejo, and R. B. Foster. 2007. Soil nutrients influence spatial distributions of tropical tree species. Proceedings of the National Academy of Sciences of the United States of America **104**:864-869.

Jones, E. R., M. H. Wishnie, J. Deago, A. Sautu, and A. Cerezo. 2004. Facilitating natural regeneration in *Saccharum spontaneum* (L.) grasslands within the Panama Canal Watershed: effects of tree species and tree structure on vegetation recruitment patterns. Forest Ecology and Management **191**:171-183.

Kembel, S. W., P. D. Cowan, M. R. Helmus, W. K. Cornwell, H. Morlon, D. D. Ackerly, S. P. Blomberg, and C. O. Webb. 2010. Picante: R tools for integrating phylogenies and ecology. Bioinformatics **26**:1463-1464.

Kraft, N. J. B. and D. Ackerly. 2010. Functional trait and phylogenetic tests of community assembly across spatial scales in an Amazonian forest. Ecological Monographs **80**.

Kraft, N. J. B., W. K. Cornwell, C. Webb, and D. Ackerly. 2007. Trait evolution. community assembly, and the phylogenetic structure of ecological communities. The American Naturalist **170**:271-283.

Kuusipalo, J., G. Adjers, Y. Jafarsidik, A. Otsamo, K. Tuomela, and R. Vuokko. 1995. Restoration of natural vegetation in degraded *Imperata cylindrica* grassland - understorey development in forest plantations. Journal of Vegetation Science **6**:205-210.

Lavin, M., M. F. Wojciechowski, P. Gasson, C. Hughes, and E. Wheeler. 2003. Phylogeny of Robinioid legumes (Fabaceae) revisited: *Coursetia* and *Gliricidia* recircumscribed, and a biogeographical appraisal of the Caribbean endemics. Systematic Botany **28**:387-409.

Lavorel, S., C. Rochette, and J. D. Lebreton. 1999. Functional groups for response to disturbance in Mediterranean old fields. Oikos **84**:480-498.

Law, B. S. and J. Anderson. 2000. Roost preferences and foraging ranges of the eastern forest bat Vespadelus pumilus under two disturbance histories in northern New South Wales, Australia. Austral Ecology **25**:352-367.

Legendre, L. and P. Legendre. 1983. Numerical ecology. Elsevier, Amsterdam. 853 pp.

Legendre, P. and M. J. Anderson. 1999. Distance-based redundancy analysis: Testing multispecies responses in multifactorial ecological experiments (vol 69, pg 1, 1999). Ecological Monographs **69**:512-512.

Letcher, S. G. 2010. Phylogenetic structure of angiosperm communities during tropical forest succession. Proceedings of the Royal Society B-Biological Sciences **277**:97-104.

Losos, J. B. 2008. Phylogenetic niche conservatism, phylogenetic signal and the relationship between phylogenetic relatedness and ecological similarity among species. Ecology Letters **11**:995-1003.

Lovette, I. J. and W. M. Hochachka. 2006. Simultaneous effects of phylogenetic niche conservatism and competition on avian community structure. Ecology **87**:S14-S28.

Maherali, H. and J. Klironomos. 2007. Influence of phylogeny on fungal community assembly and ecosystem functioning
. Science **316**:1746-1748.

Martinez-Garza, C. and R. Gonzalez-Montagut. 1999. Seed rain from forest fragments into tropical pastures in Los Tuxtlas, Mexico. Plant Ecology **145**:255-265.

McArdle, B. H. and M. J. Anderson. 2001. Fitting multivariate models to community data: A comment on distance-based redundancy analysis. Ecology **82**:290-297.

Merwin, L., T. H. He, and B. B. Lamont. 2012. Phylogenetic and phenotypic structure among Banksia communities in south-western Australia. Journal of Biogeography **39**:397-407.

Metz, M. R., W. P. Sousa, and R. Valencia. 2010. Widespread density-dependent seedling mortality promotes species coexistence in a highly diverse Amazonian rain forest. Ecology **91**:3675-3685.

Morellato, P. C. and H. F. Leitao. 1996. Reproductive phenology of climbers in a Southeastern Brazilian forest. Biotropica **28**:180-191.

Mouillot, D., R. Krasnov, I. Shenbrot, K. Gaston, and R. Poulin. 2006. Conservatism of host specificity in parasites. Ecography **29**.

Nepstad, D., C. Uhl, C. A. Pereira, and J. M. Cardoso da Silva. 1996. A comparative study of tree establishment in abandoned pasture and mature forest of eastern Amazonia. Oikos **76**:25-39.

Ness, J. H., E. J. Rollinson, and K. D. Whitney. 2011. Phylogenetic distance can predict susceptibility to attack by natural enemies. Oikos **120**:1327-1334.

Orozco-Segovia, A., M. E. Sanchez-Coronado, and C. Vazquez-Yanes. 1993. Light environment and phytochrome-controlled germination in *Piper auritum*. Functional Ecology **7**:585-590.

Paine, C. E. T., N. Norden, J. Chave, P. M. Forget, C. Fortunel, K. G. Dexter, and C. Baraloto. 2012. Phylogenetic density dependence and environmental filtering predict seedling mortality in a tropical forest. Ecology Letters **15**:34-41.

Park, A., M. van Breugel, M. S. Ashton, M. Wishnie, E. Mariscal, J. Deago, D. Ibarra, N. Cedeno, and J. S. Hall. 2010. Local and regional environmental variation influences the growth of tropical trees in selection trials in the Republic of Panama. Forest Ecology and Management **260**:12-21.

Parmentier, I. and O. J. Hardy. 2009. The impact of ecological differentiation and dispersal limitation on species turnover and phylogenetic structure of inselberg's plant communities. Ecography **32**:613-622.

Parrotta, J. A. 1995. Influence of overstory composition on understory colonization by native species in plantations on a degraded tropical site. Journal of Vegetation Science **6**:627-636.

Parrotta, J. A., J. w. Turnbull, and N. Jones. 1997. Catalizing native forest regeneration on degraded tropical lands. Forest Ecology and Management **99**:1-7.

Pollard, D. 1981. Strong consistency of k-means clustering. The annals of statistics **9**:135-140.

Powers, J. S., J. P. Haggar, and R. F. Fisher. 1997. The effect of overstory composition on understory woody regeneration and species richness in 7-year-old plantations in Costa Rica. Forest Ecology and Management **99**:43-54.

R-Development-Core-Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical omputing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Richardson, J. E., L. W. Chatrou, J. B. Mols, R. H. J. Erkens, and M. D. Pirie. 2004. Historical biogeography of two cosmopolitan families of flowering plants: Annonaceae and Rhamnaceae. Philosophical Transactions of the Royal Society B-Biological Sciences **359**:1495-1508.

Sargent, R. D., S. W. Kembel, N. C. Emery, E. J. Forrestel, and D. D. Ackerly. 2011. Effect of local community phylogenetic structure on pollen limiation in an obligately insect-pollinated plant. American Journal of Botany **98**:283-289.

Silva, I. A. and M. A. Batalha. 2010. Phylogenetic structure of Brazilian savannas under different fire regimes. Journal of Vegetation Science **21**:1003-1013.

Smithsonian Tropical Research Institute. n.d. Plant species list. Smithsonian Tropical Research Institute.

Sugden, A. M. 1982. Long-distance dispersal, isolation, and the cloud forest flora of the Serrania de Macuira, Guajira, Colombia. Biotropica **14**:208-219.

Sulaiman, S. F., A. Culham, and J. B. Harborne. 2003. Molecular phylogeny of Fabaceae based on *rbc*L sequence data: with special emphasis on the tribe Mimoseae (Mimosoideae). Asia Pacific Journal of Molecular Biology and Biotechnology **11**:9-35.

Swamy, V. and J. W. Terborgh. 2010. Distance-responsive natural enemies strongly influence seedling establishment patterns of multiple species in an Amazonian rain forest. Journal of Ecology **98**:1096-1107.

Swenson, N. G. 2009. Phylogenetic resolution and quantifying the phylogenetic diversity and dispersion of communities. Plos One **4**.

Swenson, N. G., B. Enquist, J. Thompson, and J. Zimmerman. 2007. The influence of spatial and size scale on phylogenetic relatedness in tropical forest communities. . Ecology **88**:1770-1780.

Tilman, D. 1994. Competition and biodiversity in spatially structured habitats. Ecology **75**:2-16.

Tokuoka, T. 2007. Molecular phylogenetic analysis of Euphorbiaceae sensu stricto based on plastid and nuclear DNA sequences and ovule and seed character evolution. Journal of Plant Research **120**:511-522.

Tonn, W. M., J. J. Magnuson, M. Rask, and J. Toivonen. 1990. Intercontinental comparison of small-lake fish assemblages - The balance between local and regional processes. American Naturalist **136**:345-375.

Valiente-Banuet, A. and M. Verdu. 2007. Facilitation can increase the phylogenetic diversity of plant communities Ecology Letters **10** 1029-1036.

Valiente-Banuet, A. and M. Verdu. 2008. Temporal shifts from facilitation to competition occur between closely related taxa. Journal of Ecology **96**:489-494.

Vazquez-Yanes, C. and A. Orozco-Segovia. 1992. Effects of litter from a tropical rainforest on tree seed germination and establishment under controlled conditions. Tree Physiology **11**:391-400.

Verdu, M. and J. G. Pausas. 2007. Fire drives phylogenetic clustering in Mediterranean Basin woody plant communities. Journal of Ecology **95**:1316-1323.

Verdu, M., P. J. Rey, J. M. Alcantara, G. Siles, and A. Valiente-Banuet. 2009. Phylogenetic signatures of facilitation and competition in successional communities. Journal of Ecology **97**:1171-1180.

Verdu, M. and A. Valiente-Banuet. 2011. The relative contribution of abundance and phylogeny to the structure of plant facilitation networks. Oikos **120**:1351-1356.

Webala, P. W., N. O. Oguge, and A. Bekele. 2004. Bat species diversity and distribution in three vegetation communities of Meru National Park, Kenya. African Journal of Ecology **42**:171-179.

Webb, C. and M. J. Donoghue. 2005. Phylomatic: tree assembly for applied phylogenetics. Molecular Ecology. Notes **5**:181-183.

Webb, C. O. 2000. Exploring the phylogenetic structure of ecological communities: An example for rain forest trees. American Naturalist **156**:145-155.

Webb, C. O., D. D. Ackerly, M. A. McPeek, and M. J. Donoghue. 2002. Phylogenies and community ecology. Annual Review of Ecology and Systematics **33**:475-505.

Webb, C. O., G. S. Gilbert, and M. J. Donoghue. 2006. Phylodiversity-dependent seedling mortality, size structure, and disease in a bornean rain forest. Ecology **87**:S123-S131.

Weiher, E., G. D. P. Clarke, and P. A. Keddy. 1998. Community assembly rules, morphological dispersion, and the coexistence of plant species. Oikos **81**:309-322.

Wikstrom, N., V. Savolainen, and M. W. Chase. 2001. Evolution of the angiosperms: calibrating the family tree. Proceedings of the royal Society of London **268**:2211-2220.

Wilson, J. B. and W. J. Stubbs. 2012. Evidence for assembly rules: limiting similarity within a saltmarsh. Journal of Ecology **100**:210-221.

Wishnie, M. H., D. H. Dent, E. Mariscal, J. Deago, N. Cedeno, D. Ibarra, R. Condit, and P. M. S. Ashton. 2007. Initial performance and reforestation potential of 24 tropical tree species planted across a precipitation gradient in the Republic of Panama. Forest Ecology and Management **243**:39-49.

World Agroforestry Centre. n.d. *Agroforestry Tree Database*. Retrieved September, 2011, from http://www.worldagroforestry.org/SEA/Products/AFDbases/AF/asp/SpeciesInfo.asp?SpID=.

Wright, I. J. 2007. The bushmeat harvest alters seedling banks by favoring lianas, large seeds, and seeds dispersed by bats, birds, and wind. . Biotropica **39**:363-371.

Wright, I. J., D. D. Ackerly, F. Bongers, K. E. Harms, G. Ibarra-Manriquez, M. Martinez-Ramos, S. J. Mazer, H. C. Muller-Landau, H. Paz, N. C. A. Pitman, L. Poorter, M. R. Silman, C. F. Vriesendorp, C. O. Webb, M. Westoby, and S. J. Wright. 2007. Relationships among ecologically important dimensions of plant trait variation in seven Neotropical forests. Annals of Botany **99**:1003-1015.

Wright, S. J., K. Kitajima, N. J. B. Kraft, P. B. Reich, I. J. Wright, D. E. Bunker, R. Condit, J. W. Dalling, S. J. Davies, S. Diaz, B. M. J. Engelbrecht, K. E. Harms, S. P. Hubbell, C. O. Marks, M. C. Ruiz-Jaen, C. M. Salvador, and A. E. Zanne. 2010. Functional traits and the growth-mortality trade-off in tropical trees. Ecology **91**:3664-3674.

Wurdack, K. J., P. Hoffman, and M. W. Chase. 2005. Molecular phylogenetic analysis of uniovulate Euphorbiaceae (Euphorbiaceae sensu stricto) using plastid rbcL and trnL-F DNA sequences. American Journal of Botany **92**:1397-1420.

Zahawi, R. A. and C. K. Augspurger. 2006. Tropical forest restoration: Tree islands as recruitment foci in degraded lands of Honduras. Ecological Applications **16**:464-478.

CHAPTER 2

Phylogenetic ecology applied to enrichment planting of tropical native tree species

ABSTRACT

Enrichment planting within established plantations or secondary forests is a common strategy to foster forest recovery, given that later successional forest species tend to have low dispersal and thus recruitment into these sites. It is difficult, however, to predict the relative performance of different species of seedlings used for enrichment planting under different canopy species. The field of phylogenetic ecology can provide tools to help guide the selection of seedlings, given the evolutionary conservatism of functional traits. We evaluated the performance and percent foliar damage of various native tropical tree seedlings, which ranged from 0 to 233 MY in phylogenetic distance from monospecific stands of species under which they were planted. We expected that seedlings planted under conspecific canopy trees would have low survival and growth and high percent foliar damage (as predicted by the Janzen-Connell Hypothesis), and that seedling performance would improve steadily with phylogenetic distance between seedling and canopy species. Our results showed low survivorship and growth of the planted seedlings under conspecific canopies. We did not detect any additional phylogenetic signal in seedling performance among heterospecific pairings at greater phylogenetic distance, although the power to detect such effects was limited by lack of representation of close relatives and idiosyncratic species effects. The percentage of leaves with disease symptoms decreased with phylogenetic distance from the canopy

species, but there was no significant phylogenetic effect for herbivory. Most pathogenic fungi isolated from the enrichment planted seedling species caused disease when inoculated onto the overstory species but there was no relationship between symptom development and phylogenetic distance between the seedling and the overstory species. From this research we conclude that enrichment planting with species other than those that dominate the canopy should be most successful. Further research including more species in closer ranges than in the present study is warranted; as it is in these ranges that the stronger effect of negative biotic interactions has been found.

KEY WORDS: seedling performance, restoration ecology, tropical rain forest, phylogenetic ecology, enrichment planting, herbivores, pathogens.

INTRODUCTION

The recovery of deforested areas in the humid tropics can be slow due to factors such as lack of seed dispersal, and recruitment failure (Holl *et al.*, 1999; Aide *et al.*, 2000;Holl, 2002. Even if early-successional tree species do recolonize an area, mature forest species take longer to establish or may never recover, often due to inadequate dispersal (Cole *et al.*, 2010). Enrichment planting, a strategy in which woody species are planted under an established overstory canopy (Lamb, 1998; Paquette *et al.*, 2006; Lamb, 2011), can be used to speed up succession, increase biodiversity, and increase carbon sequestration (Ashton *et al.*, 1998; Schulze, 2008; Keefe *et al.*, 2009; Paquette *et al.*, 2009). However, it is difficult to predict how a particular seedling species will perform under a given canopy species.

Empirical tests of seedling performance in the field or in greenhouses are often used to assess the likelihood of enrichment success. Most studies investigate light and competition effects of the overstory canopy and of other understory species on the enrichment planted seedlings (Ashton *et al.*, 1998; Menalled *et al.*, 1998; Pena-Claros *et al.*, 2002; Schuler and Robison, 2010). Fewer studies have looked at how biotic factors affect species performance. Studies have shown that productivity increases when mixed stands of trees include species from different functional groups; due to factors such as facilitation, differential competition for resources, and reduced pest epidemics (Menalled *et al.*, 1998; Piotto *et al.*, 2004 Erskine *et al.*, 2006; Forrester *et al.*, 2006; Piotto, 2008). These results, however, come from even-aged stands of trees in monocultures or mixed-plantations. In addition, generalizations from such studies are limited by how many species are evaluated.

Closely related species share ecologically important traits (e.g., Farrell, 2001; Blomberg *et al.*, 2003; Chazdon *et al.*, 2003); thus the expectation that closely related species should possess traits that allow them to occupy similar habitats, but also compete more strongly for resources (Elton, 1946, Dayan and Simberloff, 2005), and suffer pest-induced negative density dependence (Webb *et al.*, 2006; Gilbert and Webb, 2007). Our study tested whether phylogenetic distance between overstory trees and seedlings planted beneath them is a useful predictor of seedlings growth and survival, as well as of damage to leaves by pests and pathogens shared with the overstory trees. We anticipated that seedlings closely related to the overstory tree species would have lower performance and higher foliar damage than those more distantly related, due to the evolutionary conservatism of traits that determine performance and pathogen susceptibility (Futuyma and Mitter, 1996; Farrell, 2001). In addition, we conducted a cross-inoculation experiment to test the degree of sharing of pathogens between seedling and overstory species and to test if the likelihood of developing foliar disease symptoms decreased continuously with phylogenetic distance between seedling and overstory species.

Phylogenetic relationships among coexisting species have been integral to understanding neighborhood effects on the growth and survival of naturally recruiting tree seedlings in tropical forests. One influential hypothesis for explaining the maintenance of tropical forest tree diversity, the Janzen-Connell hypothesis (Janzen, 1970; Connell, 1971), proposed that mortality of seedlings should increase with proximity to a mother tree and with density of conspecifics, due to increased impacts of host-specific natural enemies. Numerous studies have found strong evidence of this negative density dependence affecting forest tree seedling performance (Augspurger, 1984; Clark and Clark, 1984; Gilbert *et al.*, 1994; Lin and Augspurger, 2006; Comita and Hubbell, 2009). Recent studies have shown strong evolutionary conservatism of susceptibility to diseases among species (Novotny *et al.*, 2002a; Novotny *et al.*, 2002b; Gilbert and Webb, 2007; Gilbert *et al.,* 2012), which means that negative biotic interactions are an important mechanism in shaping community assembly that operates to various degrees within the evolutionary history of a species (Barrett *et al.*, 2009).

The phylogenetic signal of the host range of pests and pathogens may influence the performance of seedlings growing under established canopies of different tree species. Some studies have shown high pest incidence on seedlings planted under monospecific stands of some commonly planted forestry tree genera, such as *Eucalyptus* and *Pinus* (Nair and Varma, 1985; Lombardero *et al.*, 2008; Zhou *et al.*, 2008; Chungu *et al.*, 2010) and under trees in the same family (e.g., dipterocarps) (Kirton and Cheng, 2007). If phylogenetic relationships are important predictors of plant species performance in a restoration setting, the approach conducted in the present study could be an important tool for restoration practitioners to select which species may be planted most successfully together. Evolutionary relationships may reduce the need for extensive multi-species field- testing and guide more efficient empirical testing. In addition, considering phylogenetic diversity in restoration is important since it has been linked to increased functional diversity, which adds resilience to the restored site and increases the ecosystem services provided (Forest *et al.*, 2007; Cadotte *et al.*, 2009; Cavender-Bares *et al.*, 2009). To test our hypothesis we planted a variety of seedling species beneath a total of 11 tree species. We selected seedling species that would span across their phylogenetic relationship to the overstory tree species and evaluated the relationship between the seedlings survival, growth, percent foliar disease and herbivory, and the phylogenetic distance between seedling and overstory species. In addition, we tested the degree of disease sharing between seedlings and overstory species in a cross-inoculation experiment.

METHODS

STUDY SITE — The study site is located in Soberania National Park in the Panama Canal Watershed, Republic of Panama, in an area used by "The Native Species Reforestation Project" (PRORENA). This project was led by the Center for Tropical Forest Science at the Smithsonian Tropical Research Institute (STRI) and by the Yale Tropical Resources Institute (http://research.yale.edu/prorena/) to assess the forestry potential of several native tree species and promote their use in forestry and reforestation (Wishnie *et al.*, 2007).

Soberania National Park has a mean annual rainfall of 2226 mm and 4.1 dry months annually (defined as months with <100 mm rainfall; dry months fall between mid-December and May) (Park *et al.*, 2010). Soberania N. P. overlies tropical ultisols that are predominantly clay or silty clay (Park *et al.*, 2010). Most of the park is covered by secondary tropical rain forest. The PRORENA study site, however, was deforested prior to the 1960s and then farmed for several decades until it was incorporated into the park in the 1980s. Before the PRORENA project, the plot was left fallow for at least 10 years and it was invaded by the exotic grass *Saccharum spontaneum* L. (Wishnie *et al.*, 2007).

ENRICHMENT PLANTING DESIGN AND METHODS — The PRORENA project consists of monospecific tree plantations of 9 × 12 m. The trees were planted in 2003 at an initial density of 20 trees per plot. For two years following planting, the understory was cleared of competing vegetation using machetes and string trimmers and the trees were sprayed with insecticide. After two years, the plots were thinned by 50% so that a total of 10 trees spaced at 6 m remained in each of the plots, and understory clearing stopped (Wishnie *et al.*, 2007) The PRORENA project planted a total of 24 native tree species at the site with three plots of each species. We chose 11 species that had good growth and that produced a closed canopy at least during the rainy season, as some species lost their leaves in the dry season (Table 2-1).

Tree seedlings for the study were selected based on their phylogenetic relationship to the overstory tree species beneath which they were going to be planted. We chose seedling species that would cover the widest breadth of phylogenetic distances (time of independent evolution) from the overstory species (Table 2-2, Appendix 2-1). The phylogenetic distances were calculated using the Phylomatic tool in Phylocom, version 4.1 (Webb *et al.*, 2008). This program automates the construction of trees using a single higher plant supertree. The tree backbone employed was created by Davies *et al.*, (2004); this is an all-angiosperm gene tree to which strict consensus trees are attached. The number of seedling species planted in each plot varied between six and seven, depending on how many species were available that would fill the range of phylogenetic distances needed (Appendix 2-1). The phylogenetic distance between the seedling and the overstory species ranged from 0 to 233.13 My of independent evolution. Time of independent evolution is twice the time to most recent common ancestor. For the species in this study, 0 My corresponds to conspecifics, 57 to 87 My to confamilials, and 90 My to extrafamilials. Congeneric species pairs were not available for the present study.

We planted a total of 2512 seedlings from 20 species and 10 families. Most seedlings came from the PRORENA nurseries and were at least six months old at the time of out planting. For some species, PRORENA did not have all the seedlings needed; in that case, additional seedlings were either collected from a nearby forest a month before planting (five species; seedlings >1 year old) or bought from commercial nurseries (three species; Appendix 2-2). Post-hoc testing (Appendix 2-3) showed no significant differences in survivorship among seedling sources for most species. The exceptions were *Sapium glandulosum,* for which seedlings collected from the forest had lower survival than those grown in the nursery, and *Swietenia macrophylla,* for which seedlings from the PRORENA grew better than those from other nurseries. Given the minimal effect of source for most species, seedling source was not further included in analytical models of seedling performance.

The average size of seedlings at outplanting ranged from 9 to 21 cm for most species, with the exceptions of *Swietenia macrophylla*, *Gliricidia sepium* and *Diphysa robinoides,* with heights of 30.6, 48.5, and 87.9 cm respectively (Appendix 2-2). Between June and August 2008, 16 or 17 individuals of each species were planted in each of the plots. Seedlings species were randomly planted along four planting lines in each plot, at 0.5 m separation between seedlings. An average of 24 individuals were planted on each line. We left 1 m separation between the lines and the edge of plot to avoid edge effects.

The understories of the different overstory tree species varied substantially, mainly with regards to the density of the invasive grass *Saccharum spontaneum.* This grass is highly dependent on light for its growth and survival and thus was less dense or absent under tree species that had closed canopy, whereas the grass grew abundantly in plots with less shade (three out of 11 overstory species). In cases where *Saccharum spontaneum* was too dense to allow planting, it was cut along the planting line, but it re-grew within two months. We did not control *Saccharum spontaneum* regrowth after planting, nor did we clear any other understory cover type since differences in understory cover among overstory species was part of the treatment of interest.

PERFORMANCE AND FOLIAR DAMAGE DATA COLLECTION — We recorded survival and height for each seedling at five census times over a period of two years: September 2008 (1 month after planting), January 2009 (5 months after planting), August 2009 (12 months after planting), March 2010 (19 months after planting), and August 2010 (23 months after planting). Dry-season censuses were conducted in January 2009 and March 2010, and wet-season censuses in August 2009 and August 2010. Height was measured from the base of the plant to its apical bud. In all censuses except the first, we counted the total number of leaves, the number of leaves with disease symptoms, and the number of leaves with herbivory in all seedlings. This provided an estimate of the average percent of leaves damaged by herbivory or disease. Leaf area and stem basal width were measured during censuses in March and August 2010.

BIOPHYSICAL VARIABLES — Because studies on seedlings performance always measure biophysical variables, we measured canopy openness, percent ground cover, and soil nutrients to assess their role in seedling performance relative to phylogenetic distance. Canopy openness is a proxy for irradiance, temperature and relative humidity in the understory (Gilbert *et al.*, 2007). For canopy openness, we took three hemispherical canopy photos per plot using a fish-eye lens mounted on a leveled digital camera (Nikon Coolpix, model 995). Pictures were taken at dusk and always facing north. In each of the plots, we took pictures with the camera placed on a tripod 1 meter above the ground, as well as at average seedling height (20-cm above the ground). The program Gap Light Analyzer v.2 (Frazer *et al.*, 1999) was used to calculate the percent canopy openness from each of the photos; estimates were averaged for each of the three photos taken within a given camera height. Photos were taken in the wet and in the dry season. We estimated percent ground cover (to the nearest percent) at ground level in 1-m^2 quadrats placed every 3 m along a 15-m diagonal transect on each plot. For the analyses, the various ground cover species were lumped into the following groups: broad leaf, fern, grass, bare ground, and litter.

We collected three 5-cm diameter × 10-cm deep soil cores at three randomly located points in each 9 × 12-m plot and combined the samples for analysis. Soil samples were kept cool (4 °C) until extraction of the nutrients, which was done within two to five hours. We extracted phosphorus using 25-ml of Mehlich-III extracting solution on 2.5-g of soil. The solution was mixed with the soil and allowed to sit for 10 min, then filtered and stored in the refrigerator. For nitrate and ammonium extractions, we used 20-ml of potassium chloride (KCL) extracting solution on 2-g of soil. The solution was mixed with the soil and allowed to sit overnight, time after which the supernatant was separated and stored in the refrigerator (detailed protocols can be found at: https://ctfs.arnarb.harvard.edu/webatlas/datasets/bci/soilmaps/BCIsoil.html, see John *et al.*, 2007) for a published version of these methods). Subsequent estimation of nitrate and ammonium was conducted using Lachat Quickchem method 12-107-04-1-B (nitrate) and 10-107-06-1-K (ammonium). KCl solution was employed as the carrier and to make combined standards between 0.5–20-mg N L^{-1} for ammonium and nitrate. Phosphorus was determined via ICP spectrometry using standards prepared in Mehlich-III extraction solution.

CROSS-INOCULATION EXPERIMENT — Isolates of pathogenic necrotrophic foliar fungi from the planted seedlings were inoculated onto the overstory tree species to assess the phylogenetic signal of shared pathogens. Between July and August 2010, one diseased leaf from every surviving seedling was collected from the field and processed in the laboratory within 1-3 hours of collection. To prepare pure cultures of fungi, we cut a triangular piece of leaf from the edge of the diseased area using a hole-puncher for mounting small insects (area: 7 mm^2). The tissue pieces were surface sterilized by immersing them for 1 min in 70% ethanol and then for 1 min in 10% commercial bleach using a tea strainer. Then we placed the tissue on Petri dishes filled with malt extract agar and chloramphenicol (MEA-chlor: 2% malt extract, 1.5% agar, 0.02% chloramphenicol), and incubated them at ambient temperature. The fungal mycelia were allowed to grow for 5-7 days, after which, a piece of mycelium-filled agar was placed on a new Petri dish filled with agar (MEA) and allowed to grow as a pure culture of the fungus. When multiple fungal morphotypes were apparent, each one was transferred to a separate dish. Less than 2% of the cultures could not be purified to single strains so they were discarded. Each strain was preserved by placing actively growing mycelial plugs in a 2 ml cryovial and filling the vial with sterile water.

After 1 week, pure, non-contaminated, fungal strains were selected to conduct inoculations on seedlings of the understory planted species and of the overstory species. We inoculated the host of origin of each strain for a proof of pathogenicity (Koch's postulates). These inoculations were conducted in a Smithsonian greenhouse in Gamboa, Panama. Ten individual seedlings from each of the species employed in the enrichment planting experiment were prepared by PRORENA nursery staff and placed in the greenhouse under partial shade with overhead netting. A total of 659 fungal strains isolated from the 20 seedlings species employed in the enrichment planting were used in the greenhouse inoculations. One leaf from the host seedling and one from the overstory species beneath which the seedling had been growing were inoculated with each strain in the greenhouse.

We followed the inoculation methodology employed by Gilbert and Webb (2007). We placed a small piece of mycelia-filled agar on top of a 2 ml autoclaved external-thread cryovial cap (Nalgene, Naperville, IL), which we had previously filled with agar. We marked the selected leaf for inoculation with the strain number and wounded the leaf with a seven-pointed Pergamano flower tool (Pergamano International, Uithoorn, The Netherlands) to allow the fungi to penetrate. After this, the cryovial cap with the fungi was pressed against the wound from the underside of the leaf and clipped to the leaf with a bent hair clip (Figure 2-1). The same procedure was conducted on a control leaf using only agar. If the control developed diseased symptoms that were similar to those developed by the inoculated leaves, those inoculations were excluded because it meant potential contamination, which occurred in <1% of the inoculations. One-week after the inoculations, the leaves were harvested, and the disease symptoms (e.g., necrosis) recorded. If the treatment leaf developed disease it was recorded as “susceptible” to that particular strain. Those strains that caused disease on the host in the greenhouse (positive Koch’s postulates) were then inoculated on the overstory tree species in the field. A total of 241 strains were inoculated in the field using the procedure explained above.

Molecular DNA characterization was conducted on those strains to identify the fungal species. The genus of the fungi were approximated using the Basic Local Alignment Tool from the National Library of Medicine (Appendix 2-4; National Center for Biotechnology, 2008).

Molecular characterization was conducted by extracting nuclear ribosomal DNA (rDNA) from the mycelia of the pure cultures prepared for the inoculations. rDNA was extracted and amplified using the *Extract-N-Amp Plant* PCR Kit from Sigma-Aldrich Laboratories (www.**sigmaaldrich**.com/). DNA extraction was conducted in the Smithsonian Molecular Laboratories in Naos, Panama. With the appropriate permits, DNA isolates were transported to the laboratory of Dr. Gregory Gilbert at the University of California for PCR amplification. We amplified the ITS region using primers ITS 1 (TCCGTAGGTGAACCTGCGG) and ITS 4 (TCCTCCGCTTATTGATATGC), which are primer pairs found to amplify ascomycete fungi (Gardes and Bruns, 1993; Larena *et al.*, 1999). All PCRs contained 4.4 μl NDI Water, 10 μl Extract-N-Amp mix, 0.8 μl of each of the primers (Forward and Reverse), and 4 μl of DNA template for a 20 μl reaction volume. The PCR protocol used was an initial 94°C for 3 min, followed by 34 cycles of 94°C for 30 seconds (denaturing phase), 54°C for 30 seconds (annealing phase) and 72°C for 1 min (extension phase) with one final extension of 72°C for 10 minutes (final extension). All PCR sequencing was conducted in UC Berkeley DNA Sequencing Facilities (http://mcb.berkeley.edu/barker/dnaseq/services).

DATA ANALYSIS — Seedling height, basal area, and foliar area were strongly correlated based on pairwise correlations ($r > 0.73$ and pP< 0.0001 in all cases); therefore, we used only seedling height for subsequent analyses. Similarly, a principal components analysis showed that all the types of understory plant cover, except litter, are well represented by the axis that also contains percent canopy openness (Appendix 2-5). Therefore, we included only canopy openness and amount of litter as variables in subsequent analyses, along with soil nitrogen and potassium.

The design of this study is such that the independent variable of interest is the phylogenetic distance between the seedlings and the tree species beneath which they were planted, rather than the species identity of the seedlings. Due to this experimental design only three species – *Colubrina glandulosa*, *Pachira quinata*, and *Terminalia amazonia* – were planted under canopies of both conspecifics and a range of heterospecifics (Figure 2-2). These three species provide a means to evaluate effects of phylogenetic distance to the canopy species with a standard reference performance (growth under conspecifics vs growth under heterospecifics). All analyses were conducted both on the whole set of seedling species and on the subset of these three species.

ANALYSIS OF PERFORMANCE AND FOLIAR DAMAGE DATA — The number of days that each individual seedling survived after outplanting was used for survival analysis. These survival data were right censored when a seedling outlived the study period; a seedling was given a censoring label of 1 if it died during the study. Survival data were analyzed employing the Log rank Chi-square (χ^2) test of the Cox proportional hazards regression (Cox, 1972). The formula for the Cox regression is the log of the hazard function:

$$\log h_i(t) = \alpha(t) + \beta_1(PD)_i + \beta_2(OS)_i + \beta_3(\text{canopy openness})_i + \beta_4(\text{litter})_i + \beta_5(\text{nitrogen})_i + \beta_6(\text{phosphorus})_i + \beta_7(\text{height at planting})_i$$

Hazard is defined as the instantaneous mortality of an individual tree. The covariates of phylogenetic distance (as a continuous variable), overstory species identity, canopy openness, soil nitrogen and phosphorus, and height at planting were tested for significance in determining risk of death of the seedlings. For ease in visualizing the results, plots of survivorship functions employ the following categories of phylogenetic distance: conspecifics (0 MY), confamilials (57-87 MY) and extrafamilials (> 90 MY).

Growth was calculated as absolute monthly height change between censuses ((t_{i+1}-t_i)/ number of months between censuses) and averaged for all seedlings of a species within each plot. Some seedling species died and resprouted, and therefore they show a negative height change. Foliar damage was analyzed as percent of leaves showing disease symptoms and/or herbivory. Percent damage was estimated as the number of damaged leaves (leaves with disease symptoms and leaves with herbivory) divided by the total number of leaves. Growth and foliar damage were analyzed by fitting a mixed-model repeated measures analysis of covariance with time in months as the repeated measure, overstory species identity as the fixed factor, replicate plots nested within overstory species as random effect factor, and phylogenetic distance, the different biophysical variables (canopy openness, litter, soil nitrogen, and soil phosphorus) and initial height as covariates. Up to three way interactions were explored. The within effects factor was time. Choice of the best model was determined by comparing the p-values for the between effects in the different models. The model with the lowest p-value and the least independent variables (more parsimonious) was chosen. Analyses were conducted both with and without extreme values of monthly growth (10 extreme values <

-5 cm mo^{-1} and 11 values >10 cm mo^{-1}) to assess influence of extreme positive or negative changes in the models. Linear and quadratic regressions were fit to inter-census growth and percent damaged leaves as a function of phylogenetic distance.

Percent foliar damage was integrated over time by calculating the Area under the Disease Progress Curve (AUDPC) using the mid-point method of Campbell and Madden, (1990) to evaluate whether the cumulative increase in damage over time was explained by phylogenetic distance. Individuals that died were considered as completely damaged. This assumption may be inflating the importance of disease to seedling survival, but provides an integrated estimate of the effect of overstory on seedling health. AUDPC results were fitted to the independent variables using linear and polynomial regression approaches, with overstory species identity as an independent variable, and phylogenetic distance and the biophysical variables as covariates. All statistical analysis were conducted using the programs JMP 9.0.0 (SAS-Institute, 2010) and R 2.10.1 (R-Development-Core-Team, 2009).

ANALYSIS OF CROSS-INOCULATION RESULTS — We looked at the percent of inoculum that caused symptoms on the host seedling (positive Koch's postulates) and then also caused symptoms on the overstory species, both in the field and in the greenhouse. We used Chi-square tests to evaluate whether the number of symptomatic individuals differed among the host seedling species and the overstory species inoculated in the greenhouse. We also used Chi-square tests to look at whether the pathogenic strains that were inoculated on adult overstory trees in the field had also been pathogenic on the overstories in the greenhouse. We tested our hypothesis of a continuous decline in disease susceptibility with phylogenetic distance between overstory tree species and understory seedling species using logistic regression models with the logarithmic of phylogenetic distance (+1) as the independent variable, and the number of diseased and healthy individuals as the response variables. We fit these models to both the overstory species inoculated in the greenhouse and the overstory trees inoculated in the field to assess whether diseases isolated from close relatives of the overstories had a higher likelihood of causing a symptomatic response on the overstory tree than those coming from more distant relatives. All analyses were conducted using R, version 2.10.1 (R-Development-Core-Team, 2009).

RESULTS

SEEDLING SURVIVAL — Of the 2512 seedlings that were planted, 1650 (65.7%) survived 23 mo. to the last census. Seedling species planted under conspecifics had, on average, 37% survivorship whereas seedlings planted under heterospecifics had 67% survival (Figure 2-2) (t-test, t_{22}=2.1, P=0.0466). The risk of seedling death declined as phylogenetic distance from the overstory species increased (logrank: relative risk increase=0.994 (95% CI= 0.9936 -0.9951), X^2= 237.7, df=1, P <0.0001, R^2=0.083; Figure 2-3A); a trend driven by conspecifics pairings (logrank test without conspecifics: relative risk reduction=0.995 (95% CI= 0.989- 1.001), X^2= 3.2, df=1, P=0.0765, R^2 = 0.013). The same result was obtained for the three species planted under both conspecifics and heterospecifics ((logrank test: relative risk reduction=0.994 (95% CI= 0.992 - 0.996), X^2= 39.62, df=1, P < 0.0001, R^2 = 0.101; Figure 2-3B).

Shade tolerance was a significant determinant of seedlings survival. However, phylogenetic relationships between seedlings and overstories, especially that of conspecifics, was still significant in the model when shade intolerants were removed from the analysis (Appendix 2-6). Overstory species identity and their interaction term with phylogenetic distance also explained a significant amount of variation in seedling survival (logrank, X^2= 388.3, df=21, P<0.0001, R^2=0.133). Seedling risk of dying was significantly higher under an *Ochroma pyramidale* overstory compared to all other overstory species (relative risk increase= 4.14 (95% CI= 2.3682-7.2367), P<0.0001). Ground cover of broad leaved species explained a significant amount of the variation in seedling survival, with seedlings risk decreasing with an increase in broad leaves ground cover (logrank, X^2= 13.32, df=1, P=0.0002632). None of the other biophysical variables explained seedling survival (Appendix 2-6).

SEEDLING GROWTH — The best model explaining seedling growth through time was a linear model that included overstory species identity, phylogenetic distance, canopy openness in the dry season, and their interactions with time (Table 2-3). Significance of canopy openness only for the dry season is due to differential loss of leaves among overstory tree species, leading to greater variability in canopy openness among species than in the wet season (Table 2-4). Separate linear regressions conducted for mean monthly growth as a function of phylogenetic distance for each census showed significant, positive relationships between monthly growth and phylogenetic distance, with the most significant relationship for the last census (Figure 2-4A). However, the models only explained between 2.9 and 7.3% of the variation in growth.

The significance of phylogenetic distance in these models was driven by conspecifics (rm ANCOVA for phylogenetic distance without conspecifics: $F_{1,126}$= 1.1, P=0.2975; linear regressions p>0.4 for all censuses except first). Similarly, the three seedling species that were planted under both conspecifics and heterospecifics grew more when planted under heterospecifics (rm ANCOVA, $F_{1,121}$=9.0, P=0.0067). The linear models for the three species explained 8 to 21% of the variation in growth, again with a stronger effect in the last census (Figure 2-4B). Even though soil nutrient variables (soil NH_4, NH_3, and P) were not significant in the overall models, seedlings grew significantly more under legumes (Mean=1.86 cm mo^{-1} ±3.23) than under non-legumes (Mean=0.94 cm mo^{-1} ± 2.62) (t-test, $t_{445.3}$=3.56, P= 0.0004).

FOLIAR DAMAGE ANALYSIS — Phylogenetic distance between seedlings and overstory species was a significant predictor of percent disease (Table 2-5), but the model with lowest p-value included the predictor variables of phylogenetic distance and overstory species identity. Significance of phylogenetic distance in these models was driven by the second census (August 2009; Figure 2-5A), in which there was a sharp decrease of disease with phylogenetic distance. When disease damage was integrated over time using the Area Under the Damage Progress Curve (AUDPC), phylogenetic distance was highly significant for percentage of leaves with disease (Figure 2-6). The significant effect of phylogenetic distance on percent disease was not driven exclusively by the presence of conspecifics (rm ANCOVA without conspecifics, $F_{11,1114}$=6.6, P=0.0116; linear regression P=0.0502). Analysis including only the three seedlings planted under both conspecifics and heterospecifics did not show a significant effect of phylogenetic distance (Figure 2-5B, rm ANCOVA, $F_{1,18}$=0.000136, P=0.9611; AUDPC P>0.05).

There was a significant effect of seasonality and overstory species identity on percent diseased leaves. Seedlings showed a higher percentage of leaves diseased in the wet (census August 2009= 55.5%, sd=23.8; August 2010=53.6%, sd=25.1) than in the dry months (January 2009=34.7%, sd=20.9; March 2010=39.4%, sd=22.8) (rm ANOVA, $F_{1,332}$=0.2, P<0.0001). The effect of the overstory species, even though significant, changed across censuses. For example, seedlings developed significantly more disease when planted under *Tectona grandis,* but only in the January 2009 and March 2010 censuses (Linear regression, Census January 2009: Coefficient= 18.7, t=2.3, P=0.0203; Census March 2010: Coefficient= 27.7, t=3.3, P=0.00142).

There was no significant effect of phylogenetic distance on percent herbivory (rm ANCOVA, $F_{1,131}$=0.007, P=0.3276), mainly because seedlings of *Tabebuia rosea,* a distant relative to most overstory species where it was planted (233.13 My for 92% of the overstory species), always experienced high herbivory (over 65% on average). When this species was excluded from the analysis, the effect of phylogenetic distance on herbivory was marginally significant to significant (rm ANCOVA, $F_{1,100}$=0.1, P=0.0594; AUDPC linear regression: 1038 – 1.25×PD, Pp<0.0001). The effect was driven by conspecifics in the AUDPC analysis (AUDPC regression without conspecifics: 750.34+0.93×PD, P=0.0905). Phylogenetic distance was not a significant explanatory variable for percent herbivory through time in the three seedling species planted under both conspecifics and heterospecifics (rm ANCOVA, $F_{1,16}$=0.011, P=0.6677; AUDPC P>0.05).

Overstory species identity was significant in explaining herbivory (rm ANCOVA, $F_{10,122}$=0.2, P=0.0406), with seedlings under *Ochroma pyramidale* showing over 50% herbivory on average through the four censuses, and significantly higher herbivory in the first census (Census January 2009: Coefficient: 20.5, t=2.2, P=0.0296). There was an effect of seasonality on percent herbivory, but only in the second year and in the opposite direction than for disease, with seedlings showing greater herbivory in the dry season (Mean=62.1%, sd=1.9) than in the wet (Mean=53.2%, sd=2.0) (rm ANOVA, $F_{1,330}$=0.02, P=0.0119).

CROSS-INOCULATION EXPERIMENT — Over 60% of inoculated leaves developed disease symptoms in all treatments (Figure 2-7). Around 75% of the strains that caused disease symptoms on the host (positive Koch's postulates) also caused disease symptoms on the overstory species in the greenhouse inoculations and close to 74% caused symptoms on the overstories inoculated in the field. There was a very high probability that strains which caused disease symptoms on the host would also develop symptoms on the overstory species in the greenhouse (X^2=101.5, df=1,p<0.0001). There was no significant relationship between the probability that a seedling of an overstory species developed symptoms from an inoculum in the greenhouse and the probability that the same strain will cause symptoms in the overstory species in the field (X^2=0.6, df=1,p>0.05).

There was no significant relationship between the proportion of overstory individuals that developed symptoms and the phylogenetic distance between them and the host seedling either when the overstories were inoculated as seedlings in the greenhouse (logit proportion diseased = 0.709-0.065 × log(phylogenetic distance + 1), P = 0.19, n=622) or when they were inoculated in the field (logit proportion diseased =1.316- 0.0572 x log(phylogenetic distance + 1) , P=0.52, n=241).

DISCUSSION

Our results indicate that tree seedlings grow and survive poorly when planted under conspecifics. These results agree with the presence of Janzen-Connell mechanisms affecting seedling performance. Several tests of these mechanisms in tropical forests have found strong and pervasive negative effects on performance of seedlings close to a parent tree or when conspecific densities are high (e.g., Augspurger and Kelly, 1984; Clark and Clark, 1984; Hubbell *et al.*, 1990;Gilbert *et al.*, 1994; Wills *et al.*, 1997; Queenborough *et al.*, 2007; Metz *et al.*, 2010) often as a result of higher host-specific shared pests and pathogens near a conspecific adult tree. We found that seedlings which were of the same species as the overstory experienced significantly higher foliar damaged due to diseases. However, our cross-inoculation tests showed that seedlings and overstory species shared pathogens to a high degree irrespective of the phylogenetic distance among them.

Classic negative density-dependence studies treated species as either conspecific or heterospecific, assuming that negative species interactions were strictly host-specific (e.g., Augspurger, 1984; Augspurger and Kelly, 1984; Clark and Clark, 1984; Comita and Hubbell, 2009; Gilbert *et al.*, 1994; Harms *et al.*, 2000; Hubbell *et al.*, 1990; Lin and Augspurger, 2006; Wills *et al.*, 1997). A more recent and subtle approach, given the availability of complete phylogenies for many species, is to look beyond this binary division and place species interactions in a phylogenetically explicit framework (e.g., Gilbert and Webb, 2007; Gonzalez *et al.*, 2009; Metz *et al.*, 2010; Gilbert *et al.*, 2012). Following this approach we examined seedling performance and disease as a function of phylogenetic distance from the overstory tree. In our system, the classic division of conspecifics versus heterospecifics was sufficient to explain most of the observed patterns. However, the lack of appropriate congeneric seedling-overstory pairs in our study may have limited our power to detect a broader phylogenetic signal: congeners have a high probability of sharing pests and pathogens than more distantly related pairs (Gilbert and Webb, 2007).

In our cross inoculation study, the high proportion of pathogenic fungi shared between seedling species and overstory species indicate that the overstory tree species are a source of pathogens for the seedlings. We did not find an effect of phylogenetic distance among plant species on the probability of developing disease symptoms, which could be the result of three factors: 1) generalist nature of the foliar pathogens present, 2) pathogens locally adapting to the species present, and 3) the swamping effect of overstories as sources of pathogens to the seedlings overriding any phylogenetic signal. Even though theoretical epidemiology models suggest a tendency toward host specialization, empirical evidence of the generalist nature of many foliar plant pathogens support the first factor (Barrett *et al.*, 2009). Even though empirical tests of changes in the genetic structure of the pathogens consistent with local adaptation are still few (Barrett *et al.*, 2009), research has shown rapid evolution of local adaptation of fungi to the most common hosts in an area due to the faster reproducing cycle of the fungi compared to the plant host (Gandon *et al.*, 1996; Burdon and Thrall, 2000; Capelle and Neema, 2005;Springer, 2007; Konno *et al.*, 2011) leading to high infection on the local hosts yet low virulence (Gilbert and Parker, 2010). The third factor of physical proximity between the original host and a potential host, like between the overstory and the planted seedlings, matters in fungal host switching (Parker and Gilbert, 2004).

We selected overstory species that had developed closed canopy, at least during the wet season. This criterion indirectly led to choosing overstory species that were mostly light demanding (Table 2-2). The light requirements of conspecifics affected their survivorship and growth in the understory (Appendix 2-7). However, it is not a sufficient explanation for their low performance, since shade intolerant species planted under heterospecifics did not show poor survival (Figure 2-2), and phylogenetic distance was still significant even after the removal of shade intolerants from the data set (Cox relative risk increase: 0.997 (95% CI: 0.9958-0.9982); X^2=25.3,df=1, P<0.0001)

Contrary to the findings of Garcia-Guzman and Dirzo (2001), seasonality was a significant factor affecting variation in foliar damage in our study site. Light reaching the understory changed significantly between seasons (Table 2-4). Increased light in the dry season may explain the lower proportion of diseased leaves found in the censuses conducted on that season in comparison with wet season censuses when shade and humidity are greater. Gilbert *et al.*, 2007) found increased presence of epifoliar fungi under dark than under light conditions in the understory. In addition, several studies have found increase in disease incidence with an increase in humidity and/or rainfall (Tessmann *et al.*, 2001; Avelino *et al.*, 2007). Research has shown a direct relationship of increased disease susceptibility, spore germination and disease development with the time water is retained on leaf surfaces (Cook, 1980; Filajdic and Sutton, 1992; Bradley *et al.*, 2003). Herbivory, however, was greater in the dry months, as observed in other studies (Gombauld and Rankin-de Merona, 1998; Van Bael *et al.*, 2004; Cuevas-Reyes *et al.*, 2006; Pringle *et al.*, 2011).

Overstory species identity was a significant variable in the models of both seedling performance and damage. Overstory species differed in terms of their crown architecture, leaf phenology, nitrogen-fixing properties, and in the composition of naturally recruiting species. However, overstory species identity turned out to be a better predictor of seedlings performance than the biophysical variables measured separately. Not surprisingly, seedlings under legumes grew more than those under non-legumes. Legumes such as *Inga punctata, Gliricidia sepium* and *Dyphisa robinoides* are used in restoration given their high growth rate, and that they quickly shade out invasive grasses and increase N-availability (Franco and DeFaria, 1997; Bouman *et al.*, 1999; Carpenter *et al.*, 2004). The site of our experiment is highly invaded with the grass *Saccharum spontaneum* making legumes good choices to plant. Some overstory species beneath which seedlings showed a significantly lower performance, like *Ochroma pyramidale,* and *Luehea seemannii,* also had a high density of *Saccharum spontaneum* (Schweizer and Cummings, personal observation). Studies have found that seedling germination, growth and survival were significantly higher in areas where *Saccharum spontaneum* had been controlled either by shading (Hooper *et al.*, 2002) or by mechanical or herbicide removal (Craven *et al.*, 2009).

Our experiment was designed to test how phylogenetic relationships between seedling and overstory plants could be used to predict performance, and disease and herbivore damage of seedlings planted in an understory, regardless of species identity. We found a significantly lower performance when seedlings of the same species as the overstory were planted. However, idiosyncratic variation among species in all the dependent variables led to a wide spread in the data (Figures 2-4 and 2-5). Studies have shown that pests are important factors that affect performance of tree seedlings in plantations, but the importance of pests varies among tree species (Menalled *et al.*, 1998; Piotto *et al.*, 2004). Such idiosyncratic variation, which may reflect intrinsic variation in host susceptibility or temporal outbreaks in pest populations, would make it less likely to detect a broader significant phylogenetic signal in field experiments. This study only planted three species under both conspecific and heterospecific overstories; future studies could test more species in this pairing array to control for noise in the data due to intrinsic species differences.

CONCLUSIONS

Enrichment planting can be an important management tool to increase biodiversity in a reforestation setting and aid those species from the mature forest that are not able to disperse into the plantation (Lamb, 1998; Lamb, 2011). Phylogenetic distances between enrichment planted seedlings and their overstories proved to be an important predictor in models of seedlings performance and foliar damage, yet the relationship was driven by conspecific interactions. Lack of representation of close relatives (e.g., congeners), and idiosyncratic effects of species may have overshadowed subtler differences at greater phylogenetic distances. Future work at close phylogenetic distances is warranted

FIGURES:

Figure 2-1. Photos of how fungal strains were inoculated onto the leaves of the plants.

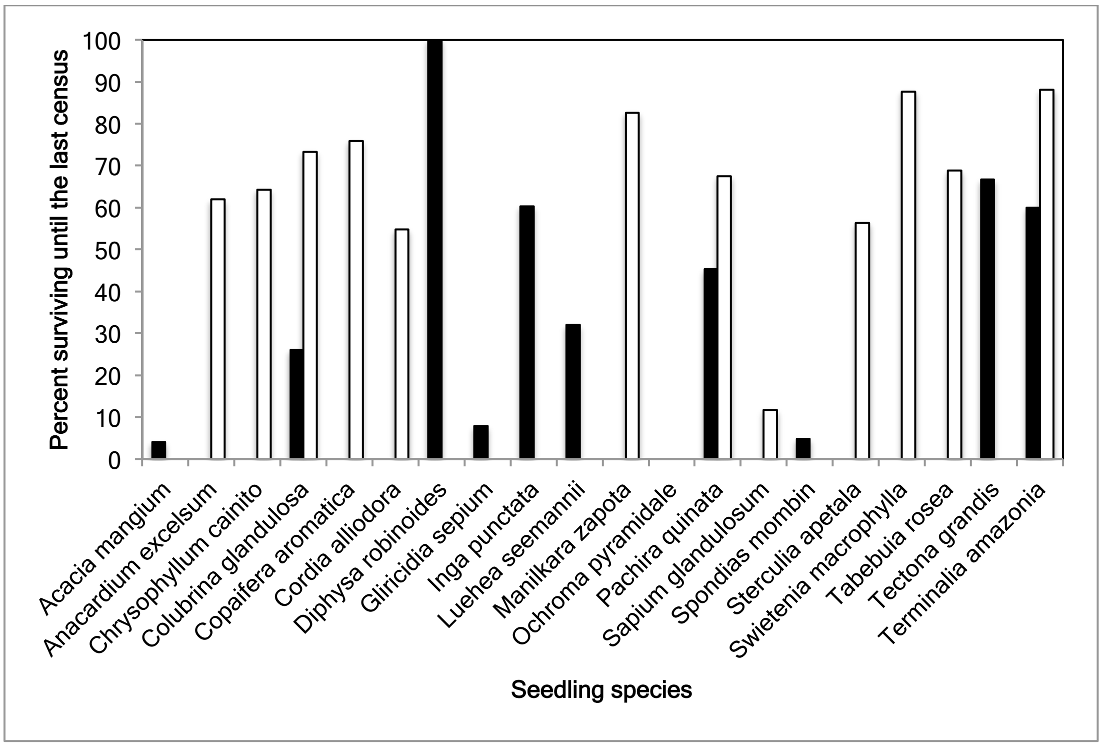


Figure 2-2. Proportion of seedlings of each species planted that survived until the last census. White bars represent the percent of seedling individuals that survived when planted under heterospecifics, black bars represent the same but for seedlings planted under conspecifics. Only three seedling species: *Colubrina glandulosa, Pachira quinata* and *Terminalia amazonia* were planted under both conspecific and heterospecific trees.

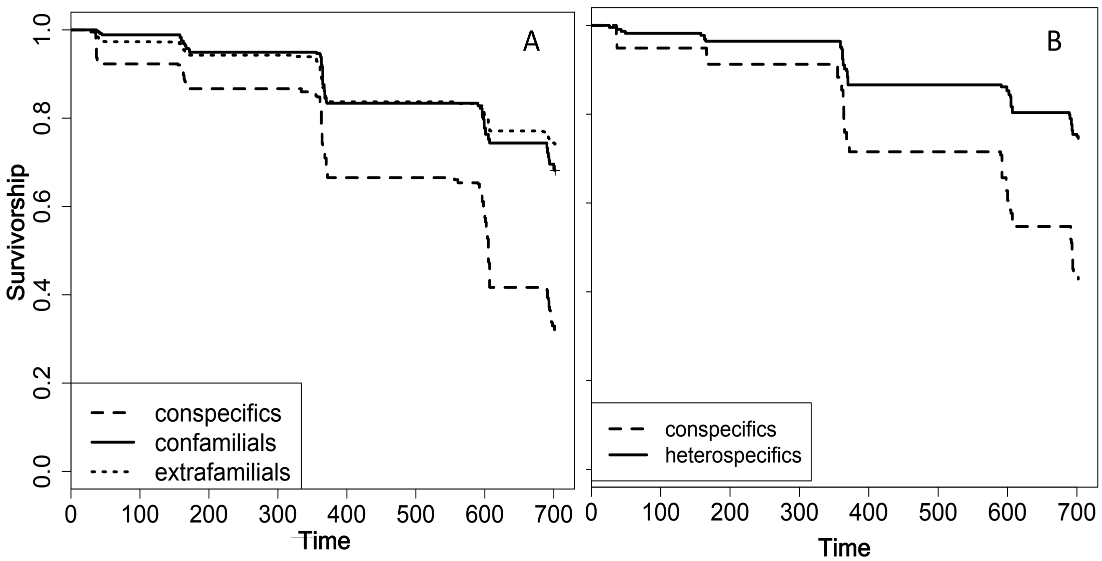


Figure 2-3 Survival estimates (Kaplan Meier) of the seedlings. Seedlings are grouped by phylogenetic ranges in the following categories: conspecifics (0 My), confamilials (50-88 My) and extrafamilials (greater than 90 My). Figure A shows the survivorship of all the species planted and figure B shows only those seedling species planted under both conspecifics and heterospecifics.

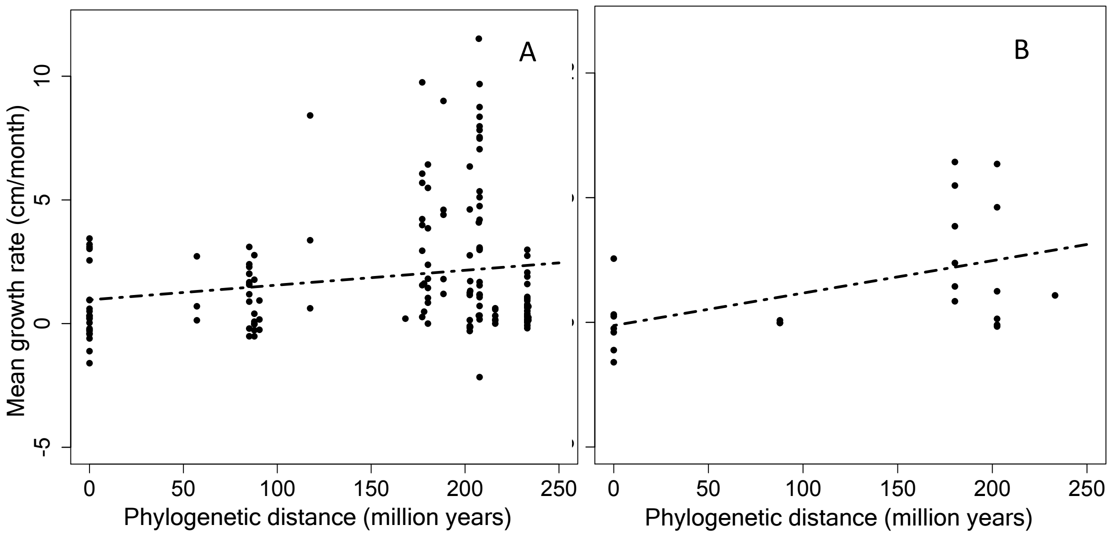


Figure 2-4. Seedlings mean growth rate as a function of phylogenetic distance to the overstory tree, showing the predicted fit line from the linear model of mean growth rate as a function of phylogenetic distance for the last census (August 2010). The relationship between mean monthly growth and phylogenetic distance was significant for all censuses, but stronger in the last one. *Panel A*: All seedlings together; *Panel B*: Three seedling species planted under conspecifics and heterospecifics. *Panel A*: Mean Growth/mo=1.59 + 0.0099 × (PD), p= 0.0179, R^2= 0.029. *Panel B*: Mean Growth/mo=-0.21 + 0.022 × (PD), p= 0.0152, R^2= 0.2139.

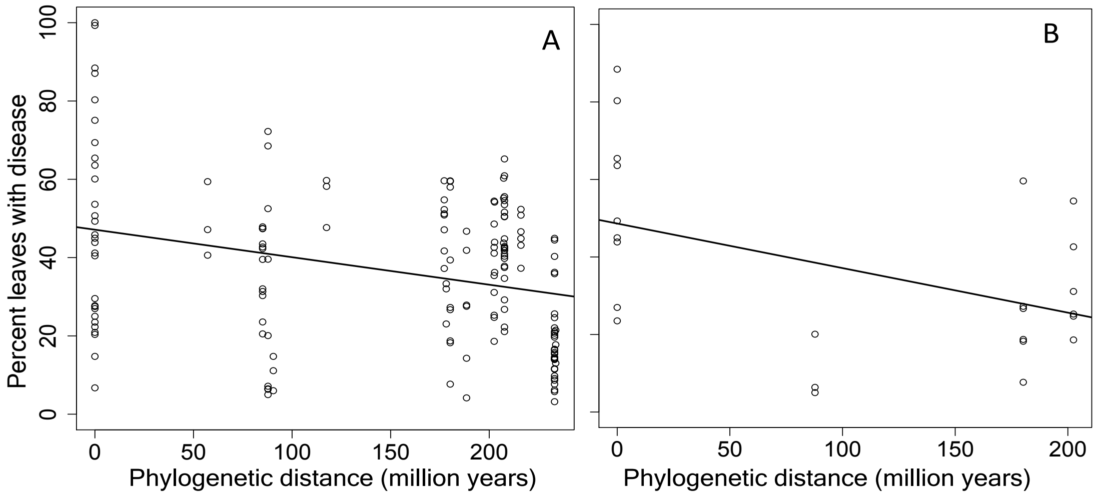


Figure 2-5. Percent of leaves showing disease as a function of phylogenetic distance to the overstory for the August 2009 census, showing the fitted line of the model. Linear regression of disease against phylogenetic distance was significant only for this census. *Panel A*: All seedlings together; *Panel B*: Three seedling species planted under conspecifics and heterospecifics . *Panel A:* Census August 2009 (12 mos. after planted): Percent leaves diseased =47.13 – 0.07 × (PD), p<0.001; *Panel B:* Census August 2009 (12 mos. after planted): Percent leaves diseased =48. 6– 0.11 × (PD), p=0.0247.

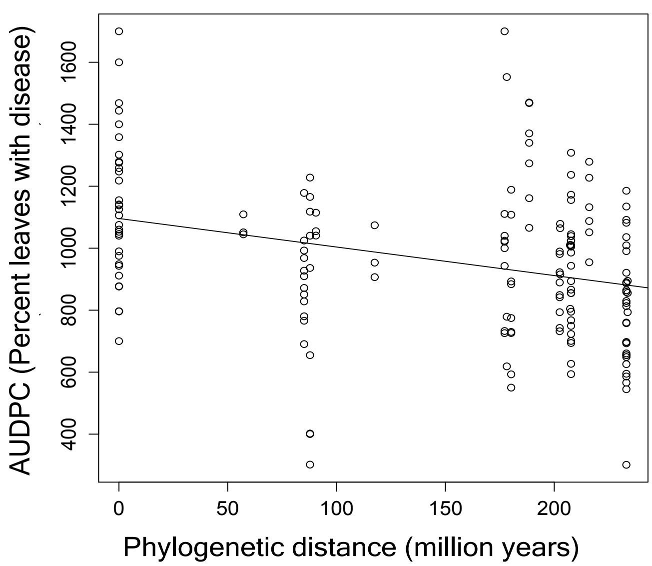


Figure 2-6. Area under the disease progress curve (AUDPC) for percent foliar disease, showing the fitted line from the regression of AUDPC against phylogenetic distance. AUDPC (percent leaves with disease)=1095 -0.92 × (PD), p<0.0001, R=0.096.

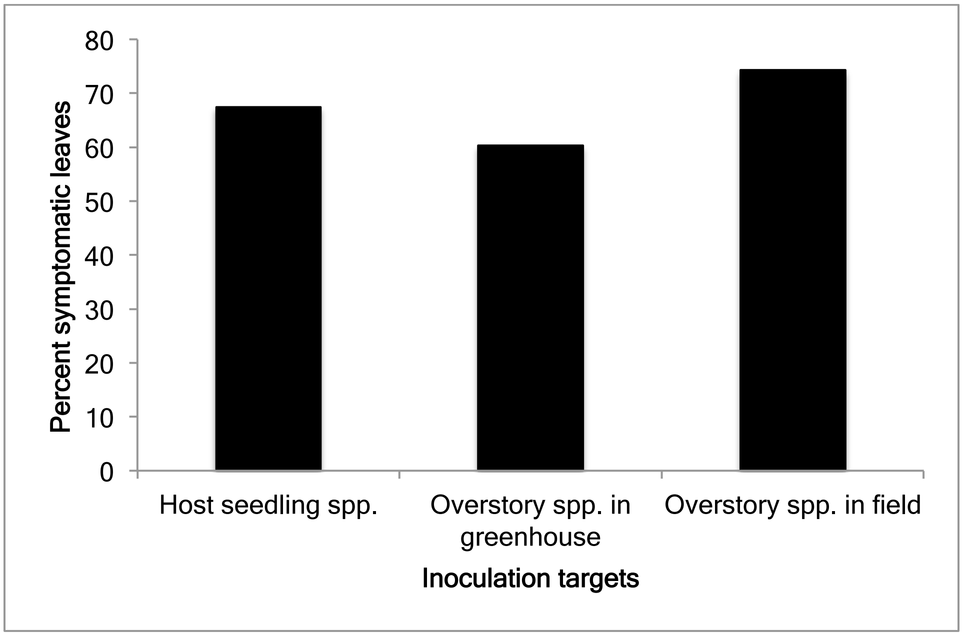


Figure 2-7. Percent symptomatic leaves after inoculation. The host seedling category corresponds to the seedling species from which the fungi were isolated.

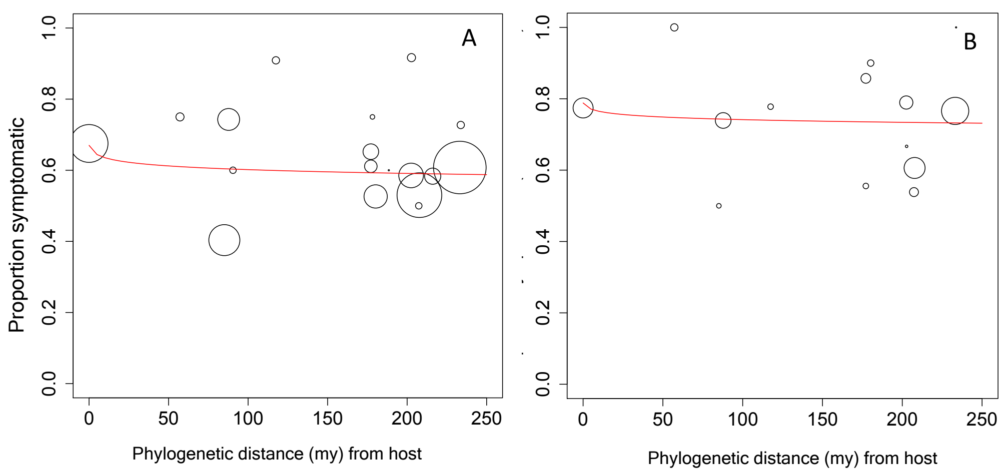


Figure 2-8. Proportion of overstory tree species that developed diseased symptoms after inoculation with foliar fungal pathogens from understory seedling species, (A) in the greenhouse and (B) in the field, as a function of their phylogenetic distance to the host seedling species. The line represents the predicted proportion of symptomatic individuals based on logistic regression conducted on raw data. The circles show data binned in groups of 10 million years, with circle size proportional to number of inoculates per bin. The inserts on each graph show the different proportion of symptomatic individuals when the fungi were isolated from conspecific seedlings versus from heterospecific seedlings. Logistic regression equations: (A) Proportion diseased (OS in greenhouse)= 0.709-0.0645 × log(Phylogenetic distance + 1), p = 0.18611, n=622; B) Proportion diseased (OS inoculations in the field)=1.316- 0.05721 x log(Phylogenetic distance + 1) , p=0.52006, n=241).

TABLES:

Table 2-1. Overstory species employed for the study. Foliar periodicity was determined from the ratio of canopy openness changes with season (table 3), using the following cut-off: less than 1.5 change for an evergreen, between 1.51 and 3 for semi-deciduous and over that for a deciduous species.

Family	**Species**	**Foliar periodicity ***
Anacardiaceae	*Spondias mombin* L.	Evergreen
Bombacaceae	*Pachira quinata* (Jacq.) W.S. Alverson	Deciduous
Combretaceae	*Terminalia amazonia* (J.F. Gmel.) Exell	Semi-deciduous
Fabaceae	*Acacia mangium* Willd.	Evergreen
Fabaceae	*Diphysa robinoides* (Mill.) M. Sousa	Evergreen
Fabaceae	*Inga punctata* Willd.	Semi-deciduous
Fabaceae	*Gliricidia sepium* Kunth ex Steud.	Evergreen
Malvaceae	*Ochroma pyramidale* (Cav. ex Lam.) Urb.	Semi-deciduous
Rhamnaceae	*Colubrina glandulosa* Perkins	Semi-deciduous
Tiliaceae	*Luehea seemannii* Triana & Planch.	Evergreen
Verbenaceae	*Tectona grandis* L. f.	Deciduous

Table 2-2. Species employed for enrichment planting. Species with asterisk (*) are also overstory species.

SPECIES	Light requirements	Source
Acacia mangium Willd *	Shade-intolerant	World Agroforestry Centre, n.d.
Anacardium excelsium (Bertero & Balb. ex Kunth) Skeels	Intermediate-shade-tolerant	Plath *et al.*, 2011
Chrysophyllum cainito L.	Shade tolerant	World Agroforestry Centre, n.d.
Colubrina glandulosa Perkins *	Shade-intolerant	World Agroforestry Centre, n.d.
Copaifera aromatica Dwyer	Shade tolerant	Wishnie *et al.*, 2007
Cordia alliodora (Ruiz & Pav.) Oken	Shade-intolerant	Condit *et al.*, 1996; Piotto, 2007
Diphysa robinioides (Mill.) M. Sousa *	Shade-intolerant	World Agroforestry Centre, n.d.
Gliricidia sepium Kunth ex Steud.*	Shade-intolerant	World Agroforestry Centre, n.d.
Inga punctata Willd.*	Shade-intolerant	World Agroforestry Centre, n.d.
Luehea seemannii Triana and Planch*	Shade-intolerant	Condit *et al.*, 1996
Manilkara zapota (L.) van Royen	Shade tolerant	Piotto, 2007
Ochroma pyramidale (Cav.ex Lam) Urb.*	Shade-intolerant	Condit *et al.*, 1996
Pachira quinata (Jacq) W. S. Alverson*	Intermediate-shade-tolerant	Wishnie *et al.*, 2007
Sapium glandulosum L. Morong	Intermediate-shade-tolerant	The Country Day School, n.d.
Spondias mombin L.*	Shade-intolerant	Condit *et al.*, 1996
Sterculia apetala (Jacq.) Karst.	Shade-intolerant	Condit *et al.*, 1996
Swietenia macrophylla King	Shade tolerant	Ramos and Delamo, 1992
Tabebuia rosea (Bertol.) DC.	Intermediate shade tolerant	Condit *et al.*, 1996
Tectona grandis L. f.*	Shade-intolerant	World Agroforestry Centre, n.d.
Terminalia amazonia (J.F. Gmel) Exell.*	Intermediate-shade-tolerant	Redondo-Brenes and Montagnini, 2006; Piotto, 2007

Table 2-3. Repeated measures ANCOVA for mean monthly growth rate for all phylogenetic distance/overstory combinations. Sources of variation are overstory species identity, phylogenetic distance (PD), canopy openness in the dry season (DS), and time × overstory, time × phylogenetic distance and time × canopy openness interactions.

Source of variation	F	df	p
Overstory species	4.3	10,134	<0.0001
PD	7.8	1,134	0.0059
Canopy openness DS	8.6	1,134	0.0045
Time*	0.9	2.2,288.5	0.3865
Time × Overstory	1.7	40,536	0.0064
Time × PD	6.9	2.2,288.5	0.0009
Time × Canopy openness DS	3.1	2.2,288.5	0.0458

*Mauchly criterion showed violation of sphericity ($X^2 = 336.49, p=<0.0001$) so adjusted G-G corrections shown

Table 2-4. Percent canopy openness of the different overstory species. Value is the mean of the three replicate plots per species ± SD.

Overstory species	**Canopy openness wet season (Aug. 2009)**	**Canopy openness dry season (March 2010)**
Acacia mangium	12.7±1.5	19.1±0.2
Colubrina glandulosa	17.9±5.2	33.3±0.2
Dyphisa robinoides	13.4±1.8	18.1±3.9
Gliricidia sepium	11.4±3.5	16.7±5.8
Inga punctata	11.5±0.6	20.7±3.5
Luehea seemannii	17.9±9.5	18.8±0.1
Ochroma pyramidale	18.7±3.9	30.7±5.2
Pachira quinata	12.7±3.2	38.2±5.3
Spondias mombin	24.6±2.3	32.3±3.5
Tectona grandis	6.79±0.9	44.7±4.4
Terminalia amazonica	12.4±3.5	20.3±0.7

Table 2-5. Repeated measures ANCOVA for the mean percent of leaves showing disease per phylogenetic distance /overstory combination. Parameters are phylogenetic distance (PD), Overstory species identity, and canopy openness in the dry season (DS).

Model	Parameters			F	df	p
Between subjects						
1	PD			4.0	1,133	0.0472
2	PD	Overstory		3.6	11,123	0.0002
3	PD		Canopy openness DS	7.6	2,132	0.0008
Within subjects *						
1	Time*			4.1	2.8,369	0.0088
1	Time × PD*			4.5	2.8,369	0.0048
2	Time*			4.9	2.8,342	0.0029
2	Time × PD*			2.1	2.8,342	0.0016
2	Time × Overstory*			2.1	30,369	0.0009
3	Time			4.8	3,130	0.0032
3	Time × PD			5.6	3,130	0.0013
3	Time × Canopy openness DS			12.1	3,130	<0.0001

* Within subjects G-G corrected

APPENDICES

Appendix 2-1. Tree seedling species planted under each overstory species and their phylogenetic distance to that overstory.

Overstory species	Seedling species	Phylogenetic distance seedling-overstory (My)
Acacia mangium Willd	*Acacia mangium* Willd	0
	Copaifera aromatica Dwyer	85.07
	Sapium glandulosum L. Morong	188.49
	Swietenia macrophylla King	207.72
	Tabebuia rosea (Bertol.) DC.	233.13
Colubrina glandulosa Perkins	*Colubrina glandulosa* Perkins	0
	Copaifera aromatica Dwyer	180.21
	Sapium glandulosum L. Morong	188.49
	Swietenia macrophylla King	207.32
	Tabebuia rosea (Bertol.) DC.	233.13
Diphysa robinioides (Mill.) M. Sousa	*Diphysa robinioides* (Mill.) M. Sousa	0
	Copaifera aromatica Dwyer	85.07
	Colubrina glandulosa Perkins	180.21
	Swietenia macrophylla King	207.72
	Tabebuia rosea (Bertol.) DC.	233.127
Gliricidia sepium Kunth ex Steud.	*Gliricidia sepium* Kunth ex Steud.	0
	Copaifera aromatica Dwyer	85.07
	Colubrina glandulosa Perkins	180.21
	Swietenia macrophylla King	207.72
	Tabebuia rosea (Bertol.) DC.	233.13
Inga punctata Willd.	*Inga punctata* Willd.	0
	Copaifera aromatica Dwyer	85.07
	Sapium glandulosum L. Morong	188.49
	Swietenia macrophylla King	207.72
	Tabebuia rosea (Bertol.) DC.	233.127

Appendix 2-1. Continuation.

Overstory species	**Seedling species**	**Phylogenetic distance seedling-overstory (My)**
Luehea seemannii Triana and Planch	*Luehea seemannii* Triana and Planch	0
	Sterculia apetala (Jacq.) Karst.	87.78
	Swietenia macrophylla King	177.18
	Copaifera aromatica Dwyer	207.72
	Tabebuia rosea (Bertol.) DC.	233.13
Ochroma pyramidale (Cav.ex Lam) Urb.	*Ochroma pyramidale* (Cav.ex Lam) Urb.	0
	Pachira quinata (Jacq) W. S. Alverson	87.78
	Sterculia apetala (Jacq.) Karst.	87.78
	Swietenia macrophylla King	177.17
	Copaifera aromatica Dwyer	202.72
	Tabebuia rosea (Bertol.) DC.	233.13
Pachira quinata (Jacq) W. S. Alverson	*Pachira quinata* (Jacq) W. S. Alverson	0
	Sterculia apetala (Jacq.) Karst.	87.78
	Swietenia macrophylla King	177.18
	Terminalia amazonia (J.F. Gmel) Exell.	202.5
	Copaifera aromatica Dwyer	207.72
	Tabebuia rosea (Bertol.) DC.	233.72
Spondias mombin L.	*Spondias mombin L.*	0
	Anacardium excelsium (Bertero & Balb. ex Kunth) Skeels	57.17
	Swietenia macrophylla King	117.49
	Terminalia amazonia (J.F. Gmel) Exell.	202.5
	Copaifera aromatica Dwyer	207.72
	Tabebuia rosea (Bertol.) DC.	233.13
Tectona grandis L. f.	*Tectona grandis* L. f.	0
	Tabebuia rosea (Bertol.) DC.	90.49
	Cordia alliodora (Ruiz & Pav.) Oken	178.19
	Chrysophyllum cainito L	216.07
	Manilkara zapota (L.) van Royen	216.07
	Swietenia macrophylla King	233.13

Appendix 2-1. Continuation

Overstory species	**Seedling species**	**Phylogenetic distance seedling-overstory (My)**
Terminalia amazonia (J.F. Gmel) Exell.	*Terminalia amazonia* (J.F. Gmel) Exell.	0
	Swietenia macrophylla King	202.5
	Copaifera aromatica Dwyer	207.72
	Tabebuia rosea (Bertol.) DC.	233.13

Appendix 2-2. Seedlings source, number planted and average of height at planting.

Seedlings and source	**Number of seedlings planted**	**Average of Initial height**
Acacia mangium		
Cristian nursery	50	20.96
Totals	50	20.96
Anacardium excelsum		
PRORENA nursery from seed	42	15.67
Totals	42	15.67
Chrysophyllum cainito		
Seedling from field	13	9.08
PRORENA nursery from seed	29	22.86
Totals	42	15.97
Colubrina glandulosa		
PRORENA nursery from seed	150	17.43
Totals	150	17.43
Copaifera aromatica		
PRORENA nursery from seed	469	19.02
Totals	469	19.02
Cordia alliodora		
Seedling from field	13	4.69
PRORENA nursery from seed	29	27.72
Totals	42	16.21
Diphysa robinoides		
PRORENA nursery from seed	30	87.88
Totals	30	87.88
Gliricidia sepium		
PRORENA nursery from seed	51	48.51
Totals	51	48.51

Appendix 2-2. Continuation

Seedlings and source	Number of seedlings planted	Average of Initial height
Inga punctata.		
PRORENA nursery from seed	43	19.26
Totals	43	19.26
Luehea seemannii		
PRORENA nursery from seed	49	19.34
Totals	49	19.34
Manilkara zapota		
PRORENA nursery from seedling	41	18.80
Ochroma pyramidale		
Seedling from field	5	27.00
PRORENA nursery from seed	38	11.07
Totals	43	19.04
Pachira quinata		
PRORENA nursery from seed	82	16.23
Totals	82	16.23
Sapium glandulosum		
Seedling from field	76	10.40
PRORENA nursery from seedling	16	8.13
Totals	92	9.26
Spondias mombin		
Seedling from field	26	9.88
PRORENA nursery from seed	14	26.54
Totals	40	18.21
Sterculia apetala		
Seedling from field	73	12.86
PRORENA nursery from seedling	5	16.80
Totals	78	14.83
Swietenia macrophylla		
PRORENA nursery from seed	468	25.89
Cristian nursery	8	41.86
Penonome nursery	20	24.00
Totals	496	30.58
Tabebuia rosea		
PRORENA nursery from seed	504	11.26
Totals	504	11.26

Appendix 2-2. Cont.

Seedlings and source	**Number of seedlings planted**	**Average of Initial height**
Tectona grandis		
PRORENA nursery from seedling	15	9.21
Cristian nursery	24	13.25
Totals	39	11.23
Terminalia amazonia		
PRORENA nursery from seedling	129	21.13
Totals	129	21.13
TOTALS	2512	
Totals	41	18.80

Appendix 2-3. Survival to the last census as a function of sources of the seedling; only for those species with more than one source. Potential sources: PRORENA nursery raised from seed, PRORENA nursery raised from seedling, collected from the field, bought from other two nurseries (Cristian and Penonome)

Seedling	Source	Coefficient	z	P
Cordia alliodora	Seedling from field	-19.5	-0.007	0.995
	PRORENA from seed	20.9	0.007	0.994
Chrysophyllum cainito	Seedling from field	0.15	0.27	0.782
	PRORENA from seed	0.64	0.94	0.348
Sapium glandulosum	Seedling from field	-1.89	-5.56	<0.0001
	PRORENA from seedling	-0.058	-0.071	0.943
Spondias mombin	Seedling from field	-20.57	-0.006	0.995
	PRORENA from seedling	18.77	0.005	0.996
Sterculia apetala	Seedling from field	0.082	0.351	0.726
	PRORENA from seedling	1.30	1.142	0.254
Swietenia macrophylla	PRORENA from seed	2.27	14.3	<0.0001
	Cristian nursery	-1.17	-1.40	0.161
	Penonome nursery	-0.88	-1.51	0.130
Tectona grandis	PRORENA from seedling	-0.41	-0.769	0.44171
	Cristiannursery	2.01	2.65	0.00803

Appendix 2-4. Foliar fungi DNA sequences in FASTA format of the fungi isolated from host seedlings and used in the cross-inoculations. Genus name corresponds to the Teleomorph (sexual) state of the fungi. NCBI genus name matches come from the Basic Local Alignment Tool (BLAST, National Center for Biotechnology, 2008).

DNA sequence	NCBI Genus
>109 GTCTCGTTGGTGACCAGCGGAGGGTTACCGAGTTTACAACTCCCAAACCCCATGTGAACAT ACCTGTTTCGTTCCCTCGGCGGTGTCCGGCAACGGCCCGCCAGAGGACCCAACAAACTCTT TTGAATTATTCAGTATCTTCTGAGTGAAAAAAACAATAAATCAAAACTTTCAACAACGGATC TCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATACGTAATGTGAATTGCAGAA TTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGTATTCTGGCGGGCATGCC TGTTCGAGCGTCATTTCAACCCTCAAGCTCAGCTTGGTGTTGGGGATCGGCAGGGCGTCCT CCGGGTCGCGCCGTCCCCCAAATCTAGTGGCGGTCTCGCTGTAGCTTCCTCTGCGTAGTAAT ACACCTCGCACTGGAGTCTCGGCGCGGCCACGCCGTAAAACCCCCAACTTTTTCTGGTTGAC CTCGAATCAGGTAGGACTACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAA CCAACAGGGATTGCCCTAGTAACGGCGAGTGAAGCGGCAACGGCTCAAATA	Ascomycete
>988 GGGGGGAATGGTGACCAGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAA CCCTTTGTGAACTTATACCTTACTGTTGCCTCGGCGCAGGCCGGCCCCCCCACCGGGGCCCC TCGGAGACGAGGAGCAGCCCGCCGGCGGCCAACCAAACTCTTGTTTCTTAGTGAATCTCTG AGTAAAAAAACATAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGAT GAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAAT CTTTGAACGCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCA ACCCTCAAGCCTGGCTTGGTGTTGGGGCACTGCTTCGAGAGGAGCAGGCCCTGAAATCTA GTGGCGAGCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGC GGTGCCCTGCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCC GCTGAACTTAAGCATATCAGGAGGAA	Botryosphaeria

>2041 CCTGCGGAGGCATTACCGAGTTTTCGAGCTCCGGCTCGACTCTCCCACCCTTGGTACCTCTGT TGCTTTGGCGGCTCCGGCCGCCAAAGGACCTTCAAACTCCAGTCAGTAAACGCAGACGTCTG ATAAACAAGTTAATAAACTAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAG AACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGA ACGCACATTGCGCCCCTTGGTATTCCGGGGGGCATGCCTGTTCGAGCGTCATTACAACCCTC AAGCTCTGCTTGGAATTGGGCACCGTCCTCACTGCGGACGCGCCTCAAAGACCTCGGCGGT GGCTGTTCAGCCCTCAAGCGTAGTAGAATACACCTCGCTTTGGAGCGGTTGGCGTCGCCCGC CGGACGAACCTTCTGAACTTTTCTCAAGGTTGACCTCGGATCAGGTAGGGATACCCGCTGAA CTTAAGCATATCAATAAGCGGAGGAA	Botryosphaeria
>2131 AGAGTGACTGCGGAGGATCATTACCGAGTTTTCGAGCTCCGGCTCGACTCTCCCACCCTTTG TGAACGTACCTCTGTTGCTTTGGCGGCTCCGGCCGCCAAAGGACCTTCAAACTCCAGTCAGT AAACGCAGACGTCTGATAAACAAGTTAATAAACTAAAACTTTCAACAACGGATCTCTTGGTT CTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGA ATCATCGAATCTTTGAACGCACATTGCGCCCCTTGGTATTCCGGGGGGCATGCCTGTTCGAG CGTCATTACAACCCTCAAGCTCTGCTTGGAATTGGGCACCGTCCTCACTGCGGACGCGCCTC AAAGACCTCGGCGGTGGCTGTTCAGCCCTCAAGCGTAGTAGAATACACCTCGCTTTGGAGC GGTTGGCGTCGCCCGCCGGACGAACCTTCTGAACTTTTCTCAAGGTTGACCTCGGATCAGGT AGGGATACCCGCTGAACTTAAGCATATCAATAGCGGAGGAA	Botryosphaeria
>2460 CATTACCGAGTTTTCGAGCTCCGGCTCGACTCTCCCACCCTTTGTGAACGTACCTCTGTTGCTT TGGCGGCTCCGGCCGCCAAAGGACCTTCAAACTCCAGTCAGTAAACGCAGACGTCTGATAA ACAAGTTAATAAACTAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACG CAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGC ACATTGCGCCCCTTGGTATTCCGGGGGGCATGCCTGTTCGAGCGTCATTACAACCCTCAAGC TCTGCTTGGAATTGGGCACCGTCCTCACTGCGGACGCGCCTCAAAGACCTCGGCGGTGGCT GTTCAGCCCTCAAGCGTAGTAGAATACACCTCGCTTTGGAGCGGTTGGCGTCGCCCGCCGG ACGAACCTTCTGAACTTTTCTCAAGGTTGACCTCGGATCAGGTAGGGATACCCGCTGAACTT AAGCATATCAATA	Botryosphaeria

>2492 GACAGCGGAGGGCTTACCGAGTTTACAACTCCCAAACCCCATGTGAACATACCTGTTTCGT TCCCTCGGCGGTGTCCGGCAACGGCCCGCCAGAGGACCCAACAAACTCTTTTGAATTTTTC AGTATCTTCTGAGTAAAAAAAACAATAAATCAAAACTTTCAACAACGGATCTCTTGGTTCT GGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGA ATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGTATTCTGGCGGGCATGCCTGTTCGA GCGTCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGATCGGCAAGGCGTCCTCCGGGTC GCGCCGTCCCCCAAATATAGTGGCGGTCTCGCTGTAGCTTCCTCTGCGTAGTAATACACCT CGCTCTGGAGTCTCGGTGCGGCCACGCCGTAAAACCCCCAACTTTTTCTGGTTGACCTCG AATCAGGTAGGACTACCCGCTGAACTTAAGCATATCAATAANCGGAGGAAA	Calonectria
>2015 CGTTGGTGACCGCGGAGGGACATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTAC CTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAA CTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGAT CTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAG AATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCAT GCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTTTA TTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTT TTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGAC CTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAA ACCAACAGGGATTGCCTTAGTAACGGCGAGTGAAGCGGCAACCTCAAATATA	Cordyceps
>1926 GACTGCGGAGATCATTATCGTAGGGGCCTCGCCCCCTTCGAGATAGCACCCTTTGTTTATG AGCACCTCTCGTTTCCTCGGCAGGCTCGCCTGCCAACGGGGACCCACCACAAACCCATTGC AGTACAAGAAGTACACGTCTGAACAAAACAAAACAAACTATTTACAACTTTCAACAACGG ATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAGTGTGAATTGC AGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCTTTGGTATTCCTTAGGGC ATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTAGCTTGGTGTTGGGCGTCTGTCCCGC CTCCGCGCGCCTGGACTCGCCTCAAAAGCATTGGCGGCCGGTTCCCAGCAGGCCACGAGC GCAGCAGAGCAAGCGCTGAAGTGGCTGCGGGTCGGCGCACCATGAGCCCCCCCACACCA GAATTTTGACCTCGGATCAGGTAGGGATACCCGCTGAACTTAAGCATATCAATAAGCGGA GGAA	Corynespora

>606 AGGCGATGGTGACCAGCGGAGGGCATTACTGAGTTCTAAACTCCAACCCTATGTGAACTTAC CACTGTTGCCTCGGCGCTGTGCCTGCGAGAGCAGGCCCGCCGGTGGACCACTAAACTCTGTT ATACCTACTGTATCTCTGAATTTATAACTGAAATACGTTAAAACTTTCAACAACGGATCTCTTG GTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAG TGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTATTCG AGCGTCATTTCAACCCTTAAGCCCCTGTTGCTTAGTGTTGGGAATCTGCGTTACGGCGCAGTT CCTTAAAGTGATTTGGCGGAGCTAGTGCATACTCTAGGCGTAGTAAATACCATTCTCGCTTTT GTAGTAGGCCTGGCGGCTTGCCGTAAAACCCCTATACTTCTAGTGGTTGACCTCGGATTAGG TAGGAATACCCGCTGAACTTAAGCATATCAATAAGAGGAAA	Daldinia
>98 GGGACCAGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAAC TTATACCTATCTGTTGCCTCGGCGCAGGCCGGCCTCTTCACTGAGGCCCCCTGGAGACAGGG AGCAGCCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACATA AATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAA ATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGC GCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGCTT GGTGATGGGGCACTGCCTTCTAGCGAGGGCAGGCCCTGAAATCTAGTGGCGAGCTCGCTAG GACCCCGAGCGTAGTAATTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAAC CCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATC AATAAGCGGAGGAA	Diaporthe
>117 AGGACAGCGGAGGTCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTT ATACCTATCTGTTGCCTCGGCGCAGGCCGGCCTCTTCGCTGAGGCCCCCTGGAGACAGGGA GCAGCCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAAACATA AATGAATCAAAACTTCCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAA ATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGC GCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGCTT GGTGATGGGGCACTACTTCCTCACGGGAGTAGGCCCTGAAATTCAGTGGCGAGCTCGCCAG GACCCCGAGCGTAGTAGTTATATCTCGCTTTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAAC CCCCAACTTTTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATC AATAAGCGGAGGa	Diaporthe

>120 CGATTGGTGACCAGCGGAGGGATCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTT TGTGAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGG AGACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAA AAAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACG CAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGC ACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGC CTAGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGC TCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCC GTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAA GCATATCAATAAGGAA	Diaporthe
>170 ACCGGAGGGATCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTTATAC CTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGACAGGGAGCA GCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAAAACATAATGA ATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCG ATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCT CTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTAGCTTGGTGT TGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGCTCGCCAGGACCC CGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAACCCCCA ACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAA GCGGAGGAA	Diaporthe
>358 GCGTTGGTGACCAGCGGAGGGACATTGCTGGAACGCGCCCCGGCGCACCCAGAAACCCTTT GTGAACTTATACCTACTGTTGCCTCGGCGCAGGCCGGCTTTTTTTGAGAAAAAGCCCCCTGG AGACAGGGAGCAGCCCGCCGGCGGCCAACCAAACTCTTGTTTCTGTAGTGAATCTCTGAGT AAAAACATAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAA CGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAAC GCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAA GCCTGGCTTGGTGATGGGGCACTGCTCTCCCACGAGAGCAGGCCCTGAAATCTAGTGGCGA GCTCGCCAGGACCCCGAGCGCAGTAGTTATATCTCGCTCTGGAAGGCCCTGGCGGTGCCCT GCCGTTAAACCCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACT TAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCCCTAGTAACGGCGAGT GAAGCGGCAACCCTCAAATA	Diaporthe

>399 CAGCGGAGGGCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTTATA CCTATTTGTTGCCTCGGCGTAGGCCGGCCTCTTCACTGAGGCCCCCTGGAAACAGGGAGC AGCCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACATAAA TGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAA ATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTG CGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGC TTGGTGATGGGGCACTGCCTTCTAACGAGGGCAGGCCCTGAAATCTAGTGGCGAGCTCGC TAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGT TAAACCCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAG CATATCAATAAGCGGAGGAA	Diaporthe
>414 GACCAGCGGAGGGATCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAAC TTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGACAG GGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAAAA CATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAG CGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCA CATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGC CTGGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGA GCTCGCCAGGACCCCGAGCGTAGTANTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCC TGCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAA CTTAAGCATATCAATAAGCGGAG	Diaporthe
>416 ACCAGCGGAGGGAcATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTT ATACCTATTTGTTGCCTCGGCGTAGGCCGGCCTCTTCACTGAGGCCCCCTGGAGACAGGG AGCAGCCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACAT AAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGC GAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCAC ATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCC TGGCTTGGTGATGGGGCACTGCCTTCTAGCGAGGGCAGGCCCTGAAATCTAGTGGCGAG CTCGCTAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCT GCCGTTAAACCCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAAC TTAAGCATATCAATAAGCGGAGGAA	Diaporthe

>579GATGGTGACAGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTT TGTGAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGG AGACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAA AAAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACG CAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGC ACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGC CTAGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGC TCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCC GTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAA GCATATCAATAGGAGGAAN	Diaporthe
>630 GATGGTGACCAGCGGAGGgACATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGT GAACTTATACCTATCTGTTGCCTCGGCGCAGGCCGGCCTCTTCACTGAGGCCCCCTGGAGAC AGGGAGCAGCCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAA CATAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAG CGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACA TTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTG GCTTGGTGATGGGGCACTGCCTTCTAGCGAGGGCAGGCCCTGAAATCTAGTGGCGAGCTCG CTAGGACCCCGAGCGTAGTAATTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTT AAACCCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCA TATCAATAAGCGGAGGAA	Diaporthe
>862 CGGAGGGCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTTATACCTAT CTGTTGCCTCGGCGCAGGCCGGCCTCTTCACTGAGGCCCCCTGGAGACAGGGAGCAGCCCG CCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACATAAATGAATCA AAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAA GTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCTCTGG TATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGCTTGGTGATGGG GCACTGCCTTCTAGCGAGGGCAGGCCCTGAAATCTAGTGGCGAGCTCGCTAGGACCCCGAG CGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAACCCCCAACTTC TGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGA GGAA	Diaporthe

>916 GACCAGCGGAGGGATCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACT TATACCTATTTGTTGCCTCGGCGTAGGCCGGCCTCTTCACTGAGGCCCCCTGGAGACAGGGA GCAGCCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACATAA ATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAA TGCGATAAGTAATGTGAATTGCANAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCG CCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGCTTG GTGATGGGGCACTGCCTTCTAGCGAGGGCAGGCCCTGAAATCTAGTGGCGAGCTCGCTAGG ACCCCGAGCGTANTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAACC CCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCA ATAAGCGGAGGAA	Diaporthe
>931 GAANGGTGACCAGCGGAGGGATCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTT GTGAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGA GACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAA AAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGC AGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCA CATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCT GGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGCTC GCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGT TAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGC ATATCAATAANNCGGAGGAA	Diaporthe
>956 GAGGTGACCAGCGGAGGGCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGA ACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGACA GGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAAAAC ATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCG AAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATT GCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTAGC TTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGCTCGCC AGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAA ACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATAT CAATAAGGAGGAA	Diaporthe

>1053 GCGTTGGGACGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGT GAACTTATACCTATCTGTTGCCTCGGCGCAGGCCGGCCTCTTCACTGAGGCCCCCTGGAGA CAGGGAGCAGCCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAA AAACATAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAAC GCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAA CGCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTC AAGCCTGGCTTGGTGATGGGGCACTGCCTTCTAGCGAGGGCAGGCCCTGAAATCTAGTGG CGAGCTCGCTAGGACCCCGAGCGTAGTAATTATATCTCGTTCTGGAAGGCCCTGGCGGTG CCCTGCCGTTAAACCCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCT GAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCCCTAGTAACG GCGAGTGAAGCGGCAACGCTCAAATA	Diaporthe
>1065 GGGGGAGACCAGCGGAGGTCATTGCTGGAACGCGCTTCCGCGCACCCAGAAACCCTTTGT GAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAG ACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAA AAAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAAACG CAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAAC GCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCA AGCCTACTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCG AGCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCC CTGCCGTAAACCCCCACTTCTGAAATTTTGACCTCGGATCAGTAGAATACCCGCTGAATTA AGCATATCAATAAGCGGAGAA	Diaporthe
>1070 GCGGAGGGATCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTTATA CCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGACAGGGAG CAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAAAACATAA TGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAA ATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTG CGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGC TTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCAAGCTCGC CAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGT TAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAG CATATCAATAAGCGGAGGAA	Diaporthe

>1182 GGACCAGCGGAGGGATCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAAC TTATACCTATTTGTTGCCTCGGCGTAGGCCGGCCTCTTCACTGAGGCCCCCTGGAGACAGGG AGCAGCCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAAACAT AAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGA AATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTG CGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGCTT GGTGATGGGGCACTGCCTTCTAACGAGGGCAGGCCCTGAAATCTAGTGGCGAGCTCGCTAG GACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAAC CCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATC AATAAGCGGAGGAA	Diaporthe
>1200 CCGCGGAGGGACATTGCTGGAACGCGCCTCGGCGCACCCAGAAACCCTTTGTGAACTTATA CCTACTGTTGCCTCGGCGCAGGCCGGCTTTTTTTGAGAAAAAGCCCCCTGGAGACAGGGAG CAGCCCGCCGGCGGCCAACCAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACATAAA TGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAAT GCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGC CCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGCTTGG TGATGGGGCACTGCCTGTAAAAAGGCAGGCCCTGAAATCTAGTGGCGAGCTCGCCAGGACC CCGAGCGTAGTAGTTACATCTCGCTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAACCCCC AACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATA AGGAGGAA	Diaporthe
>1201 AAGGAGAGGGACCGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTT TGTGAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGG AGACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAA AAAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACG CAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGC ACATTGCGCCCACCTCGGATCAGGTAGGAATACCCGCTGAACTTAANCATATCAATAANNG GAGGAA	Diaporthe

>1342 CGTTGGTGACCAGCGGAGGGATCATTGCTGAGAACCGCTTCCGCACCCACTTTGTGAACTTTA TCTGTTGCCGGGCCGGCCTCTCGCTGAGGCCCCCTGGAACGGACCCGCCGGCAACTAAACT CTTGTTTCTATANTGAATCTCTGAGTAAAAAACATAAATGAATCAAAACTTTCAACACGGATCT CTTGTTCGCATCGATGAANAACGCATGCATAATTGTGAATTGAAATTCATGAATCATCAATCT TTGAACGCTCATTGCCCCTCTGGTTTCCGGAGGGTGTGTTCAGCTTTTCACCCTCCCGGCTTGG TGATGGGGCACTACTTCGGGAGTAGCCTGAAATTCAGCAGCTCCCGACCCCNANCGTANTAC CTTTGGAAGGCCTGGGGTGCCCTGCTACCCCCACTTTTGAAAATTCCTCNATCAGTAGAATAC CCGNTGAANTTAAGCATATCAATNGGCGGANGAAAANAAACCNACANGGATTGCC	Diaporthe
>1522 ACGCGGAGGGATCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTTATA CCTATCTGTTGCCTCGGCGCAGGCCGGCCTCTTCACTGAGGCCCCCTGGAGACAGGGAGCAG CCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACATAAATGAA TCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGA TAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCTCT GGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGCTTGGTGATG GGGCACTGCCTTCTAGCGAGGGCAGGCCCTGAAATCTAGTGGCGAGCTCGCTAGGACCCCG AGCGTAGTAATTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAACCCCCAACT TCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCG GAGGAA	Diaporthe
>1619 GCGGAGGGATCATTGCTGGAACGCGCCTCGGCGCACCCAGAAACCCTTTGTGAACTTATACC TACTGTTGCCTCGGCGCAGGCCGGCTTCTGTCACAAGAAGCCCCCTGGAAACAGGGAGCAGC CCGCCGGCGGCCAACCAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACATAAATGAAT CAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGAT AAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCTCTG GTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGGCTTGGTGATGG GGCACTGCCTGTAAAAAGGCAGGCCCTGAAATCTAGTGGCGAGCTCGCCAGGACCCCGAGC GTAGTAGTTACATCTCGCTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAACCCCCAACTTCT GAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAG GAA	Diaporthe

>1654 GACCAGCGGAGGGAATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTT ATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGACAGG GAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAAAAC ATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGC GAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCAC ATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCC TAGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGC TCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTG CCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACT TAAGCATATCAATAGGAGGAAN	Diaporthe
>1837 GCTCGTtGGTGACCAGCGGAGGGATCATTGCTGGAACGCGCCCCAGGCGCACCCAGAAAC CCTTTGTGAACTTATACCTTTTGTTGCCTCGGCGCATGCTGGCCTCTAGTAGGCCCCTCACC CCGGTGAGGAGAAGGCACGCCGGCGGCCAAGTTAACTCTTGTTTTTACACTGAAACTCTG AGAAAAAACACAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGA AGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCT TTGAACGCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAA CCCTCAAGCATTGCTTGGTGTTGGGGCACTGCTTCTAACGAAGCAGGCCCTGAAATCTAGT GGCGAGCTCGCCAGGACCCCGAGCGTAGTAGTTAAACCCTCGCTCTGGAAGGCCCTGGCG GTGCCCTGCCGTTAAACCCCCAACTTTTGAAAATTTGACCTCGGATCAGGTAGGAATACCC GCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCCCTAGTAA CGGCGAGTGAAGCGGCAACCTCAAATA	Diaporthe
>2111 CCAGCGGAGGGACATTGCTGGAACGCGCCCCGGCGCACCCAGAAACCCTTTGTGAACTTA TACCTACTGTTGCCTCGGCGCAGGCCGGCTTTTTTTGAGAAAAAGCCCCCTGGAGACAGG GAGCAGCCCGCCGGCGGCCAACCAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACA TAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGC GAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCAC ATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTTAACCCTCAAGCC TGGCTTGGTGATGGGGCACTGCTCTCCCACGAGAGCAGGCCCTGAAATCTAGTGGCGAGC TCGCCNGGACCCCGAGCGTAGTANNTATANCNCNCTCTGGAAGGCCCTGGCGGNGCCCT GCCGTTNAACCCCCAACTTCTGAAAATTTGACCTNNNATCANGTAGGAATACCNGCTGAA	Diaporthe

>2792 CGCGGAGGGATCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTTATAC CTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGACAGGGAGCA GCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAAACATAATGA ATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCG ATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCT CTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTAGCTTGGTGT TGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGCTCGCCAGGACCC CGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAACCCCCA ACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAA GCGGAGGAA	Diaporthe
>2875 GTCTCCGTTGGTGACCaGCGGAGGGTTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTT GTGAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGA AACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAA AAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGC AGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCA CATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCT AGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGCTC GCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGT TAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGC ATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCCCTAGTAACGGCGAGTGAAGC GGCAACGCTCAAATA	Diaporthe
>2914 GATGTGACCAGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTG AACTTATACCTACCGTTGCCTCGGCGCAGGCCGGCCTTTGGTGACAAAGGCCCCCTGGAGAC AGGGAGCAGCCCGCCGGCGGCCAACTAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAA CATAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAG CGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACA TTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTG GCTTGGTGATGGGGCACTGCCTTCTAGCGAGGGCAGGCCCTGAAATCTAGTGGCGAGCTCG CCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTT AAACCCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCA TATCAATAAGCGGAGGAA	Diaporthe

>858 GAGTGACCTGCGGAGGATCATTACCGAGTTCTAGGGGTCTTCGGACCTCTTCTCTCACACC CTATGTGTACCTACCTCTGTTGCTTTGGCGGGCCGCGGTCCTCCGCGGCCGGCCCCCTAAC CGGGGCTGGCCAGCGCCCGCCAGAGGACTACCAAACTCCAGTCAGTAAACGTAGCTGTCT GATCAAAAGTTTAATAAACTAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGA AGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCT TTGAACGCACATTGCGCCCCTTGGTATTCCGAGGGGCATGCCTGTTCGAGCGTCATTTCAC CACTCAAGCTCTGCTTGGTATTGGGCGCCGTCCTTCACCGGACGCGCCTCAAAGACCTCGG CGGTGGCGTCTTGCCTCAAGCGTAGTAGAAAACACCTCGCTTTGGAGGACGGACGTTCG CTCGCCGGACGAACCTTCTGAATTTTCTCAAGGTTGACCTCGGATCANGTAGGGATACCCG CTGAACTTAAGCATATCAATAGGAGGAA	Fungal endophyte
>71 GCGTTGGTGACCAGCGGAGGGCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTT GTGAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGG AGACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGT AAAAAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGA ACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTG AACGCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCC TCAAGCCTAGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGT GGCGAGCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGG TGCCCTGCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCG CTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCCCTAGTAAC GGCGAGTGAAGCGGCAACTCAAATA	Fungal endophyte
>96 GCGTTGGTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACT TACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTA AACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACG GATCTCTTGGTTCTGGCATCNATGAANAACGCAGCGAAATGCGATAAGTAATGTGAATTG CANAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTANTATTCTAGTGGG CATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTC TTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTATAATT TTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTG ACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGA AACCAACAGGGATTGCCTTATAACGGCGAGTGAAGCGGCAACCTCAAATA	Fungal endophyte

>131 ACAGCGGAGGGTTACAGAGTTATCCAACTCCCAAACCCATGTGAACTTATCTCTTTGTTGC CTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGCCGGCGGACAAACCAAA CTCTGTTATCTTAGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAACTTTCAACAACGG ATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGC AGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGC ATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTTGGGAATCTACGCCCTA GTAGTTCCTCAAAGACATTGGCGGAGTGGCAGTAGTCCTCTGAGCGTAGTAATTCTTTATC TCGCTTTTGTTAGGTGCTGCCTCCCCGGCCGTAAAACCCCCAATTTTTTCTGGTTGACCTCG GATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAA	Fungal endophyte
>137 GACGCGGAGGGATCATTAACGAGTTCCATTCTCCTTAATACACCCGTGAACGTTTCTTCAA CTGTTCGTTGCTTCGGCGGGCGGCCCCGGGGAGGGGCCGCAGCCCGCAAGGGCGCCCGC CGGCGGCAGCGCAGCACAACTCTTGCGATTTAGGCCCCTCTGAGAAGACACTAAATGAGT CAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCG ATAAGTAATGTGAATTGCAGAACTCAGCGAATCATCGAATCTTTGAACGCACATTGCGCCC GCCGGCATTCCGGCGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCGAGCCCTGCTCGGT GTTGGGGCCCCGCGGCCGCCGCGGGCCCTGAAAAGAAGTGGCGGGCGCGCCTGGACCC GTAGCGCAGTAATACACCTCGCTCGCGGCGTCCCGGCGCGTGCCGGCCGTAAAACCCCTT TATCTCAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAG CGGAGGAA	Fungal endophyte
>172 GTCTCGTTGGTGACCAGCGGAGGGATCATTACAGAGTTATCCAACTCCCAAACCCATGTG AACTTATCTCTTTGTTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGC CGGCGGACAAACCAAACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTAATAAGTCA AAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGAT AAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCAT TAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTT GGGAATCTACGCCCTAGTAGTTCCTCAAAGACATTGGCGGAGTGGCAGTAGTCCTCTGAG CGTAGTAATTCTTTATCTCGCTTTTGTTAGGTGCTGCCTCCCCGGCCGTAAAACCCCCAATT TTTTCTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCG GAGGAAAAGAAACCAACAGGGATTCCCCTAGTAACGGCGAGTGAAGCGGCAACAAATAA	Fungal endophyte

>177 GTCTCGTTGGTGACCAGCGGAGGGTTACTGAGTTTACGCTCTAGAACCCTTTGTGAACATA CCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGG CGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGGT ACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACG CAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACG CACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAG CTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTAGTGGCGGACCCTC CCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATCCGGAGGGACTCTTGCC GTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTT AAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCCTCAGTAACGGCGAGTG AAGCGGCAACTCAAATA	Fungal endophyte
>303 GAGGGACCCGGAGGGTTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTT GCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTA TTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGTT CTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTG AATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTCGA GCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAG TTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTT GTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGG TAGGAATACCCGCTGAACTTAAGCATATCAATAACGGAGGAAN	Fungal endophyte
>315 GAGGTGACCAGCGGAGGGNCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGT GAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAG ACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAA AAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACG CAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACG CACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAG CCTAGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGA GCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCT GCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACT TAAGCATATCGGAGGAN	Fungal endophyte

>380 GACCGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGCTTTA CTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGACAGGGAGC AGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAAACATAAT GAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAA TGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGC GCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTAGCT TGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGCTCGCC AGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTT AAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGC ATATCAATAAGCGGAGGAA	Fungal endophyte
>395 AGGTCCGATGGTGACCAGCGGAGGGACATTATAGAGTTTTCTAAACTCCCAACCCATGTG AACTTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGAC CATTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAAC AACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGA ATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGT GGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACT TCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAG TAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGT GGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAGGAGGAAA	Fungal endophyte
>590 GGGGGAGTGACCGCGGAGGGATCATTACTGAGTTTACGCTCTATAACCCTTTGTGAACAT ACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGG GCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTG GTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAA CGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGA ACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTCAACCCT CAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTAGTGGCGGA CCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATCCGGAGGGACTC TTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTG AACTTAAGCATATCAATAAGCGGAGGAA	Fungal endophyte

>805 CATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTTATACCTATACTGTT GCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGACAGGGAGCAGCCCGCCG GCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAAAACATAATGAATCAAA ACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAA GTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCTCT GGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTAGCTTGGTGT TGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAGTGGCGAGCTCGCCAGGAC CCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTAAACC CCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATAT CAATA	Fungal endophyte
>996 GGGAGACCGCGGAGGGCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGA ACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGA CAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAA AAACAATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAA CGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGA ACGCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCC TCAAGCCTAGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCTAG TGGCGAGCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGC GGTGCCCTGCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATAC CCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Fungal endophyte
>1116 GTCTCGTTGGTGACCAGCGGAGGGATCATTACAGAGTTATCCAACTCCCAAACCCATGTG AACATATCTCTTTGTTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCG CCGGCGGACACACCAAACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTAATAAGT CAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCG ATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCC CATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTAT TGTTGGGCGTCTACGTCTGTAGTGCCTCAAAGACATTGGCGGAGCGGCAGTAGTCCTCTG AGCGTAGTAATTCTTTATCTCGCTTTTGTTAGGTGCTGCCCCCCCCGGCCGTAAAACCCCC AATTTTTTCTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATA AGCGGAGGAAAAGAAACCAACAGGGATTCCCCTAGTAACGGCGAGTGAAGCGGCAACT CAAAT	Fungal endophyte

>1226 GACCAGCGGAGGGACATTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTATAAC TGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGGCGGGTCG GCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGGTACAAGC AAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGA AATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATT GCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCTCTG CTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTAGTGGCGGACCCTCCCGG AGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATCCGGAGGGACTCTTGCCGTAA AACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGC ATATCAATAAGCGGAGGAA	Fungal endophyte
>1282 CGGGTGACGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTG AACTTATACCTTACTGTTGCCTCGGCGCAGGCCGGCCCCCCACCGGGGCCCCTCGGAGAC GAGGAGCAGCCCGCCGGCGGCCAACCAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAA AACATAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACG CAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAAC GCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCA AGCCTGGCTTGGTGTTGGGGCACTGCTCCGAGAGGAGCAGGCCCTGAAATCTAGTGGCG AGCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCC CTGCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGA ACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCCCTAGTAACGGC GAGTGAAGCGGCTCAAATA	Fungal endophyte
>1298 CGTTGGTGACCAGCGGAGGGCATTACAGAGTTATCCAACTCCCAAACCCATGTGAACTTAT CTCTTTGTTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGCCGGCGG ACAAACCAAACTCTGTTATCTTAGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAACTT TCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAA TGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTAT TCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTTGGGAA TCTACGCCCTAGTAGTTCCTCAAAGACATTGGCGGAGTGGCAGTAGTCCTCTGAGCGTAGT AATTCTTTATCTCGCTTTTGTTAGGTGCTGCCTCCCCGGCCGTAAAACCCCCAATTTTTTCTG GTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA AAGAAACCAACAGGGATTCCCCTAGTAACGGCGAGTGAAGCGGCAAACTCAAATA	Fungal endophyte

>1320 GTCTCGTTGGTGACCAGCGGAGGGATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCC TTTGTGAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCC TGGAAACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTG AGTAAAAAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATG AAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAAT CTTTGAACGCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTC AACCCTCAAGCCTAGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAA TCTAGTGGCGAGCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCC TGGCGGTGCCCTGCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGA ATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCC CTAGTAACGGCGAGTGAAGCGGCAATCAAAA	Fungal endophyte
>1328 GTCtCGTTGGTGACCAGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAAC CCTTTGTGAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCC CCTGGAGACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTC TGAGTAAAAAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGA TGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGA ATCTTTGAACGCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCAT TTCAACCCTCAAGCCTAGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGA AATATAGTGGCGAGCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGG CCCTGGCGGTGCCCTGCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTA GGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATT GCCCTAGTAACGGCGAGTGAAGCGTCAAATAN	Fungal endophyte
>1355 CGTTGGTGACGCGGAGGGACATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTG TGAACTTATACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGG AGACAGGGAGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGT AAAAAACATAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAG AACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTT GAACGCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAAC CCTCAAGCCTGGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCT AGTGGCGAGCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTG GCGGTGCCCTGCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAAT ACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCCCT AGTAACGGCGAGTGAAGCGGCAACAGCTCAAATAN	Fungal endophyte

>1594 GAGGACGGGAGGGTCATTGCTGGAACGCGCCTCGGCGCACCCAGAAACCCTTTGTGAAC TTATACCTACTGTTGCCTCGGCGCAGGCCGGCTTTTTTTGAGAAAAAGCCCCCTGGAGAC AGGGAGCAGCCCGCCGGCGGCCAACCAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAA AACATAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAAC GCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAA CGCACATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTC AAGCCTGGCTTGGTGATGGGGCACTGCCTGTAAAAAGGCAGGCCCTGAAATCTAGTGGC GAGCTCGCCAGGACCCCGAGCGTAGTAGTTACATCTCGCTCTGGAAGGCCCTGGCGGTG CCCTGCCGTTAAACCCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGC TGAACTTAAGCATATCAATAAGCGGAGGAA	Fungal endophyte
>1774 ACAGCGGAGGGCATTGCTGGAACGCGCTTCGGCGCACCCAGAAACCCTTTGTGAACTTA TACCTATACTGTTGCCTCGGCGCTGGCCGGCCTCCTCACCGAGGCCCCCTGGAGACAGGG AGCAGCCCGCCGGCGGCCAAACAAACTCTTGTTTCTTAGTGAATCTCTGAGTAAAAAACA TAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGC GAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCAC ATTGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGC CTAGCTTGGTGTTGGGGCACCGCCTTTGCAAAAGGGCGGGCCCTGAAATCCAGTGGCGA GCTCGCCAGGACCCCGAGCGTAGTAGTTATATCTCGTTCTGGAAGGCCCTGGCGGTGCCC TGCCGTTAAACCCCCAACTTCTGAAATTTTGACCTCGGATCAGGTAGGAATACCCGCTGA ACTTAAGCATATCAATAAGCGGAGGAA	Fungal endophyte
>1826 GCTCGTTGGTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGA ACTTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGATGGACC ATTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAAC AACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTG AATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTA GTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCT ACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGC GTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTT TTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCG GAGGAAAAGAAACCAACAGGGATTGCCTTAGTAACGGCGAGTGAAGCGGCAACCTCAA ATAA	Fungal endophyte

>1848 ACCAGCGGAGGGTCATTGCTGGAACGCGCCTCGGCGCACCCAGAAACCCTTTGTGAACTTA TACCTACTGTTGCCTCGGCGCAGGCCGGCTTTTTTTGAGAAAAAGCCCCCTGGAGACAGGG AGCAGCCCGCCGGCGGCCAACCAAACTCTTGTTTCTATAGTGAATCTCTGAGTAAAAACAT AAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCG AAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACAT TGCGCCCTCTGGTATTCCGGAGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCCTGG CTTGGTGATGGGGCACTGCCTGTAAAAAGGCAGGCCCTGAAATCTAGTGGCGAGCTCGCC AGGACCCCGAGCGTAGTAGTTATATCTCGCTCTGGAAGGCCCTGGCGGTGCCCTGCCGTTA AACCCCCAACTTCTGAAAATTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCAT ATCAATAAGCGGAGGAA	Fungal endophyte
>1895 AGTCTCGTTGGTGACAGCGGAGGGATCATTACCGAGTTTACAACTCCCAAACCCCTGGAAC ATACCTATTGTTGCCTCGGCGGATCAGCCCGGCCCCGGTAAAAGGGACGGCCCGCCAGGA CCCTAAANTCTGTTTTTAGTGTAACTTCTGAGTAAAACAAACAAATAAATCAAAACTTTCAA CAANNNATCTCTTGGTTCTGGNATCNATGAANAACGCANCANAATGCNNNNNNTAATGT GAATTGNANAATTCAGTGAATCATCNAATCTTTNANCNCNCATTGAGCCCGCCANTATTCT GGNGGGNATGCCTGTTCGAGCGTCATTTCAACCCTCCACATTGGGGNATTTGNNGAGTAA TTCGCANTCCCCNNNTCTATTGGCGGTCANNNNNAGCTTCCATANNGAANNAATTACNCC TCNTTACTGGNAATCNNCNCGGCCACNCCGTTNAACCCCNNCTTCTGAATGTTGACCTCNG ATCAGGTAGGAATACCCGCTGAACTTAAGCATATCNATNANCGGANNAAAAGAAACCNN NNNGNATTGNNNTANTAACGGANAGTGAANNNNNNNNNNNNTCAANNNNNNAGAAACC AACAGGGATGTAACGGATGAAGCGGCAACNGGCTCTA	Fungal endophyte
>1969 CCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTT GCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGATGGACCATTAAACTCTTGTTA TTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGTT CTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTG AATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTCGA GCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAG TTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTT GTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGG TAGGAATACCCGCTGAACTTAAGCATATCAATAACGGAGGAA	Fungal endophyte

>2047 GAGTGACCTGCGGAGGATCATTACCGAGTGCGGGCCCCTCGGGGCCCAACCTCCCACC CGTGTTGCCCGAACCTATGTTGCCTCGGCGGGCCCCGCGCCCGCCGACGGCCCCCCTGA ACGCTGTCTGAAGTTGCAGTCTGAGACCTATAACGAAATTAGTTAAAACTTTCAACAACG ATCTCTTGGTTCCGGCATCATGAAAAACGCNCGAAATGCNATAACTAATGTGAATTGCA GAATTCAGTGAATCATCGAGTCTTTGAACGCACATTGCGCCCTCTGGTATTCCGGAGGG CATGCCTGTCCGACGTCATTGCTGCCCTCAAGCCCGGCTTGTGTGTTGGGCCCCGTCCCC CCCGCCGGGGGGACGGGCCCGAAAGGACGGCGACCGCGTCCGGTCTCGAGCGTAGGG GCTTCGCCCCGCTCTAGTAGGCCCGGCCGGCCAGCCGACCCCCAATAATTATTCAGGTT GACCTCGATCAGTAGGATCCCTGAACTT	Fungal endophyte
>2172 GCGATGGTGACCGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAAC TTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCA TTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAAC AACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTG AATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCT AGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATC TACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAG CGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAAT TTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAA GCGGAGGAA	Fungal endophyte
>2387 CGATGGTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAAC TTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCA TTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAAC AACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTG AATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCT AGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATC TACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAG CGTAGTAATTCTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAAT TTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAA GAGGAA	Fungal endophyte

>2505 GGGACCGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACC TTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAA ACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAAC GGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGA ATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCT AGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAA TCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCT GAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCC CCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATAT CAATAAGCGGAGGAA	Fungal endophyte
>2539 GGGACGCGGAGGGATTACTGAGTTTACGCTCTACAACCCTTTGTGAACATACCTATAA CTGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTCCCGCCCCCGGGCGG GTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGGT ACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAGA ACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTT TGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTC AACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTA GTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATC CGGAGGGACTCTTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGT AGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Fungal endophyte
>2567 GACGCGGAGGGCATTACCGAGTTTACAACTCCCAAACCCAATGTGAACCATACCAAAC TGTTGCCTCGGCGGGGTCACGCCCCGGGTGCGTCGCAGCCCCGGAACCAGGCGCCCG CCGGAGGGACCAACCAAACTCTTTCTGTAGTCCCCTCGCGGACGTTATTTCTTACAGCT CTGAGCAAAAATTCAAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCA TCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAAT CATCGAATCTTTGAACGCACATTGCGCCCGCCAGTATTCTGGCGGGCATGCCTGTCCG AGCGTCATTTCAACCCTCGAACCCCTCCGGGGGGTCGGCGTTGGGGATCGGGAACCC CTGAGACGGGATCCCGGCCCCGAAATACAGTGGCGGTCTCGCCGCAGCCTCTCCTGC GCAGTAGTTTGCACAACTCGCACCGGGAGCGCGGCGCGTCCACGTCCGTAAAACACC CAACTTCTGAAATGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATAT CAATAAGCGGAGGAA	Fungal endophyte

>2669 ACCTGCGGAGGGATCATTACACAAATAAACATGGAAAGGCTGCCCGCGGCCGGTGTTTCC CCTTCTCGGGAGGCGCCAGTTGGCGGACGCTGGACTATTTTATTACCCTTGTCTTTTGCGC ACTTGTTGTTTCCTGGGCGGGTTCGCCCGCCACCAGGACCACACTATAAACCTTTTGTATG CAGTTGCAATCAGCGTCAGTACAACAAATGTAAAATCATTTACAACTTTCAACAACGGATC TCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATACGTAGTGTGAATTGCAGA ATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCTTTGGTATTCCAAAGGGCATG CCTGTTCGAGCGTCATTTGTACCCTCAAGCTTTGCTTGGTGTTGGGCGTTTTTGTCTTGGGG CCTGCCCCTAAAAGACTCGCCTTAAAAAGATTGGCAGCCGGCCTACTGGTTTCGCAGCGCA GCACATTTTTGCGCTTGCAACCAGCCCTAAAGAGGACGGCACTCCATCAAGTCTCTTTATTC ACTTTTGACCTCGGATCAGGTAGGGATACCCGCTGAACTTAAGCATATCAATAAGCGGAG GAA	Fungal endophyte
>2841 GTTGGTGACCAGCGGAGGGTTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTAT AACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGGCGGG TCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGGTACAA GCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGC GAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCAC ATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAGCT CTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTAGTGGCGGACCCTCC CGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATCCGGAGGGACTCTTGCCG TAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTA AGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCCTCAGTAACGGCGAGTG AAGCGGCAACTCAAATA	Fungal endophyte
>961 GGAAAGGGGGGGGAAAGGAGACCGCGGAGGGACATTACAGAGTTATCCAACTCCCAAA CCCATGTGAACATATCTCTTTGTTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGG CGGCCCGCCGGCGGACACACCAAACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTA ATAAGTCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGA AATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATT GCGCCCATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAG CTTATTGTTGGGCGTCTACGTCTGTAGTGCCTCAAAGACATTGGCGGANCGGCAGTAGTC CTCTGAGCGTAGTAATTCTTTATCTCGCTTTTGTTAGGTGCTGCCCCCCCGGCCGTAAAACC CCCAATTTTTTCTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCA ATAAGCGGAGGAA	Fusarium

>1024 GGAGACCAGCGGAGGGCATTACAGAGTTATCCAACTCCCAAACCCATGTGAACATATC TCTTTGTTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGCCGGCG GACACACCAAACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAA CTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATA AGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCA TTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATT GTTGGGCGTCTACGTCTGTAGTGCCTCAAAGACATTGGCGGAGCGGCAGTAGTCCTCT GAGCGTAGTAATTCTTTATCTCGCTTTTGTTAGGTGCTGCCCCCCCGGCCGTAAAACCCC CAATTTTTTCTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCA ATAAGCGGAGGAAA	Fusarium
>2356 GAGGTGACCAGCGGAGGGATCATTACCGAGTCTAAACAACTCATCAACCCTGTGAACA TACCTAAAACGTTGCTTCGGCGGGAACAGACGGCCCCGTAAAACGGGCCGCCCCCGCC AGAGGACCCCTAACTCTGTTGCTATATGTATCTTCTGAGTAAACAAGCAAATAAATTAA AACTTTCAACAACGGATCTCTTGGCTCTGGCATCGATGAAGAACGCAGCGAAATGCGA TAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCC CGCCAGTATTCTGGCGGGCATGCCTGTTCGAGCGTCATTACAACCCTCAGGCCCCCGG GCCTGGCGTTGGGGATCGGCGAGGCGCCCCCTGTGGGCACGCGCCGTCCCCCAAATA CAGTGGCGGTCCCGCCGCAGCTTCCATTGCGTAGTAGCTAACACCTCGCAACTGGAGA GCGGCGCGGCCATGCCGTAAAACACCCAACTTCTGAATGTTGACCTCGAATCAGGTAG GAATACCCGCTGAACTTAAGCATATCACGGAGGAA	Fusarium
>105 GGTGACCAGCGGAGGGACATTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCT ATAACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGGC GGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTG GTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAG AACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCT TTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTC AACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTA GTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATCC GGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTA GGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Glomerella

>134 CGCGGAGGGTTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTATAACTGT TGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGGCGGGTC GGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGGTA CAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAGA ACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATC TTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCAT TTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAA GGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTG GGATCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTTGACCTCGG ATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Glomerella
>428 ACGCGGAGGGTTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTATAACTG TTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGGCGGGT CGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGGT ACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAG AACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAAT CTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCA TTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAA AGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACT GGGATCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTTGACCTCG GATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Glomerella
>587 CCAGCGGAGGGATTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTATAAC TGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTCCCGCCCCCGGGCGG GTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTG GTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGA AGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGA ATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGT CATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTC AAAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCA CTGGGATCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTTGACCTCG GATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAAACGGAGAAA	Glomerella

>648 GCGATGGTGACCAGCGGAGGgTTATCGAGTTACCGCTCCTTATAACCCTTTGTGAACATA CCCCAAACGTTGCCTCGGCGGGCAGTCGGAGCCTAGCTCCGTCGCCCGGAGCCGCCGTC TCGGCGCGCCCCACCCGCCGGCGGACCACCAAACTCTATTTAAACGACGTCTCTTCTGAG TGGCACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAA GAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTT TGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTCAA CCCTCAAGCACCGCTTGGCGTTGGGGCCCTACGGCTTCCGTAGGCCCCGAAATACAGTG GCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACATACCACCTCGCACTGGGATCCGGAG GGACTCCTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGAATA CCCGCTGAACTTAAGCATATCAATAAGGAGGAA	Glomerella
>870 GGGGGATGTGACCAGCGGAGGGTCATTATCGAGTTACCGCTCCTTATAACCCTTTGTGAA CATACCCCAAACGTTGCCTCGGCGGGCAGCCGGAGCCCAGCTCCGGCGCCCGGAGCCGC CGTCTCGGCGCGCCCCACCCGCCGGCGGACCACTAAACTCTATTTAAACGACGTCTCTTCT GAGTGGCACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGAT GAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAA TCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATT TCAACCCTCAAGCACCGCTTGGCGTTGGGGCCCTACGGCTTCCGTAGGCCCCGAAATACA GTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACATACCACCTCGCACTGGGATCCG GAGGGACTCCTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGA ATACCCGCTGAACTTAAGCATATCAATAAGGAGGA	Glomerella
>957 GACCAGCGGAGGGATCATTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTATA ACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGGCGGGT CGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGGTACAA GCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAG CGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCA CATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTCAACCCTCAAG CTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTAGTGGCGGACCCT CCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATCCGGAGGGACTCTTG CCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAA CTTAAGCATATCAATAAGCGGAGGAA	Glomerella

>975 GATGGTGACGCGGAGGGTCATTACTGAGTTTACGCTCTATAACCCTTTGTGAACATAC CTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCG GGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGA GTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGAT GAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCG AATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGT CATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCA AAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACT GGGATCCGGAGGGACTCTTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGA TCAGGCAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Glomerella
>1057 ACCAGCGGAGGGAcATTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTATAA CTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGGCGG GTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGGT ACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAGA ACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTT TGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTC AACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTA GTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATC CGGAGGGACTCTTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGT AGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Glomerella
>1110 GGTGACCAGCGGAGGGTTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTAT AACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGGCG GGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGG TACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAG AACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATC TTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATT TCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGG TAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGA TCCGGAGGGACTCTTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAG GTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAG GGATTGCCTCAGTAACGGCGAGTGAAGCGGTCAAATAN	Glomerella

>1183 GCTTGGTGACCAGCGGAGGGACATTATCGAGTTACCGCTCCTTATAACCCTTTGTGA ACATACCCCAAACGTTGCCTCGGCGGGCAGCCGGAGCCTAGCTCCGTCGCCCGGAG CCGCCGTCTCGGCGCGCCCCACCCGCCGGCGGACCACCAAACTCTATTTAAACGAC GTCTCTTCTGAGTGGCACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGT TCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATT CAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCAT GCCTGTTCGAGCGTCATTTCAACCCTCAAGCACCGCTTGGCGTTGGGGCCCTACGGC TTCCGTAGGCCCCGAAATACAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTA ACATACCACCTCGCACTGGGATCCGGAGGGACTCCTGCCGTAAAACCCCCCAATTTT CCAAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATA AGCGGAGGAAAAGAAACCAACAGGGATTGCCTCAGTAACGGCGAGTGAAGCGGC AAC	Glomerella
>1187 AGGGGGAGGTGACCAGCGGAGGGACATTACTGAGTTTACGCTCTATAACCCTTTGT GAACATACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTC CCGCCTCCGGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGAC GTTTCTTCTGAGTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGT TCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATT CAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCAT GCCTGTTCGAGCGTCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGC TGATGTAGGCCCTCAAAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTA ACTTTACGTCTCGCACTGGGATCCGGAGGGACTCTTGCCGTAAAACCCCCCAATTTT CCAAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATA AGNGGAGGAN	Glomerella
>1208 GCGATGGTGACAGCGGAGGGACATTACTGAGTTTACGCTCTATAACCCTTTGTGAA CATACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTCCCG CCCCCGGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTT TCTTCTGAGTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCT GGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCA GTGAATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATG CCTGTTCGAGCGTCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCT GATGTAGGCCCTCAAAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAA CTTTACGTCTCGCACTGGGATCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCC AAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAG GAGGAA	Glomerella

>1212 AGCTCGGGTGACCAGCGGAGGGCATTACTGAGTTTACGCTCTATAACCCTTTGTGAACA TACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTCCCGCCCCC GGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGA GTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGA AGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATC TTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTC AACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTAG TGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATCCG GAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGA ATACCCGCTGAACTTAAGCATATCAATAANNGGAGGAA	Glomerella
>1221 GATGGTGACAGCGGAGGGACATTACTGAGTTTACGCTCTACAACCCTTTGTGAACATAC CTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTCCCGCCCCCGG GCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGT GGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAA GAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCT TTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATTTC AACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAGGTAG TGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGATCCG GAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGA ATACCCGCTGAACTTAAGCATATCAATACGGAGGAA	Glomerella
>1242 AGTCTCTTTGGTGACAGCGGAGGGATCATTACTGAGTTTACGCTCTATAACCCTTTGTGA ACATACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTCCCGCC CCCGGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTC TGAGTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGA TGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCG AATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTC ATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAAG GTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGGGA TCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGT AGGAATACCCGCTGAACTTAAGCATATCAATAGGAGGAAN	Glomerella

>1318 GCTCGTTGGTGACCAGCGGAGGGACATTACTGAGTTTACGCTCTATAACCCTTTGTG AACATACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCC GCCTCCGGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGT TTCTTCTGAGTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCT GGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAG TGAATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCC TGTTCGAGCGTCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGAT GTAGGCCCTCAAAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTT ACGTCTCGCACTGGGATCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAA GGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAGGAGG AA	Glomerella
>1345 GCGTTGGTGACCNGCGGAGGGTCATTACTGAGTTTACGCTCTATAACCCTTTGTGAA CATACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGC CTCCGGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTC TTCTGAGTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGC ATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGA ATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTT CGAGCGTCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTA GGCCCTCAAAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACG TCTCGCACTGGGATCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTT GACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAGGAGGAA	Glomerella
>1446 GTCGTTGGTGACCAGCGGAGGGACATTACTGAGTTTACGCTCTATAACCCTTTGTGA ACATACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTCCCG CCCCCGGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTT CTTCTGAGTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGG CATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTG AATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTG TTCGAGCGTCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGT AGGCCCTCAAAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTAC GTCTCGCACTGGGATCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGT TGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGG AA	Glomerella

>1576 GACGCGGAGGGACATTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTATA ACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGGC GGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAG TGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGAT GAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATC GAATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAG CGTCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCC CTCAAAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTC GCACTGGGATCCGGAGGGACTCTTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGA CCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Glomerella
>1593 AGGGGACGAgGTGACCGGAGGGATCATTACTGAGTTTACGCTCTATAACCCTTTGT GAACATACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTC CCGCCCCCGGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGAC GTTTCTTCTGAGTGGTACAAGCAAATAATCAAAACTTTTACAACGGATCTCTTGGTTC TGGCATCGATGAAAAGACGAAATGCATAATAATGTGAATTGCAAATTCATGAATCA TCAATCTTTGAACCACATTGCGCCCGCCAGCATTCTGGCGGATGCCTGTTCAGCGTC ATTTCAACCCTCAAGCTCTGCTTGGTGTGGGGCCCTACGCTGATGTAGGCCCTCAAA GGTAGTGGCGGACCCTCCCGGAGCCTCTTTGCTATAACTTTACGTCTCGCACTGGGA TCCGGAGGACTTGCCGAAACCCCCAATTTTAGGTTGACCCATCAGTAGAATATGAAC TTAAATCAAAACGAGAA	Glomerella
>1600 AGGCGATGGTGAcAGCGGAGGGACATTACTGAGTTTACGCTCTACAACCCTTTGTG AACATACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTCC CGCCCCCGGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACG TTTCTTCTGAGTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTC TGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCA GTGAATCATCGAATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATG CCTGTTCGAGCGTCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCT GATGTAGGCCCTCAAAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAA CTTTACGTCTCGCACTGGGATCCGGAGGGACTCTTGCCGTAAAACCCCCCAATTTTC CAAAGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAA NNGGAGGA	Glomerella

>1618 TTGTGAACATACCTATAACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCT CCCGCCTCCGGGCGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGT TTCTTCTGAGTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGC ATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATC ATCGAATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGC GTCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCA AAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTGG GATCCGGAGGGACTCTTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAG GTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAN	Glomerella
>1732 GTCTCGTTGGTGACGCGGAGGGACATTATCGAGTTACCGCTCCTTATAACCCTTTGTGAA CATACCCCAAACGTTGCCTCGGCGGGCAGCCGGAGCCTAGCTCCGTCGCCCGGAGCCGC CGTCTCGGCGCGCCCCACCCGCCGGCGGACCACCAAACTCTATTTAAACGACGTCTCTTCT GAGTGGCACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGAT GAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAA TCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATT TCAACCCTCAAGCACCGCTTGGCGTTGGGGCCCTACGGCTTCCGTAGGCCCCGAAATACA GTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACATACCACCTCGCACTGGGATCCG GAGGGACTCCTGCCGTAAAACCCCCCAATTTTCCAAAGGTTGACCTCGGATCAGGTAGGA ATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCC TCAGTAACCGAGTGAAGCGGCAACTCAAATA	Glomerella
>1744 GCGTTGGTGACCAGCGGAGGGATCATTATCGAGTTACCGCTCCTTATAACCCTTTGTGAA CATACCTCAAACGTTGCCTCGGCGGGCAGCCGGAGCCCAGCTCCGGCGCCCGGAGCCGC CTTCTCGGCGCGCCCCACCCGCCGGCGGACCACTAAACTCTATTGCAACGACGTCTCTTCT GAGTGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGAT GAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAA TCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCATT TCAACCCTCAAGCACCGCTTGGCGTTGGGGCCCTACGGCTTCCGTAGGCCCCGAAATACA GTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACATACCACCTCGCACTGGGATCCG GAGGGACTCCTGCCGTAAAACCCCCCAATTTATCAAGGTTGACCTCGGATCAGGTAGGA ATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTGCC TCAGTAACGGCGAGTGAAGCGGCAACTCAATA	Glomerella

>1906 AGCCGATGGTGACCAGCGGAGGGACATTATCGAGTTACCACTCTATAACCCTTTGTG AACATACCTACATGTTGCTTCGGCGGTCGGCCCCCGGGCCCCCGGCCCCGCTCACG CGGGGCGTCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGG CACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAG AACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATC TTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCAT TTCAACCCTCAAGCACTGCTTGGTGTTGGGGCTCTACGGTTGACGTAGGCCCCCAAA ACTAGTGGCGGACCCTCTCGGAGCCTCCTTTGCGTAGTAACTTTTGTCTCGCACTGGG ATTCGGAGGGATTCTAGCCGTTAAACCCCCAATTTTCTAAAGGTTGACCTCGGATCAG GTAGGAATACCCGCTGAACTTAAGCATATCAATAAGGAGGAA	Glomerella
>2072 GGGACAGCGGAGGGCATTACTGAGTTTACGCTCTATAACCCTTTGTGAACATACCTA TAACTGTTGCTTCGGCGGGTAGGGTCTCCGCGACCCTCCCGGCCTCCCGCCTCCGGG CGGGTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAG TGGTACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATG AAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCG AATCTTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCG TCATTTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTC AAAGGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCA CTGGGATCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTTGACCTC GGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGAA	Glomerella
>2972 CAGCGGAGGGATCATTACTGAGTTTACGCTCTACAACCCTTTGTGAACATACCTATAA CTGTTGCTTCGGCGGGTAGGGTCTCCGTGACCCTCCCGGCCTCCCGCCCCCGGGCGG GTCGGCGCCCGCCGGAGGATAACCAAACTCTGATTTAACGACGTTTCTTCTGAGTGG TACAAGCAAATAATCAAAACTTTTAACAACGGATCTCTTGGTTCTGGCATCGATGAAG AACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATC TTTGAACGCACATTGCGCCCGCCAGCATTCTGGCGGGCATGCCTGTTCGAGCGTCAT TTCAACCCTCAAGCTCTGCTTGGTGTTGGGGCCCTACAGCTGATGTAGGCCCTCAAA GGTAGTGGCGGACCCTCCCGGAGCCTCCTTTGCGTAGTAACTTTACGTCTCGCACTG GGATCCGGAGGGACTCTTGCCGTAAAACCCCCAATTTTCCAAAGGTTGACCTCGGA TCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Glomerella

>415 TTTCTAGGATTGATCCTTCCACAGTGACGCTTATGAGAAGCCTTTGTAGCCCCGCAAGGGG TACCTGCCGCGACTATAAAAAAAGCATGTGGGTATTAAATTGCAAGTCAGCGGAAGCTGG CAACACTTTCGAATTGCGGGGATACCCTGAGAGCCCACTCTACCAACCTAGCAGGGAAAC TTGGCTAGGGGCCTATGTTAACAGCATAGGGTACGGTAAGAATGAGTTGGGATTGGGCA ATCCGCAGCCAAGATCCTACGGCATGTTAAATGGCTAAGGATAAGGTTCACAGACTAAGT GGAAGTGGGCGGGAGCAATCCTGCTTAAGATATAGTCGGGCCCCATGGGAAACTATGGG GGAGTCACTACATAATATCAGCTAGAAATCAATCTGCTTTTATTATGATGAGAAATGGTTT CCATGTCTCTTTCTACCGTTCCGTAGGTGAACCTGCGGAAGGATCATTAACAGGAAAAGG GTGCCCTCGCGGCCCCGATTCTCAAACCACTGTTTACCAAACGTTTCGTTGCCTCGGCGGG CCGGCACCGGCTCGACTGGCGCCCCTCCCTCGGGAGGAGCAGCCCGCCGCAGGACGCTA CAAAACCATTCTGTTCGAAGAACGTCTGATTTTACCTTCGCGAATGCGATAAATACAACTTT CAACAATGGATCTCTTGGCTCCAGCATCGATGAAGAACGCAGCGAAATGCGATAACTAGT GTGAATTGCAGATTTCAGTGAATCATCGAGTCTTTGAACGCACATTGCGCCTCTTGGTATT CCTCGAGGCATGCCTATTCGAGCGTCGTTTCGACCCTTAAGCGCAAGCTTAGTGTTGGGGA CCGCCCCTGAAATACGGANGCGGCCCTTGAATCCATCGGCGGTGCCGGTGCAGCCTGGN NCGCAGCANCAATGCAGCTTTGAGCAGCCCGAAGCCAGCCGGANAAACGAAACTTCATTT TTTCTCNCGTCGACCTCGAATTNGNNAGGGATACCCGCTGA	Monacrosporium
>297 GCGTTGGTGACCAGCGGAGGGATCATTACAGAGTTATCCAACTCCCAAACCCATGTGAAC TTATCTCTTTGTTGCCTCGGCGCAAGCTACCCGGGACCTCGGTCACGGGCGGCCCGCCGGT GGACACACTAAACTCTGTTATCTTTGTGATTATCTGAGTGTCTTATTTAATAAGTCAAAACT TTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTA ATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATGAGTA TTCTCGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTTGGGA ATCTACGTTTGTAGTTCCTCAAAGACATTGGCGGAGTGGCAGCAGTCCTCTGAGCGTAGTA ATTTTTTATCTCGCTTTTGTTAGGCGCTGCCTCCCCGGCCGTTAAACACCCCATTTTTTCTGG TTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAA AGAAACCAACAGGGATTCCCCTAGTAACGGCGAGTGAAGCGGCAATCAAATAA	Nigrospora

>561 CCAGCGGAGGGTCATTACAGAGTTATCCAACTCCCAAACCCATGTGAACATATCTCTTTG TTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGCCGGCGGACACA CCAAACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAACTTTCAA CAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGT GAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTC TAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTTGGGCGT CTACGTCTGTAGTGCCTCAAAGACATTGGCGGAGCGGCAGTAGTCCTCTGAGCGTAGTA ATTCTTTATCTCGCTTTTGTTAGGTGCTGCCCCCCCGGCCGTAAAACCCCCAATTTTTTCT GGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAG GAAA	Nigrospora
>806 ACAGCGGAGGGACTTACAGAGTTATCCAACTCCCNAACCCATGTGAACATATCTCTTTGT NGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGCCGGCGGACACAC CAAACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAACTTTCAAC AACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTG AATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCT AGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTTGGGCGTC TACGTCTGTAGTGCCTCAAAGACATTGGCGGAGCGGCAGTAGTCCTCTGAGCGTANTAA TTCTTTATCTCGCTTTTGTTAGGTGCTGCCCCCCCGGCCGTAAAACCCCCAATTTTTTCTG GTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGNAGG AAN	Nigrospora
>967 GACAGCGGAGGGATCATTACAGAGTTATCCAACTCCCAAACCCATGTGAACTTATCTCTT TGTTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGCCGGCGGACA AACCAAACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAACTTTC AACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAAT GTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTAT TCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTTGGGA ATCTACGCCCTAGTAGTTCCTCAAAGACATTGGCGGAGTGGCAGTAGTCCTCTGAGCGT AGTAATTCTTTATCTCGCTTTTGTTAGGTGCTGCCTCCCCGGCCGTAAAACCCCCAATTTT TTCTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCG GAGGAAAA	Nigrospora

>1011 CGGAGGGATCATTACAGAGTTATCCAACTCCCAAACCCATGTGAACATATCTCTTTGT TGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGCCGGCGGACAC ACCAAACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAACTTT CAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGT AATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATT AGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATT GTTGGGCGTCTACGTCTGTAGTGCCTCAAAGACATTGGCGGAGCGGCAGTAGNCCT CTGANCGTANTAATTCTTTNTCNCGCTTTTGTTAGGTGCTGCCCCCCCGGCCGTAAAA CCCCCAATTTTTTCTGGTTGACCTCGGATCAGTAGGAATACCCGCTGAACTTAACATA TCATAAGCGGAGGAA	Nigrospora
>1149 GCGTTGGTGACCAGCGGAGGGATCATTACAGAGTTATCCAACTCCCAAACCCATGTG AACTTATCTCTTTGTTGCCTCGGCGCAAGCTACCCGGGACCTCGGTCACGGGCGGCC CGCCGGTGGACACACTAAACTCTGTTATCTTTGTGATTATCTGAGTGTCTTATTTAATA AGTCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGA AATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCA CATTGCGCCCATGAGTATTCTCGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTA AGCACAGCTTATTGTTGGGAATCTACGTTTGTAGTTCCTCAAAGACATTGGCGGAGT GGCAGCAGTCCTCTGAGCGTAGTAATTTTTTATCTCGCTTTTGTTAGGCGCTGCCTCC CCGGCCGTTAAACACCCCATTTTTTCTGGTTGACCTCGGATCAGGTAGGAATACCCGC TGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCAACAGGGATTCCCCTAGT AACGGCGAGTGAAGCGGCAACCTCAAATA	Nigrospora
>1707 CGCGGAGGGCATTACAGAGTTATCCAACTCCCAAACCCATGTGAACTTATCTCTTTGT TGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGGCGGCCCGCCGGCGGACA AACCAAAACTCTTGTTATCTTAGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAAC TTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATA AGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCC CATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCT TATTGTTGGGAACCTACGGCTTCGTAGTTCCTCAAAGACATTGGCGGAGTGGCAGTG GTCCTCTGAGCGTAGTAATCTTTTATCTCGCTTCTGTTAGGTGCTGCCCCCCCGGCCG TAAAACCCCCAATTTTTTCTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTT AAGCATATCAATAAGCGGAGGAA	Nigrospora

>1841 GCTCGATTGGTGACCAGCGGAGGGATCATTACAGAGTTATCCAACTCCCAAACCCATGTG AACATATCTCTTTGTTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGC CGGCGGACACACCAAACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTAATAAGTCA AAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGAT AAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCAT TAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTT GGGCGTCTACGTCTGTAGTGCCTCAAAGACATTGGCGGAGCGGCAGTAGTCCTCTGAGCG TAGTAATTCTTTATCTCGCTTTTGTTAGGTGCTGCCCCCCCGGCCGTAAAACCCCCAATTTTT TCTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGNCGG AGGAA	Nigrospora
>767 GAACCTGCGGAGGATCATTACCGAGTGCGGGTTCAACGACCCCTACCTCCCCCGTGTTTAC TGTTACCGCGTTGCCTCGGCGGGCCCACTGGGGCCTGGCCCCGGTCNCCGGGGGGCTTCT GCCCCCGGGCCCGCTCCCGCCAACACCCTAAACCCTGCCTGAACAGTGAGTCTGATGAGA TTTTAAATCATTAAAACTTTCAACAACGGATCTCTTGGTTCCGCATCGATGAAAAACGCAG CAAAATGCGATAAGTAATGTGAATTGCAGAATTCCGTGAATCATCNAATCTTTGAACGCAC ATTGCGCCCCCTGGCATTCCGGGGGGCATGCCTGTCCAACGTCATTTCTGCCCTCCAGCAC GGCTGGGTGTTGGGCGCTGTCCCCCCGGGGACAC	Penicillium
>206 GTCTCCGGGTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAA CTTACCTTTTGTTGCCTCGGCAGAGGTTACCTGGTACCTGGAGACAGGTTACCCTGTAGCA ACTGCCGGTGGACTACTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAG TCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGC GATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCC CATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGT GTTGGGAATTTACAGTTATGTAATTCCTGAAATACAACGGCGGATCTGTGGTATCCTCTGA GCGTAGTAAATTATTTCTCGCTTTTGTTAGGTGCTGCAGCTCCCAGCCGCTAAACCCCCAAT TTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGC GGAGGAAAAGAAACCAACAGGGATTGCCTTAGTAACGGCGAGTGAAGCGGCAC	Pestalotiopsis

>294 GACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTT TGTTGCCTCGGCAGAGGTTACCTGGTACCTGGAGACAGGTTACCCTGTAGCAACTGCCG GTGGACTACTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAA CTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAA GTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATT AGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGT TGGGAATTTACAGTTATGTAATTCCTGAAATACAACGGCGGATCTGTGGTATCCTCTGA GCGTAGTAAATTATTTCTCGCTTTTGTTAGGTGCTGCAGCTCCCAGCCGCTAAACCCCCA ATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATA AGCGGAGGAA	Pestalotiopsis
>295 GANGGTGACCAGCGGAGGGNCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTT ACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATT AAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAA CGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAA TTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAG TGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTA CTTCTTTTATTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGT AGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTT TGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAGGAGGAA N	Pestalotiopsis
>299 ACCAGCGGAGGGTCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTG TTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTT GTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTC TTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGA ATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCAT GCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTTT ATTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATT TTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTT GACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis

>309 CCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTT TGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAAC TCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACG GATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAA TTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCT AGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGA ATCTACTTCTTTTATTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTC TGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACC CCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATA TCAATAAGCGGAGGAAN	Pestalotiopsis
>329 AGCTCGTGGTGACCAGCGGAGGGCATTATAGAGTTTTCTAAACTCCCAACCCATGTG AACTTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTG GACCATTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAAC TTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATA AGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCC CATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCT TAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATT TGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCC AGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCT GAACTTAAGCATATCAATAAGCGGAGGAAA	Pestalotiopsis
>334 ACGCGGAGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTG TTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTC TTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGA TCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATT GCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAG TGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATC TACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTG AGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCC CAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATC AATAAGCGGAGGAA	Pestalotiopsis

>335 CCGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTTG CCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTA TTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGT TCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGT GAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTC GAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGT AGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCT TTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATC AGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis
>463 CAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTTG CCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTA TTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGT TCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGT GAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTC GAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTTTATTAGTTGT AGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCT TTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATC AGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis
>554 GACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTT GTTGCCTCGGCAGAGGTTACCTGGTACCTGGAGACAGGTTACCCTGTAGCAACTGCCGGT GGACTACTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTT CAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAAT GTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATT CTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAAT TTACAGTTATGTAATTCCTGAAATACAACGGCGGATCTGTGGTATCCTCTGAGCGTAGTAA ATTATTTCTCGCTTTTGTTAGGTGCTGCAGCTCCCAGCCGCTAAACCCCCAATTTTTTGTGG TTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis

>929 CGGAGGGATCATTATAAGTTTTCTAAACTCCCAACCCATGTGAACTTANNNNNTNTNGC CTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTA TTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGG TTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCA GTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTG TTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGA GTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTCTTT TCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGAC CTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAN	Pestalotiopsis
>1388 GATGGTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACT TACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCAT TAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACA ACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGA ATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTA GTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCT ACTTCTTTTAAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGT AGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTT TGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGG AGGAA	Pestalotiopsis
>1393 GGGACCAGCGGAGGGCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTT TGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTC TTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATC TCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAG AATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCA TGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTT TATTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAAT TTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGT TGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis

>1396 GACGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTT TGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAAC TCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACG GATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAA TTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCT AGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGA ATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCT CTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAAC CCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCAT ATCAATAAGCGGAGGAA	Pestalotiopsis
>1426 GGAGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTT ACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCA TTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCA ACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAA TGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAG TATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGT TGGGAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGT ATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGC TAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTA AGCATATCAATAAGCGGAGGAA	Pestalotiopsis
>1609 ACGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTT GTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACT CTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGG ATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAAT TGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTA GTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAAT CTACTTCTCTTAAGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCT GAGCGTANTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCC CCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCcGTGAACAGCATATCAAT AAGCGGAGGAA	Pestalotiopsis

>1691 GTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTT TTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTC TTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTC TTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAAT TCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCC TGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTTTATTA GTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTC TCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTC GGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATATCCGGAGGAA	Pestalotiopsis
>1777 CCAGCGGAGGGACATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTT GCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTT ATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGG TTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAG TGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTC GAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTTTATTAGTTGT AGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCT TTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATC AGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis
>1789 GACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTT GTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTT GTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTT GGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTC AGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTG TTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGT TGTAGTTCCTGAAATACAACGGCGGATTTGCAGTATCCTCTGAGCGTAGTAATTTTTTTCTC GCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGG ATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAGGGAGGAA	Pestalotiopsis

>1823 GAGGTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTT ACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATT AAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAA CGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAA TTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAG TGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTA CTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGCAGTATCCTCTGAGCG TAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTT TTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAGCGG AGGAA	Pestalotiopsis
>1842 GGACAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTT TGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTC TTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATC TCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAG AATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCA TGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTT TATTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAAT TTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGT TGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis
>1977 GGGACCAGCGGAGGGCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCAT TGTTGCCTCGGCAGAAGCTGCTCGGCGCGCCTTACCTTGGAACGGCCTACCCTGTAGCG CCTTACCCTGGAACGGCTTACCCTGCAACGGCTGCCGGTGGACTACCAAACTCTTGTTAT TTTATGGTTATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGG TTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCA GTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTG TTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAGCCTACTGCTTTTGCTA GCTGTAGCTCCTGAAATACAACGGCGGATCTGCGATATCCTCTGAGCGTAGTAATTTTTA TCTCGCTTTTGACTGGAGTTGCAGCGTCTTTAGCCGCTAAACCCCCCAATTTTTAATGGTT GACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis

>1980 GACCAGCGGAGGGCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTT GTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACT CTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGA TCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTG CAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTG GGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTAC TTCTTTTATTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCG TAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATT TTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAG CGGAGGAA	Pestalotiopsis
>2092 CGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGT TGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTT GTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCT CTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCA GAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGG GCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACT TCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCG TAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATT TTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAA GCGGAGGAA	Pestalotiopsis
>2335 CATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTTGCCTCGGCAG AAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTATTTTATG TAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGTTCTG GCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTG AATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTT CGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAG TTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTT TCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTG ACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATA	Pestalotiopsis

>2343 AGTCTCGTTGGTGACAGCGGAGGGACATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACT TACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAA CTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCT CTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATT CAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGT TCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTTTATTAGTTGT AGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTT TGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGT AGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAA	Pestalotiopsis
>2416 AGATGGGACCNGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTAC CTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTC TTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTT GGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAG TGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTCG AGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTTTATTAGTTGTAGT TCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGT TAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAG GAATACCCGCTGAACTTAAGCATATCAATAAGNCGGAGGAAN	Pestalotiopsis
>2431 AGCCGATGGTGACCAGCGGAGGGCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTT ACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAA CTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCT CTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATT CAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGT TCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGT AGTTCCTGAAATACAACGGCGGATTTGCAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTT TGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGT AGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAA	Pestalotiopsis

>2467 GgGACCGCGGAGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTT TGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTC TTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATC TCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAG AATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCA TGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTTT TATTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAAT TTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGT TGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis
>2477 AGGGGGGAGACAGCGGAGGGACATTATAGAGTTTTCTAAACTCCCAACCCATGTGAAC TTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCA TTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAAC AACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTG AATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCT AGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATC TACTTCTTTTATTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGC GTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATT TTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAG CGGAGGAA	Pestalotiopsis
>2540 AGGGACCAGCGGAGGGTCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACC TTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAA CTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGG ATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTG CAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGG GCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTT CTTTTATTAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAG TAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTG TGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAGGAGGAA N	Pestalotiopsis

>2550 GATGGTGACCAGCGGAGGGCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTT ACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCAT TAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAAC AACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATG TGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTAT TCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGG GAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCC TCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAA CCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCA TATCAATAAGCGGAGGAA	Pestalotiopsis
>2739 GACGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTT GTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACT CTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGA TCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTG CAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTG GGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTAC TTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGC GTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAAT TTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATA AGCGGAGGAA	Pestalotiopsis
>2743 GGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTTGC CTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTT ATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTT GGTTCTGGCATCGATGAAGAACGCANCGAAATGCGATAAGTAATGTGAATTGCAGAA TTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCAT GCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTC TTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGT AATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTT GTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCG GAGGAA	Pestalotiopsis

>2748 GACCAGCGGAGGGACATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTT GCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTATT TTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGTTCTG GCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCA TCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCA TTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAA ATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGC TATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACC CGCTGAACTTAAGCATATCAATAAGGAA	Pestalotiopsis
>2820 GACGCGGAGGGTTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTANNNTTTGTTGCCTC GGCAGAGGTTACCTGGTACCTGGAGACAGGTTACCCTGTAGCAGCTGCCGGTGGACTACTAA ACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATC TCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAAT TCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTG TTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATTTACAGTTATGTAATTCCC GAAATACAACGGCGGATCTGTGGTATCCTCTGAGCGTAGTAAATTATTTCTCGCTTTTGTCAG GTGCTGCAGCTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAA TACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Pestalotiopsis
>2838 GAGGGACAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTT TGTTGCCTCGGCAGAGGTTACCTGGTACCTGGAGACAGGTTACCCTGTAGCAGCTGCCGGTG GACTACTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAA CAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAA TTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGG GCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATTTACAGTTAT GTAATTCCTGAAATACAACGGCGGATCTGTGGTATCCTCTGAGCGTAGTAAATTATTTCTCGC TTTTGTCAGGTGCTGCAGCTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCA GGTAGGAATACCCGCTGAACTTAAGCATATCAATACGGAGGAA	Pestalotiopsis

>2927 AGCGATGGTGACCGCGGAgGGcATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTT ACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATT AAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAA CGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAA TTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAG TGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTA CTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCG TAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTT TTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCG GAGGAA	Pestalotiopsis
>2961 CGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTTGC CTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTA TTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGG TTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCA GTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTG TTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGA GTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTT TCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGAC CTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAA	Pestalotiopsis
>342 GGCAGGGCATTCACTTTTTGTCCCCCCCTCCTCAAGACAAATTCTTTGACACACCAAAAA TTTAAGTAATTTATCNCTAAACGAGATTAAGGAAAATGAANAAGTGCAAGAATTCNATA ACGAGGATTTCTTCTTTCACGATATTCCGAAAGATTTATCGCTCAAAGATACGCTGAATG GCTCACCCAGTAAGGTAGTTCCAAGAGCCCCACGATTACTCAAACGTTCCCTTCAATCAT TGTCGGATTTGACAATGAGTACNAGGAAGATAACAACAATGATAAACATGATGAAAAG GAAGAACAACAAACNACNACCGACAATAAAACGAGAAATCTTTCACCTACCAAACAAA ATGGTAAAGCTACCCATCCAAGGATAAAAATACCTTTAANAAGAGCAGCTTCANAACCA AACGGGTTGCAACTCGCATCTGCCACATCGCCGACATCTTCTTCAGCAAGGAAAACATC NGGGTCCAGTAATATAAACGACAAAATCCCAGGCCAATCANTGCCTCCNNCAAACTCAT TTTTCCCTCAAGAACCCTCTCCAAANATTTCTGATTTTCCAGANNNNANGANGTCCCNAC GTNNGANAACTAAATCTTNCANCAATAAATTTCAAGATATNNNGGTGG	Saccharomyces

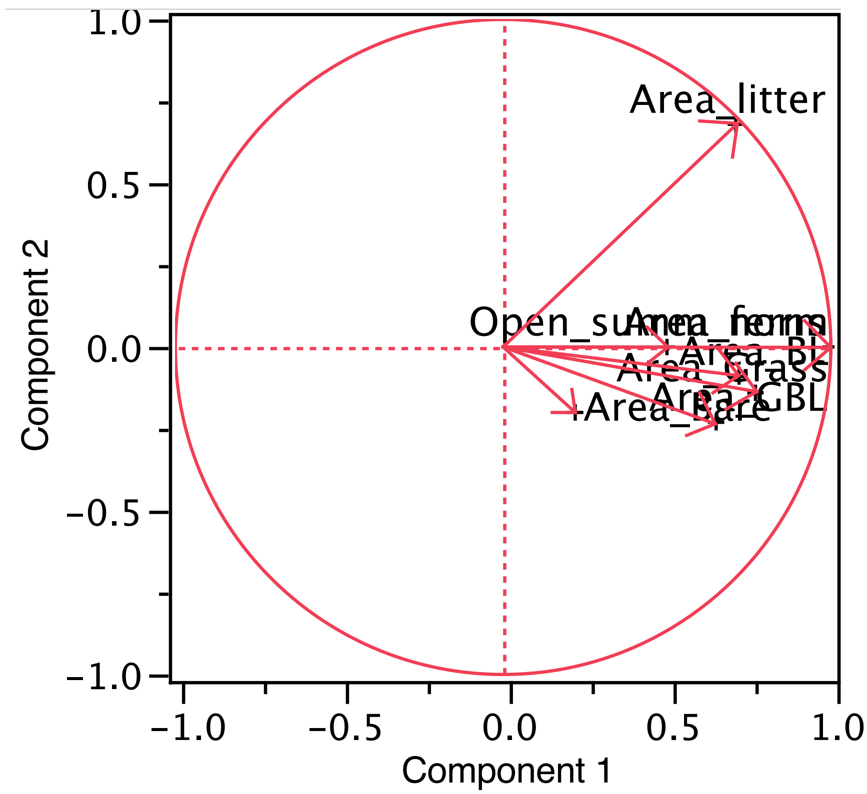
>129 GACTGCGGAGGACATTAACGAGTTTTGAAACGGGTTGTAGCTGGCCTTCCGAGGCAT GTGCACACCCTGCTCATCCACTCTACACCTGTGCACTTACTGTAGGTTGGCGTGGGCTT CGGACCTCCGGGTTCGAGGCATGCGGCCTATGTACACTACAAACTCCGAAGTAACAG AATGTAAACGCGTCTAACGCATCTTAATACAACTTTCAGCAACGGATCTCTTGGCTCTC GCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTG AATCATCGAATCTTTGAACGCACCTTGCGCTCCTTGGTATTCCGAGGAGCATGCCTGTT TGAGTGTCATGGAATTCTCAACCCATAGATCCTTGTGGTCTACGGGCTTGGATTTGGA GGCTTGCCGGCCCTTACACGGGGTCGGCTCCTCTTGAATGCATTAGCTTGATTCCGTG CGAATCGGCTTTCAGTGTGATAATTGTCTACGCTGTGGCCGTGAAGCGTTTGGCGAGC TTCTAACTGTCCGTTAGGACAACTTCTTGACATCTGACCTCAAATCAGGTAGGACTACC CGCTGAACTTAAGCATATCAATAAGGAGGAA	Trametes
>2284 CATTACCGAGTTTACAACTCCCAAACCCAATGTGAACCATACCAAACTGTTGCCTCGGC GGGGTCACGCCCCGGGTGCGTCGCAGCCCCGGAACCAGGCGCCCGCCGGAGGGACC AACCAAACTCTTTCTGTAGTCCCCTCGCGGACGTTATTTCTTACAGCTCTGAGCAAAAA TTCAAAATGAATCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAA CGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTT GAACGCACATTGCGCCCGCCAGTATTCTGGCGGGCATGCCTGTCCGAGCGTCATTTCA ACCCTCGAACCCCTCCGGGGGGTCGGCGTTGGGGATCGGGAACCCCTAAGACGGGAT CCCGGCCCCGAAATACAGTGGCGGTCTCGCCGCAGCCTCTCCTGCGCAGTAGTTTGCA CAACTCGCACCGGGAGCGCGGCGCGTCCACGTCCGTAAAACACCCAACTTCTGAAAT GTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAN GAA	Trichoderma
>2736 AGGGCGATGGTGACCAGCGGAGGGTCATTACCGAGTTTACAACTCCCAAACCCAATG TGAACGTTACCAAACTGTTGCCTCGGCGGGATCTCTGCCCCGGGTGCGTCGCAGCCCC GGACCAAGGCGCCCGCCGGAGGACCAACCTAAAACTCTTTTGTATACCCCCTCGCGG GTTTTTTATATCTGAGCCATCTCGGCGCCTCTCGTAGGCGTTTCGAAAATGAATCAAAA CTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATA AGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCC GCCAGTATTCTGGCGGGCATGCCTGTCCGAGCGTCATTTCAACCCTCGAACCCCTCCG GGGGGTCGGCGTTGGGGATCGGCCCTTTACGGGGCCGGCCCCGAAATACAGTGGCG GTCTCGCCGCAGCCTCTCCTGCGCAGTAGTTTGCACACTCGCATCGGGAGCGCGGCGC GTCCATTGCCGTAAAACACCCAACTTTCTGAAATGTTGACCTCGGATCAGGTAGGAAT ACCCGCTGAACTTAAGCATATCAATAANNGGAGGAA	Trichoderma

>95 GTGGTGACCGCGGAGGGTTACGAGTTATCCNACTCCCAAACCCATGTGAACTTATCTCTTTG TTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGCCGGCGGACAAACCA AACTCTGTTATCTTCGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAACTTTCAACAACGG ATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCA GAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCAT GCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTTGGGAATCTACGCCCTAGTA GTTCCTCAAAGACATTGGCGGAGTGGCAGTAGTCCTCTGAGCGTAGTAATTCTTTATCTCGC TTTTGTTAGGTGCTGCCTCCCCGGCCGTAAAACCCCCAATTTTTTCTGGTTGACCTCGGATCA GGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGGGAGGAA	Uncultured fungus
>122 CCGTGGTGACCAGCGGAGGGATCATTACAGAGTTATCCAACTCCCAAACCCATGTGAACTTA TCTCTTTGTTGCCTCGGCGCAAGCTACCCGGGACCTCGCGCCCCGGGCGGCCCGCCGGCGG ACAAACCAAACTCTGTTATCTTAGTTGATTATCTGAGTGTCTTATTTAATAAGTCAAAACTTTC AACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGT GAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAG TGGGCATGCCTGTTCGAGCGTCATTTCAACCCCTAAGCACAGCTTATTGTTGGGAATCTACG CCCTAGTAGTTCCTCAAAGACATTGGCGGAGTGGCAGTAGTCCTCTGAGCGTAGTAATTCTT TATCTCGCTTTTGTTAGGTGCTGCCTCCCCGGCCGTAAAACCCCCAATTTTTTCTGGTTGACCT CGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAAAAGAAACCA ACAGGGATTCCCCTAGTAACGGCGAGTGAAGCGGCAACACAAATAAA	Uncultured fungus
>552 ATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTTGCCTCGGCAGAAGTT ATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTATTTTATGTAATCTGAG CGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGA ACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAA CGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAA GCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCG GATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCA GCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTT AAGCATATCAATAAGCGGAGGAA	Uncultured fungus

>1188 GANNGGTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAN	Uncultured fungus
>1423 CAGCGGAGGGTTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATAAGCGGAGGAA	Uncultured fungus
>2153 TATGGTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTGAACTTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTGGACCATTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCCCATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCTGAACTTAAGCATATCAATA	Uncultured fungus

>2671 AGGTCTCGTGGTGACCAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCA TGTGAACTTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCC GGTGGACCATTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCA AAACTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGC GATAAGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTG CGCCCATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCT AGCTTAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCG GATTTGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAAC TCCCAGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCC GCTGAACTTAAGCATATC	Uncultured fungus
>2711 GGGAATGGTGACAGCGGAGGGATCATTATAGAGTTTTCTAAACTCCCAACCCATGTG AACTTACCTTTTGTTGCCTCGGCAGAAGTTATAGGTCTTCTTATAGCTGCTGCCGGTG GACCATTAAACTCTTGTTATTTTATGTAATCTGAGCGTCTTATTTTAATAAGTCAAAAC TTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGAAATGCGATA AGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACATTGCGCC CATTAGTATTCTAGTGGGCATGCCTGTTCGAGCGTCATTTCAACCCTTAAGCCTAGCT TAGTGTTGGGAATCTACTTCTCTTAGGAGTTGTAGTTCCTGAAATACAACGGCGGATT TGTAGTATCCTCTGAGCGTAGTAATTTTTTTCTCGCTTTTGTTAGGTGCTATAACTCCC AGCCGCTAAACCCCCAATTTTTTGTGGTTGACCTCGGATCAGGTAGGAATACCCGCT GAACTTAAGCATATCAATA	Uncultured fungus

Appendix 2-5. Principal components analysis conducted on the different ground cover types (broad leaves, ground broad leaves, grass, bare ground, litter) and on canopy openness.



Appendix 2-6. Survival analysis models of abiotic variables significance on survival of the seedlings

Abiotic variables:
Canopy openness
Soil nitrogen (NH_4 and NO_3)
Percent ground cover of broad leaves, ferns, grass, litter and bare ground

Models:

- Risk of death of seedling ~ Canopy openness in the rainy season:
Logrank relative risk increase=1.002 (95% CI= 0.9928-1.012), X^2= 0.24, df=1, p=0.6264

- Risk of death of seedling ~ Canopy openness in the dry season:
Logrank relative risk increase=0.995 (95% CI= 0.989 -1.001), X^2= 2.61, df=1, p=0.1062

- Risk of death of seedling ~ soil NH4:
Logrank relative risk increase=1.008 (95% CI= 0.9944 -1.023), X^2= 1.39, df=1, p=0.239

-Risk of death of seedling ~ soil NO3:
Logrank relative risk increase=1.007 (95% CI= 0.9691 -1.046), X^2= 0.12, df=1, p=0.7317

-Risk of death of seedling ~ soil P:
Logrank relative risk increase=1.016 (95% CI= 0.987 -1.046), X^2= 1.18, df=1, p=0.2778

-Risk of death of seedling ~ Area broad leaves:
Logrank relative risk increase=0.9312 (95% CI= 0.8643 -1.003), X^2= 3.52, df=1, p=0.06073

-Risk of death of seedling ~ Area ground broad leaves:
Logrank relative risk increase=0.811 (95% CI= 0.7244 -0.9078), X^2= 13.32, df=1, p=0.0002632

-Risk of death of seedling ~ Area ferns:
Logrank relative risk increase=0.3554 (95% CI= 0.1065 -1.186), X^2= 2.83, df=1, p= 0.09224

-Risk of death of seedling ~ Area grass:
Logrank relative risk increase=1.022 (95% CI= 0.9624 -1.085), X^2= 0.5, df=1, p=0.4796

-Risk of death of seedling ~ Area litter:
Logrank relative risk increase=1.039 (95% CI= 0.9804 -1.101), X^2= 1.67, df=1, p=0.1963

-Risk of death of seedling ~ Area bare ground:
Logrank relative risk increase=1.090 (95% CI= 0.8988 -1.321), X^2= 0.76, df=1, p=0.382

Appendix 2-7. Light tolerance survival analysis results

Light tolerance was a significant predictor in the risk analysis. Shade intolerants have a much higher risk of death

Categories average number of days surviving

Shade intolerant	Light-intermediate	Shade tolerant
519.1194	625.9644	626.3785

Model results
Shade intolerant: relative risk increase= 3.46 (95% CI 2.94-4.06), P>|z|< 0.0001
Light intermediate: relative risk increase=1.27 (95% CI 1.08-1.51), P>|z|= 0.0053
Shade tolerant: Not informative, due to not enough variability in the data set with respect to affecting risk
Logrank test X^2=277.7, df=2, P <0.0001, R^2=0.086

LITERATURE CITED

Aide, T. M., J. K. Zimmerman, J. B. Pascarella, L. Rivera, and H. Marcano-Vega. 2000. Forest regeneration in a chronosequence of tropical abandoned pastures: Implications for restoration ecology. Restoration Ecology **8**:328-338.

Ashton, P. M. S., S. Gamage, I. Gunatilleke, and C. V. S. Gunatilleke. 1998. Using Caribbean pine to establish a mixed plantation: testing effects of pine canopy removal on plantings of rain forest tree species. Forest Ecology and Management **106**:211-222.

Augspurger, C. K. 1984. Seedling survival of tropical tree species: Interactions of dispersal distance, light-gaps, and pathogens. Ecology **65**:1705-1712.

Augspurger, C. K. and C. K. Kelly. 1984. Pathogen mortality of tropical tree seedlings - experimental studies of the effects of dispersal distance, seedling density, and light conditions. Oecologia **61**:211-217.

Avelino, J., S. Cabut, B. Barboza, M. Barquero, R. Alfaro, C. Esquivel, J. F. Durand, and C. Cilas. 2007. Topography and crop management are key factors for the development of American leaf spot epidemics on coffee in Costa Rica. Phytopathology **97**:1532-1542.

Barrett, L. G., J. M. Kniskern, N. Bodenhausen, W. Zhang, and J. Bergelson. 2009. Continua of specificity and virulence in plant host-pathogen interactions: causes and consequences. New Phytologist **183**:513-529.

Blomberg, S. P., T. , J. Garland, and A. R. Ives. 2003. Testing for phylogenetic signal in comparative data: behavioral traits are more labile. . Evolution **57**:717–745.

Bouman, B. A. M., A. Nieuwenhuyse, and M. Ibrahim. 1999. Pasture degradation and restoration by legumes in humid tropical Costa Rica. Tropical Grasslands **33**:98-110.

Bradley, R., G. S. Gilbert, and I. M. Parker. 2003. Susceptibility of clover species to fungal infection: The interaction of leaf surface traits and environment. American Journal of Botany **90**:857-864.

Burdon, J. J. and P. H. Thrall. 2000. Coevolution at multiple spatial scales: *Linum marginale-Melampsora lini* - from the individual to the species. Evolutionary Ecology **14**:261-281.

Cadotte, M. W., J. Cavender-Bares, D. Tilman, and T. H. Oakley. 2009. Using phylogenetic, functional and trait diversity to understand patterns of plant community productivity. Plos One **4**.

Campbell, C. L. and L. V. Madden. 1990. Introduction to plant disease epidemiology. Wiley Interscience. 532 pp.

Capelle, J. and C. Neema. 2005. Local adaptation and population structure at a micro-geographical scale of a fungal parasite on its host plant. Journal of Evolutionary Biology **18**:1445-1454.

Carpenter, F. L., J. D. Nichols, and E. Sandi. 2004. Early growth of native and exotic trees planted on degraded tropical pasture. Forest Ecology and Management **196**:367-378.

Cavender-Bares, J., K. Kozak, P. Fine, and S. W. Kembel. 2009. The merging of community ecology and phylogenetic biology. Ecology Letters **12**:693-715.

Chazdon, R. L., S. Careaga, C. Webb, and O. Vargas. 2003. Community and phylogenetic structure of reproductive traits of woody species in wet tropical forests. Ecological Monographs **73**:331-348.

Chungu, D., A. Muimba-Kankolongo, M. J. Wingfield, and J. Roux. 2010. Plantation forestry diseases in Zambia: Contributing factors and management options. Annals of Forest Science **67**.

Clark, D. A. and D. B. Clark. 1984. Spacing dynamics of a tropical rain-forest tree - Evaluation of the Janzen-Connell model. American Naturalist **124**:769-788.

Cole, R. J., K. D. Holl, and R. A. Zahawi. 2010. Seed rain under tree islands planted to restore degraded lands in a tropical agricultural landscape. Ecological Applications **20**:1255-1269.

Comita, L. S. and S. P. Hubbell. 2009. Local neighborhood and species' shade tolerance influence survival in a diverse seedling bank. Ecology **90**:328-334.

Condit, R., S. P. Hubbell, and R. B. Foster. 1996. Assessing the response of plant functional types to climatic change in tropical forests. Journal of Vegetation Science **7**:405-416.

Connell, J. 1971. On the role of natural enemies in preventing competitive exclusion in some marine animals and in rain forest trees. Pages 298–312 *in* G. G. PJ Boer, editor. Dynamics of Numbers in Populations (Proc. Adv. Stud. Inst., Osterbeek 1970), Wageningen: Cent. Agric. Publ. Document.

Cook, M. 1980. Peanut leaf wettability and susceptibility to infection by puccina-arachidis. Phytopathology **70**:826-830.

Cox, D. R. 1972. Regression models and life-tables. Journal of the Royal Statistical Society Series B-Statistical Methodology **34**:187-&.

Craven, D., J. Hall, and J. M. Verjans. 2009. Impacts of herbicide application and mechanical cleanings on growth and mortality of two timber species in *Saccharum spontaneum* grasslands of the Panama Canal Watershed. Restoration Ecology **17**:751-761.

Cuevas-Reyes, P., M. Quesada, and K. Oyama. 2006. Abundance and leaf damage caused by gall-inducing insects in a Mexican tropical dry forest. Biotropica **38**:107-115.

Davies, T. J., T. G. Barraclough, M. W. Chase, P. S. Soltis, D. E. Soltis, and V. Savolainen. 2004. Darwin's abominable mystery: Insights from a supertree of the angiosperms. Proceedings of the National Academy of Sciences of the United States of America **101**:1904-1909.

Dayan, T. and D. Simberloff. 2005. Ecological and community-wide character displacement: the next generation. Ecology Letters **8**:875-894.

Elton, C. S. 1946. Competition and the structure of ecological communities. Journal of Animal Ecology **15**: 54–68.

Erskine, P. D., D. Lamb, and M. Bristow. 2006. Tree species diversity and ecosystem function: Can tropical multi-species plantations generate greater productivity? Forest Ecology and Management **233**:205-210.

Farrell, B. D. 2001. Evolutionary assembly of the milkweed fauna: Cytochrome oxidase I and the age of Tetraopes beetles. Molecular Phylogenetics and Evolution **18**:467-478.

Filajdic, N. and T. B. Sutton. 1992. Influence of temperature and wetness duration on infection of apple leaves and virulence of different isolates of *Alternaria mali*. Phytopathology **82**:1279-1283.

Forest, F., R. Grenyer, M. Rouget, T. J. Davies, R. M. Cowling, D. P. Faith, A. Balmford, J. C. Manning, S. Proches, M. van der Bank, G. Reeves, T. A. J. Hedderson, and V. Savolainen. 2007. Preserving the evolutionary potential of floras in biodiversity hotspots. Nature **445**:757-760.

Forrester, D. I., J. Bauhus, A. L. Cowie, and J. K. Vanclay. 2006. Mixed-species plantations of Eucalyptus with nitrogen-fixing trees: A review. Forest Ecology and Management **233**:211-230.

Franco, A. A. and S. M. DeFaria. 1997. The contribution of N-2-fixing tree legumes to land reclamation and sustainability in the tropics. Soil Biology & Biochemistry **29**:897-903.

Frazer, G. W., C. D. Canham, and K. P. Lertzman. 1999. Gap Light Analyzer (GLA), Version 2.0: Imaging software to extract canopy structure and gap light transmission indices from true-colour fisheye photographs, users manual and program documentation. Simon Fraser University, Burnaby, British Columbia, and the Institute of Ecosystem Studies, Millbrook, New York. pp.

Futuyma, D. J. and C. Mitter. 1996. Insect-plant interactions: The evolution of component communities. Philosophical Transactions of the Royal Society B-Biological Sciences **351**:1361-1366.

Gandon, S., Y. Capowiez, Y. Dubois, Y. Michalakis, and I. Olivieri. 1996. Local adaptation and gene-for-gene coevolution in a metapopulation model. Proceedings of the Royal Society of London Series B-Biological Sciences **263**:1003-1009.

Gardes, M. and T. D. Bruns. 1993. ITS primers with enhanced specificity for basidiomycetes - application to the identification of mycorrhizae and rusts. Molecular Ecology **2**:113-118.

Gilbert, G. S., S. P. Hubbell, and R. B. Foster. 1994. Density and distance-to-adult effects of a canker disease of trees in a moist tropical forest. Oecologia **98**:100-108.

Gilbert, G. S., R. Magarey, K. Suiter, and C. Webb. 2012. Evolutionary tools for phytosanitary risk analysis: phylogenetic signal as a predictor of host range of plant pests and pathogens. Evolutionary Applications:1-10.

Gilbert, G. S. and I. M. Parker. 2010. Rapid evolution in a plant-pathogen interaction and the consequences for introduced host species. Evolutionary Applications **3**:144-156.

Gilbert, G. S., D. R. Reynolds, and A. Bethancourt. 2007. The patchiness of epifoliar fungi in tropical forests: host range, host abundance, and environment. Ecology **88**:575-581.

Gilbert, G. S. and C. O. Webb. 2007. Phylogenetic signal in plant pathogen-host range. Proceedings of the National Academy of Sciences of the United States of America **104**:4979-4983.

Gombauld, P. and J. Rankin-de Merona. 1998. Influence of season on phenology and insect herbivory on saplings of tropical rain forest trees in French Guiana. Annales Des Sciences Forestieres **55**:715-725.

Gonzalez, M. A., A. Roger, E. A. Courtois, F. Jabot, N. Norden, C. E. T. Paine, C. Baraloto, C. Thebaud, and J. Chave. 2009. Shifts in species and phylogenetic diversity between sapling and tree communities indicate negative density dependence in a lowland rain forest. Journal of Ecology **98**:137-146.

Harms, K. E., S. J. Wright, O. Calderon, A. Hernandez, and E. A. Herre. 2000. Pervasive density-dependent recruitment enhances seedling diversity in a tropical forest. Nature **404**:493-495.

Holl, K. D. 2002. Effect of shrubs on tree seedling establishment in an abandoned tropical pasture. Journal of Ecology **90**:179-187.

Holl, K. D., G. C. Daily, S. C. Daily, P. R. Ehrlich, and S. Bassin. 1999. Knowledge of and attitudes toward population growth and the environment: university students in Costa Rica and the United States. Environmental Conservation **26**:66-74.

Hooper, E., R. Condit, and P. Legendre. 2002. Responses of 20 native tree species to reforestation strategies for abandoned farmland in Panama. Ecological Applications **12**:1626-1641.

Hubbell, S. P., R. Condit, and R. B. Foster. 1990. Presence and absence of density dependence in a neotropical tree community. Philosophical Transactions of the Royal Society of London Series B-Biological Sciences **330**:269-281.

Janzen, D. H. 1970. Herbivores and number of tree species in Tropical forests. American Naturalist **104**:501-528.

John, R., J. W. Dalling, K. E. Harms, J. B. Yavitt, R. F. Stallard, M. Mirabello, S. P. Hubbell, R. Valencia, H. Navarrete, M. Vallejo, and R. B. Foster. 2007. Soil nutrients influence spatial distributions of tropical tree species. Proceedings of the National Academy of Sciences of the United States of America **104**:864-869.

Keefe, K., M. D. Schulze, C. Pinheiro, J. C. Zweede, and D. Zarin. 2009. Enrichment planting as a silvicultural option in the eastern Amazon: Case study of *Fazenda Cauaxi*. Forest Ecology and Management **258**:1950-1959.

Kirton, L. G. and S. Cheng. 2007. Ring-barking and root debarking of dipterocarp saplings by termites in an enrichment planting site in Malaysia. Journal of Tropical Forest Science **19**:67-72.

Konno, M., S. Iwamoto, and K. Seiwa. 2011. Specialization of a fungal pathogen on host tree species in a cross-inoculation experiment. Journal of Ecology **99**:1394-1401.

Lamb, D. 1998. Large-scale ecological restoration of degraded tropical forest lands: The potential role of timber plantations. Restoration Ecology **6**:271-279.

Lamb, D. 2011. Regreening the bare hills: Tropical forest restoration in the Asia-Pacific region. Springer Verlag, New York. 535 pp.

Larena, I., O. Salazar, V. Gonzalez, M. C. Julian, and V. Rubio. 1999. Design of a primer for ribosomal DNA internal transcribed spacer with enhanced specificity for ascomycetes. Journal of Biotechnology **75**:187-194.

Lin, Y. C. and C. K. Augspurger. 2006. Long-term study of neighbour-regulated demography during a decline in forest species diversity. Journal of Vegetation Science **17**:93-102.

Lombardero, M. J., P. Vazquez-Mejuto, and M. P. Ayres. 2008. Role of plant enemies in the forestry of indigenous vs. nonindigenous pines. Ecological Applications **18**:1171-1181.

Menalled, F. D., M. J. Kelty, and J. J. Ewel. 1998. Canopy development in tropical tree plantations: a comparison of species mixtures and monocultures. Forest Ecology and Management **104**:249-263.

Metz, M. R., W. P. Sousa, and R. Valencia. 2010. Widespread density-dependent seedling mortality promotes species coexistence in a highly diverse Amazonian rain forest. Ecology **91**:3675-3685.

Nair, K. S. S. and R. V. Varma. 1985. Some ecological aspects of the termite problem in young Eucalypt plantations in Kerala, India. Forest Ecology and Management **12**:287-303.

National Center for Biotechnology. 2008. BLAST: Basic local alignment search tool.*in* N. L. o. Medicine, editor.

Novotny, V., Y. Basset, S. E. Miller, P. Drozd, and L. Cizek. 2002a. Host specialization of leaf-chewing insects in a New Guinea rainforest. Journal of Animal Ecology **71**:400-412.

Novotny, V., Y. Basset, S. E. Miller, G. D. Weiblen, B. Bremer, L. Cizek, and P. Drozd. 2002b. Low host specificity of herbivorous insects in a tropical forest. Nature **416**:841-844.

Paquette, A., A. Bouchard, and A. Cogliastro. 2006. Survival and growth of under-planted trees: A meta-analysis across four biomes. Ecological Applications **16**:1575-1589.

Paquette, A., J. Hawryshyn, A. V. Senikas, and C. Potvin. 2009. Enrichment planting in secondary forests: A promising clean development mechanism to increase terrestrial carbon sinks. Ecology and Society **14**:31-46.

Park, A., M. van Breugel, M. S. Ashton, M. Wishnie, E. Mariscal, J. Deago, D. Ibarra, N. Cedeno, and J. S. Hall. 2010. Local and regional environmental variation influences the growth of tropical trees in selection trials in the Republic of Panama. Forest Ecology and Management **260**:12-21.

Parker, I. M. and G. S. Gilbert. 2004. The evolutionary ecology of novel plant-pathogen interactions. Annual Review of Ecology Evolution and Systematics **35**:675-700.

Pena-Claros, M., R. G. A. Boot, J. Dorado-Lora, and A. Zonta. 2002. Enrichment planting of *Bertholletia excelsa* in secondary forest in the Bolivian Amazon: effect of cutting line width on survival, growth and crown traits. Forest Ecology and Management **161**:159-168.

Piotto, D. 2007. Growth of native tree species planted in open pasture, young secondary forest and mature forest in humid tropical Costa Rica. Journal of Tropical Forest Science **19**:92-102.

Piotto, D. 2008. A meta-analysis comparing tree growth in monocultures and mixed plantations. Forest Ecology and Management **255**:781-786.

Piotto, D., E. Viquez, F. Montagnini, and M. Kanninen. 2004. Pure and mixed forest plantations with native species of the dry tropics of Costa Rica: a comparison of growth and productivity. Forest Ecology and Management **190**:359-372.

Plath, M., K. Mody, C. Potvin, and S. Dorn. 2011. Establishment of native tropical timber trees in monoculture and mixed-species plantations: Small-scale effects on tree performance and insect herbivory. Forest Ecology and Management **261**:741-750.

Pringle, E. G., R. I. Adams, E. Broadbent, P. E. Busby, C. I. Donatti, E. L. Kurten, K. Renton, and R. Dirzo. 2011. Distinct leaf-trait syndromes of evergreen and deciduous trees in a seasonally dry tropical forest. Biotropica **43**:299-308.

Queenborough, S. A., D. Burslem, N. C. Garwood, and R. Valencia. 2007. Neighborhood and community interactions determine the spatial pattern of tropical tree seedling survival. Ecology **88**:2248-2258.

R-Development-Core-Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical omputing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Ramos, J. M. and S. Delamo. 1992. Enrichment planting in a tropical secondary forest in Veracruz, Mexico. Forest Ecology and Management **54**:289-304.

Redondo-Brenes, A. and F. Montagnini. 2006. Growth, productivity, aboveground biomass, and carbon sequestration of pure and mixed native tree plantations in the Caribbean lowlands of Costa Rica. Forest Ecology and Management **232**:168-178.

SAS-Institute. 2010. JMP 9: Statistical software. Cary, North Carolina.

Schuler, J. L. and D. J. Robison. 2010. Performance of northern red oak enrichment plantings in naturally regenerating Southern Appalachian hardwood stands. New Forests **40**:119-130.

Schulze, M. 2008. Technical and financial analysis of enrichment planting in logging gaps as a potential component of forest management in the eastern Amazon. Forest Ecology and Management **255**:866-879.

Springer, Y. 2007. Clinal resistance structure and pathogen local adaptation in a serpentine flax-flax rust interaction. Evolution **61**:1812-1822.

Tessmann, D. J., J. C. Dianese, A. C. Miranda, and L. H. R. Castro. 2001. Epidemiology of a Neotropical rust (*Puccinia psidii*): periodical analysis of the temporal progress in a perennial host (*Syzygium jambos*). Plant Pathology **50**:725-731.

The Country Day School. n.d. *Sapium glandulosum* L. Morong. Retrieved August 15, 2011, from http://www.cds.ed.cr/teachers/harmon/page53.html.

Van Bael, S. A., A. Aiello, A. Valderrama, E. Medianero, M. Samaniego, and S. J. Wright. 2004. General herbivore outbreak following an El Nino-related drought in a lowland Panamanian forest. Journal of Tropical Ecology **20**:625-633.

Webb, C. O., D. D. Ackerly, and S. W. Kembel. 2008. Phylocom: software for the analysis of phylogenetic community structure and trait evolution. Bioinformatics **24**:2098-2100.

Webb, C. O., G. S. Gilbert, and M. J. Donoghue. 2006. Phylodiversity-dependent seedling mortality, size structure, and disease in a bornean rain forest. Ecology **87**:S123-S131.

Wills, C., R. Condit, R. B. Foster, and S. P. Hubbell. 1997. Strong density- and diversity-related effects help to maintain tree species diversity in a neotropical forest. Proceedings of the National Academy of Sciences of the United States of America **94**:1252-1257.

Wishnie, M. H., D. H. Dent, E. Mariscal, J. Deago, N. Cedeno, D. Ibarra, R. Condit, and P. M. S. Ashton. 2007. Initial performance and reforestation potential of 24 tropical tree species planted across a precipitation gradient in the Republic of Panama. Forest Ecology and Management **243**:39-49.

World Agroforestry Centre. n.d. *Agroforestry Tree Database*. Retrieved September, 2011, from http://www.worldagroforestry.org/SEA/Products/AFDbases/AF/asp/SpeciesInfo.asp?SpID=.

Zhou, X. D., Y. J. Xie, S. F. Chen, and M. J. Wingfield. 2008. Diseases of eucalypt plantations in China: challenges and opportunities. Fungal Diversity **32**:1-7.

CHAPTER 3

Environmental governance in the Panama Canal Watershed.

ABSTRACT

Today, the power of the central state in natural resource management has been redistributed among many society actors, such as local communities and non-governmental organizations. I studied the case of a multi-stakeholder governance regime in the Panama Canal Watershed. To achieve their mission of conserving water in quality and quantity for Canal operations, the Panama Canal Authority implemented a multi-stakeholder environmental governance regime in the Canal Watershed. This regime involves the participation of local actors in reforestation for water conservation, and in sustainable development activities. I assessed, using participant observation and semi-structured and open-ended interviews, the positive aspects and challenges of the current governance regime. In addition, I researched the power dynamics between two actors: the local community and the Panama Canal Authority. I employed a post-structural political ecology approach based in the analysis of discourses held by the different actors. I found the governance regime is creating important spaces for environmental education and communication between the communities and the government. However, there is a strong top-down hierarchy, led by the Panama Canal Authority. This institution employs the win-win discourse of sustainable development when questioned about their goals for the governance regime. However, tangible results are still mostly lacking. The local communities expressed frustration by the lack of projects, their minimal involvement in decision-

making, and the life quality improvements to date. The Panama Canal Authority struggles to achieve greater collaboration from other government institutions in charge of solving pressing social issues in the watershed.

INTRODUCTION

Today, renewable natural resource management is framed by socio-political and economic trends that started in the 1980's. Trends that include, on one hand, neo-liberal agendas that praise Polanyi's idea of the "self regulating market" (Polanyi, 2001) and thus promote market liberalism, a privatization and commodification of nature, and a reduction in state regulations (McCarthy and Prudham, 2004); and on the other hand, the involvement of non-governmental organizations and other social groups in policy and management (Busch *et al.*, 2005). This push for a diminished State has directly affected the State's role as the central figure in natural resource management to allow for the redistribution of some of its functions and powers to various social actors at different scales. Management has been allocated, both to local entities (such as city governances, local citizen groups, and private entities), and to international and transnational institutions (such as global NGOs and aid agencies) (Bulkeley, 2005; Batterbury and Fernando, 2006; Lemos and Agrawal, 2006).

The interaction of different actors in natural resource management is referred to as multi-stakeholder or "hybrid" environmental governance (Lemos and Agrawal, 2006). Proponents claim that through "the recognition that no single agent possesses the necessary capabilities to address the multiple facets, scales and interdependencies of environmental problems… hybrid environmental governance can produce positive social as well as ecological outcomes" (Agrawal and Lemos, 2007: 39). In hybrid environmental governance regimes, complex alliances develop around the conservation and management of natural resources. With this study, I aim to contribute to conversations on hybrid environmental governance, by analyzing the extent to which its claims are realized on the ground by using the Integrated Management of the Panama Canal Watershed as a case study. One fundamental question of hybrid environmental governance regimes is whether the allegedly increased participation of actors from different social spheres truly leads to an increase in their influence on policy and environmental outcomes. I approach this question by looking at 1) which aspects of the current state of the Integrated Watershed Management regime signal a possible increase in multi-stakeholder influence over political, social and environmental outcomes, and what are the challenges to achieve this? and 2) what are the prevailing power dynamics among the main actors that may prevent or promote a more equal distribution of power?

The Panama Canal Watershed is an important feature of the global landscape, since it provides the water for a key component of the World's economy: the Panama Canal. Around 4 % of the global trade travels across the canal (United States Agency for International Development, 2005). The Canal connects the Pacific and Atlantic Oceans via Gatun Lake, an artificial freshwater lake, which is fed by several rivers in the watershed. The water storage capacity of two artificial lakes in the Panama Canal Watershed - the Gatun and Alajuela lakes - allows the Canal to function, act as a buffer against seasonal variation in precipitation, and provides the water for the two main cities of the Republic of Panama: Panama City and Colon (Heckadon, 1986). Fear that deforestation and climate change may render water provision for the Canal unstable, especially during the dry season, made conservation of forest cover in the

Panama Canal Watershed a key responsibility of the Panamanian Government (Condit *et al.*, 2001). A single government institution, the Panama Canal Authority (ACP, table 3-1) became, by constitutional mandate (Law 19, June 11 1997), responsible for overseeing the functioning of the Canal and guaranteeing continuous water supply via the conservation of critical areas (Morris Carrera and Mendoza, 2002; ANAM, 2004).

Agriculture, cattle ranching and urban sprawl, mostly under conditions of extreme poverty and lack of basic services, are expanding throughout the watershed (ANAM, 2004). These activities place the mandate of the ACP in conflict with the socioeconomic and cultural needs of the people that live in the Panama Canal Watershed (Condit *et al.*, 2001). To achieve its mandate, while meeting the needs of the local communities, the ACP, with strong support from the US Agency for International Development (USAID) adopted a hybrid environmental governance approach to managing the Panama Canal Watershed. This approach created various governance structures, at the local and regional scale, that constitute spaces where actors can communicate and collaborate in managing the Panama Canal Watershed for conservation of the water resource.

I approached the present study from a political ecology perspective, since it brings to the forefront of analytical studies of environmental governance the multi-scalar nature of governance regimes (inherent in hybrid environmental governance), and the power dynamics between the different actors (see Robbins, 2004). In that sense, political ecology allows asking if governance regimes lead to a fair distribution of power, and it questions who may lose and who may benefit from the governance structure. My expectation going into this study was that the ACP would be at the top of the power pyramid dictating the structure and functioning of the governance system, while the local communities would be at the bottom. However, I also expected that the communities would struggle against this hierarchical structure and that this struggle would be higher in peri-urban than in rural communities given higher education level in the former leading them to question authority. To test this, I gathered data from two peri-urban and two rural communities within the Panama Canal Watershed.

The present manuscript is organized as follows. In the first section, I review the main literature on hybrid environmental governance and political ecology that informs this research, and to which I aim to contribute. In the second section, I provide the geographical context of my research by describing the Panama Canal Watershed environment and the history of human settlements. In turn, I describe the history and development of the Integrated Watershed Management regime. In the third section, I describe and explain the methodological approach employed. Finally, I develop and discuss the results of this research. I highlight and discuss the positive outcomes and challenges I observed of the Panama Canal Watershed's Integrated Watershed Management as a hybrid environmental governance regime claimed by its proponents to increase participation, and influence of local communities in their sustainable development. In addition, through the lenses of political ecology, I aim to uncover and understand struggles for power that arise among stakeholders by looking at the discursive elements of government actors and of local community members.

THEORETICAL FRAMEWORK

HYBRID ENVIRONMENTAL GOVERNANCE — Governance relates to the sets of formal and informal rules that determine actions in the public realm (Hyden *et al.*, 2004). It is a term that encompasses the interactions of several political actors, which include the government, non-governmental organizations, businesses and local communities (Lemos and Agrawal, 2006). In the arenas of global policy and international financial aid, governance has institutionalized as a guiding principle of development efforts, implying increased social justice in comparison to centralized government regimes, due to its intrinsic democratic structure (Graham *et al.*, 2003; Batterbury and Fernando, 2006). As such, the United Nations Development Program (UNDP) has defined governance, as well as some principles to guide its development:

> *"…governance can be seen as the exercise of economic, political and administrative authority to manage a country's affairs at all levels. It comprises the mechanisms, processes, and institutions, through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences. Good governance is, among other things, participatory, transparent, accountable, effective, equitable and it promotes the rule of law. Good governance ensures that political, social and economic priorities are based on broad consensus in society and that the voices of the poorest and the most vulnerable are heard in decision-making over the allocation of development resources" (United Nations Development Program, 1997: 1).*

Environmental governance arose from the idea of governance but explicitly looks at different arrangements between policy, economics, society and the environment for the achievement of environmental sustainability (Batterbury and

Fernando, 2006). Lemos and Agrawal (2006) define environmental governance as a set of “interventions related to modify environmental regimes, incentives, decision making, knowledge and institutions” (p. 298). Environmental governance ranges from drafting regulations to establishing new schemes of increased participatory social and political organization, aimed at solving pressing socio-economic and environmental issues. A key basis for environmental governance are the links between environmental quality and socio-political factors, for example, the strong relationship between increased poverty, increased socio-economic disparity, and decreased environmental quality observed under certain capitalist economies and corrupt governments (Batterbury and Fernando, 2006).

Traditionally, analyses of environmental governance have centered on which of the three main actors - the state, markets, or communities - would be best equipped to address the negative externalities inherent in the use of natural resources or in the use of the commons (Agrawal and Lemos, 2007). For example, community-based natural resource management has been endorsed based on the assumption that communities in a given locality can more effectively and equitably manage their resources since they have a greater interest in their sustainable use than does the state or distant corporate managers plus they know the intricacies of local ecological and socio-political processes (Brosius *et al.,* 1998; Agrawal and Gibson, 1999).

Currently, an understanding of the great complexity of environmental management issues, and a trend towards a more decentralized government have led to the notion that a single actor cannot resolve all environmental issues. Integration across hierarchies of governance and across actors has been promoted with the hope that one actor will cover the weaknesses of another. Agrawal and Lemos (2007) call the governance regimes that come out of this integration as "hybrid governance regimes". The "promise" of hybrid governance regimes is that synergies between different actors can create opportunities for learning and adapting and thus the possibility for finding balanced decisions and policy changes that take into account perspectives from all groups (Bebbington and Bury, 2009; Gunningham, 2009; Lockwood and Davidson, 2010). Integration among actors can take different forms: co-management, public-private partnerships (e.g., concessionary partnerships) or private social partnerships (e.g., payments for environmental services) (Agrawal and Lemos, 2007). Key to hybrid forms of environmental governance is that there should be clear allocation of responsibilities to the different actors and the goals of environmental protection and human welfare must be in the forefront of the arrangements (Lemos and Agrawal, 2006).

Skeptics of the idea and implementation of different forms of environmental governance have raised some valid points that caution against idealizing environmental governance. The main points of contention include the potential for increased privatization schemes for natural resources, fear of greater inequality in access to common goods, the lack of true changes in power dynamics, increased "rent seeking" behavior by decentralized government institutions, and concerns of potential paralysis or slowness in the drafting of necessary and urgent environmental policy reforms (Castree, 2003; Papadopoulos, 2003; Batterbury and Fernando, 2006; Lemos and Agrawal, 2006). Increased privatization and the potential increase in inequality of access to natural resources can derive from the concession of resources by the central state only to powerful private, market, actors (Castree, 2003; Lemos and Agrawal, 2006). Along these lines, one key question about hybrid environmental governance regimes is whether broader participation in environmental governance truly leads to more actors being able to influence policy and environmental outcomes, or if it is just a superficial reconfiguration of the same, hierarchical, power structures (Li, 1999; Ribot, 1999). This study seeks to address this question through a detailed analysis of the hybrid management regime implemented for the Panama Canal Watershed that will help shed some light on the positive and negative aspects of this type of governance as implemented on the ground.

POLITICAL ECOLOGY — My work responds to calls by researchers such as Batterbury and Fernando (2006) for more studies of governance that incorporate analyses across multiple scales of interaction, and the power dynamics arising between government and civil society actors. By scales I mean the different spatial, (e.g., localities and regions), managerial (e.g. projects and strategies) and social dimensions (e.g. local communities and government institutions) that are involved in the multi-scalar management of natural resources. In a multi-scalar governance regime there is "vertical interplay" among these different scales, which can be balanced or highly asymmetrical depending on the power dynamics at play (Cash et al., 2006).

I employed a political ecology framework in this study because this discipline has brought to the forefront of socio-environmental studies the multi-scalar nature of environmental issues and the dynamics of power that emerge among socio-political actors (Blaikie and Brookfield, 1987; Robbins, 2004; Peet and Watts, 2004). The work by Blaikie, in 1985, and by Blaikie and Brookfield, in 1987, linked the classic approach of cultural ecology to poverty leading to environmental degradation, with the role that politics and economics play on those issues. As such, Political Ecology arose as a discipline that focuses on broader politics and economics as the core of environmental issues (Bryant, 1998). For example, a classic focus of Political Ecology research is on degradation of the environment but not as a deterministic outcome of the use of the "commons", but rather an outcome of larger political contexts (Peet and Watts, 2004). Along those lines, it lifts the blame for environmental degradation from the rural poor and places it into a larger and more complex context.

Robbins, (2004) in his book*: "Political Ecology. A Critical Introduction"* mentions that Political Ecology research is generally based on one or more of the following theses. The first one is a critical analysis of socio-economic and political contexts leading to marginalization of rural or poor people as root causes of environmental degradation. Secondly, the control of natural resource use by government or other elite groups that limits local community users of the resources in the name of conservation or sustainability, under a basic Malthusian view of environmental degradation. The third thesis has to do with the social conflicts that arise over natural resource management and ownership. A last thesis is that of environmental identity and the social movements that arise as management regimes are changing. This thesis highlights how critical social processes such as identity, culture and ethnicity are grounded in how people make a living and their environment.

Environmental issues arise not only from tangible changes in environmental quality, but from socio-political narratives (Hannigan, 2006). Actors become powerful as they dominate certain knowledge regimes, such as the scientific, which prevails over local knowledge in our Western value system (e.g. Robbins, 2000; Adams and Hutton, 2007). This realization, within the field of Political Ecology, led to the rise of a strand of Poststructuralist Political Ecology, based strongly on writings by Foucault, and pushed forward by authors such as Arturo Escobar (e.g., Escobar, 1995; Escobar, 1999), Richard Peet and Michael Watts (e.g., Peet and Watts, 2004). The basis is in the study of "knowledge, power and discourse" (p. 20), this work emphasizes the role of human agency beyond underlying political institutions, and social structures (Peet and Watts, 2004). Post-structural political ecology looks at discourses held by different actors involved in a given environmental issue, as the tools actors use to "construct" the environmental issue based on given knowledge bases, understandings, cultures and/or political agendas (Escobar, 1999). This approach recognizes the importance of discourses as vehicles humans use to gain power over one another, and thus the integral part they play in the study of human interactions and culture (Escobar, 1995). I use a post-structural political ecology approach to my research by looking at core narratives held by the main actors involved in the Panama Canal Watershed Integrated Watershed Management regime as they allow me to understand power dynamics among them. Narratives shed light into how actors gain or maintain influence, and legitimacy over other actors, and also how less powerful actors struggle to maintain certain agency over decisions.

Environmental governance in the Panama Canal Watershed clearly constitutes a politicized environment. The different actors are "brought" together by the ACP around concern over water conservation in the Panama Canal Watershed. However, as they come together power dynamics arise among them within the governance structures created under the regime, namely the Watershed Committees and Consultative Councils. My work contributes to the field of Post-structural Political Ecology as I look critically at the sustainable development discourse that permeates from international development players, such as USAID, down to regional government institutions, such as the Panama Canal Authority. Under the knowledge of a potential "water scarcity", the ACP obtains a "right" to manage the water resource (Robbin's second thesis). On the other hand, I look at narratives of members of the local communities to assess their agency as they dance between passively accepting the recipes preached upon them by the sustainable development discourse, and actively becoming agents of their own development (Robbin's third thesis).

I situate the gathered narratives in the context of the meta-discourses described by Bäckstrand and Lövbrand, (2006) as being the ones that underpin most academic and policy debates on environmental governance. These discourses are:

"*Environmental modernization"*, a discourse based on two key approaches, the first one is a market approach that makes economic growth compatible with environmental protection, and the second one is a technological optimism that asserts that humans can resolve current environmental problems with technological fixes; "*Green governmentality",* which closely links government with the prevailing scientific understanding of environmental problems; "*Civic environmentalism"* that relates to improving "environmental multilateralism", by which all the groups who have a stake in a given issue should have a voice in finding solutions. Placing the observed narratives from the Panama Canal Watershed in the context of these global discourses is important, because these global discourses are affecting how people perceive environmental problems and therefore which solutions to environmental issues become the norm among international aid agencies and national governments regardless of local realities.

BACKGROUND

GEOGRAPHIES OF THE CANAL WATERSHED — The Panama Canal Watershed is located in the central part of Panama (between 8°40' and 9°30' N and 79°14' and 80°08' W) and covers 339,639 hectares which represents 4.5% of the national territory. The Canal Watershed receives an average of 2,591 mm of rain per year. The climate is tropical with a mean annual temperature of 26.5 °C and high humidity. The watershed has 47 main sub-watersheds that feed the Canal, with the most important being the rivers Chagres, Gatun, Boqueron, Pequeni, Ciri Grande and Trinidad (CICHb, 2008) (Figure 3-1).

Around 40% of the watershed is comprised of alluvial plains, which have been very productive for cattle ranching and agriculture. The extensive land area of the watershed is under various types of management and land uses. Currently, forests cover roughly 47% of the watershed, and an additional 15% of the watershed is covered by abandoned pasturelands or shrublands. The remaining area is comprised of active agricultural lands, extensive cattle pasturelands, and urban sprawl. Most of the remaining tree-cover is in areas designated as national parks (ACP, 2008).

Due to its geographical position, during pre-colonial times the Panama isthmus was used as a bridge for migration and goods exchange between the Atlantic and Pacific oceans. Around this time, the cities of Gorgona and Las Cruces were founded in what today forms the Eastern part of the Canal Watershed (Pinzon and Estuarin,1986; McKay, 1984). During the gold rush era, between 1850 and 1855, building of the railway brought further colonization into that part of the watershed. Later, with the construction of the Canal, between 1880 and 1915, population increased (McKay, 1984; Pinzon and Estuarin, 1986).

Today, the Panama Canal Watershed is home to around 432 human settlements, spread heterogeneously between two Provinces, Panama and Colon. The two most important cities in Panama, Panama City and Colon, are located in the Eastern part of the Canal Watershed. These two cities comprise the axis of development of the Panamanian economy (McKay, 1984). As has happened throughout Latin America, the increase in capitalist investment around major cities created waves of immigration from rural areas into the city. Approximately 80% of the watershed population resides along the Transismica road, between Panama City and Colon (Diaz and Cerrud, 1986; ACP and USAID, 2002). In the last 50 years, the population along the Transismica corridor has quadrupled from 22,000 in 1950 to 144,042 in 2000 (CGR, 2001 *cit*. CICH 2008).

The Western areas of the watershed have received mainly immigrants coming from the interior of the country and indigenous Embera people from Darien (Heckadon-Moreno *et al*., 1999, Heckadon, 1986, McKay, 1984). These immigrants utilized the land mainly for swidden agriculture, which involves a rotational system of fields that are cleared and planted for a period and then left fallow for another period, and cattle farming (Heckadon, 1984, 1986a, 1986b). Today, the western part of the watershed is dominated by these two human land uses, along with some large commercial pineapple plantations, palmito palm operations, and chicken farms. Population is more scattered across the landscape than in the East (Personal observation).

HISTORY OF ENVIRONMENTAL GOVERNANCE OF THE PANAMA CANAL WATERSHED — When the United States managed all Canal operations, it strictly regulated the land uses allowed inside the Canal Zone (a 10 km buffer area along the Canal) and around the main water reservoirs. A special "rural police corps" patrolled those areas closely and enforced the regulations. This led to very low deforestation rates inside these areas (Pinzon and Estuarin, 1986). On the other hand, in areas outside of US jurisdiction, the Government of Panama allowed the construction of roads and relatively anarchic land occupation. The law of familiar patrimony of 1941 and the law of 1942 about settlement of "latifundios" or "haciendas" (farm estates) supported cattle ranching. These laws gave peasants title over pieces of land and eased credit lines through financial organizations (McKay, 1984; Heckadon, 1986).

The Torrijos-Carter Treaty of 1977 established the return to the Government of Panama of all Canal operations, and thus the duty to protect the water resources in the Panama Canal Watershed, by the year 2000. That same year, increase use of water resources by Canal operations, population, and agriculture, plus a severe drought significantly reduced the water level of Gatun Lake. This led to strong reactions within the Panamanian and United States Governments of the need to increase management of the Canal Watershed for water protection; a radical change in the perspective of the Government of Panama, who previously saw deforestation as progress, and now as a crime. A key actor of this change of perspective was the forester Dr. Frank Wadsworth, who held strongly that water shortages were the direct result of deforestation by "shifting cultivators", and stated that the "solution to maintaining the Canal's capacity lied in the forests" (Wadsworth, 1978 *cit.* Carse, 2012). With his perspective, and his narrative of "water scarcity" and the "death of the Canal", he triggered intervention of the state in managing the Panama Canal Watershed for water conservation (Carse, 2012).

In 1979, INRENARE (Instituto de Recursos Naturales/Natural Resources Institute), currently ANAM (Autoridad Nacional del Ambiente/National

Environmental Authority), initiated a USAID funded reforestation plan for the watershed. That year, the US Government created the Panama Canal Commission to manage the Canal operations, the Canal Zone and the Watershed. During the 1980's, under Noriega's government, enforcement of laws to protect against deforestation became strongly enforced by the Panamanian army. A policy called "Forest Law 13" legally protected second growth forests older than 5 years. Many people in the watershed went to jail for practicing swidden agriculture, which previously they had been entitled, and even encouraged to do (Pinzon and Estuarin, 1986). This points toward a change in how the Government of Panama "conceptualized" forests, and the big implications of this change on rural people's livelihoods and cultural relation to the land (Carse, 2012).

The coercive enforcement of the Forest Law disappeared after Noriega's government. In 1997, the Panamanian Government created an agency, the Autoridad del Canal de Panama (ACP), to take over the duties of the Canal Commission. Most of the structure, rules, and regulations of the Canal Commission were adopted by the ACP, and this agency began emphasizing local participation in water protection. This represented another milestone in the perspective changes over water management, to which the local communities are expected to abide to.

Aside from the ACP, many other government and non-governmental institutions are present in the watershed. The different districts have their own local governments and branches of the different ministries, ANAM, various local and national religious groups, organized civil society groups and non-governmental organizations (Heckadon, 1986b, Guerra Reyes, 2006). In addition, the US Federal Government continues to support the Government of Panama and the ACP in the form of technical and financial aid via the USAID.

To better coordinate the efforts of all these actors, the ACP created the "*Comision Interinstitucional de la Cuenca Hidrografica (CICH)*" (Interinstitutional Commission for the Panama Canal Watershed). The CICH brings together eight government institutions and two NGOs (Figure 3-2). These institutions meet monthly in the Permanent Technical Committee, which is the inter-institutional coordination core of the CICH in charge of decision-making. Six additional entities join the CICH in the Expanded Technical Committee, which supports the actions of the Permanent Technical Committee (Figure 3-2). Since 2001, the CICH, with financial and technical help from USAID, has undertaken a process of planning and management of the sub-watersheds considered of top priority for the conservation of the Canal (CICH, 2007).

The main outcome of this planning process was the Integrated Management Plan for the Watershed (*Plan de Desarrollo Sostenible y Gestion Integrada de los Recursos Hidricos de la Cuenca Hidrografica del Canal de Panama: DS-GIRH*) drafted in 2008. The five action lines in the DS-GIRH are the conservation, protection, and monitoring of natural systems and water resources; the consolidation of urban development plans; the transformation and strengthening of sustainable production systems; the modernization of the state (governance and transparency); community strengthening, and infrastructure development. The execution of the DS-

GIRH is supervised by the team for Interinstitutional Coordination of the CICH, who must guide all members of the CICH in what to do with the funding they have designated for the watershed (CICHa, 2008).

The USAID defined Integrated Watershed Management as an inter-institutional effort, which requires all relevant actors in the watershed to be involved in decision-making - " *energies of local residents would be directed to issues meaningful to them…the issues would be relevant and the solutions would not only protect natural resources Watershed but would also direct improvements to local standards of living and quality of life* " (IRG, 2002: 21). This approach follows prevailing international discourses regarding development objectives that meet environmental, social and economic needs, and also involves the local residents as actors actively involved and responsible for water management (Carse, 2012). This is an important reason why USAID has supported the implementation of this Integrated Watershed Management Regime in Panama. Since the UN Conference for Environment and Development (UNCED) in 1992, these development objectives are increasingly recommended to governments in developing countries (Busch *et al.*, 2005).

To achieve the goals of the DS-GIRH, the CICH developed a multi-scale governance regime that begins at the local scale with the creation of the Watershed Committees (Figure 3-3). To create these local institutions, the CICH divided the Watershed into seven regions, based on hydrologic, environmental, cultural and socio-economic criteria. Within each region, the CICH adopted a sub-watershed geographic focus, given additional bio-physical and socio-economic differences between sub-watersheds within a region. Each sub-watershed was further divided into the upper, medium and lower part of the river (CICH, 2007). Between 2001 and 2003, the ACP, as the designated CICH member in charge of implementing the DSGHIR, began organizing the local communities of each sub-watershed part into local governance bodies called Watershed Committees (Watershed Committees). The idea of the CICH is that members of the Watershed Committees will represent the voice of their communities regarding socio-environmental concerns -*"The Watershed Committees are autonomous coordination bodies for the socio-environmental management of the Canal Watershed, organized under criteria of water planning"* (CICHb, 2008: 12).

For the initial formation of the Watershed Committees, the ACP visited the different communities, and invited members of established Community Based Organizations to be part of the Watershed Committees. Community Based Organizations are, for example, church groups, parent associations, health committees or rural aqueduct committees (Figure 3-3). The ACP capitalized on the existing Community Based Organizations because they believe that these organizations represent a local and pre-existing platform on which to build further actions of sustainable development (CICH, 2007). The Watershed Committees are formed by 28 to 30 community members. Three community members hold the main managerial positions of President, Secretary and Treasurer, for one year, with the possibility of re-election. They meet on a monthly basis to discuss environmental issues, projects in the area, fund raising activities, and plan which issues they will communicate to regional government authorities at Consultative Council meetings.

The next scale of environmental governance, the regional scale, is the Consultative Councils (Figure 3-3). Consultative Councils are a regional governance body that brings together regional and local offices of the different governmental institutions that have stakes in the Panama Canal Watershed, with all the Watershed Committees from one region of the watershed. The Councils were established in the DS-GIRH based on social and cultural criteria, similar socio-economic profiles, proximity to protected areas, and access to basic services. This resulted in five Councils, which bring together two or more sub-watersheds, in other words, six or more Watershed Committees. Local non-governmental organizations and the members of the private, productive sector can participate in these Councils.

In their 2007 project report, the CICH summarized well the role of the Council as an *"entity to facilitate the coordination, participation, communication, consultation, and harmonization of projects and policies between the actors of the sub-watersheds, with regards to the conservation, sustainable use and recovery of their natural resources, emphasizing the water resource"* (CICH, 2007:34). The CICH established that the Consultative Councils would be guided by the following governance principles: autonomy, participation, coordination, communication, compromise and integration of all actors. This quote from one of my key informants nicely summarizes the main idea behind Consultative Councils:

> *"Sometimes people in the region come all the way to Panama City to bring up a given problem when they have local authorities that they can talk to. The idea is that in the Consultative Council the community can meet the local branches of the authorities and coordinate solutions"* (Fernandez, T., CICH secretary, June 28 2010).

The basis for the work at the level of the Consultative Council are the Management and Action plans drafted by the Watershed Committees during environmental assessments and prioritization exercises conducted with the ACP. The Councils meet every three months, but there are permanent Working Groups organized around specific thematic areas (e.g., environment). Three elected members from the Watershed Committees hold the main managerial positions at the Council (President, Secretary and Treasurer) for one year without possibilities for re-election. Active members of the Consultative Councils elect the people who hold these managerial position and elections happen during Consultative Council meetings. Other Watershed Committee members represent private productive sectors and they give reports to the Council regarding their Thematic Working Groups (Figure 3-3). These reports range from projects conducted to visits to environmentally problematic sites (Participant observation, Consulative meeting Ciri Grande-Trinidad, August 2010 and August 2011).

Watershed Committee members lead the Council meetings. Other community members are present at the Councils but only as observers. In addition, officials from the local branches of government provide information to the community regarding the status of projects or to answer petitions for the resolution of issues (e.g. building of a road). Around five to seven government officials were present during the meetings I attended. CICH and ACP staff are also present at the meetings. They give presentations regarding projects conducted by them and are there to answer any question from the community (Participant observation, Consulative meeting Ciri

Grande-Trinidad, August 2010 and August 2011). The Permanent Technical Committee and the Expanded Technical Committee of the CICH, described before, represent the national governance scale of this Integrated Watershed Management Regime (Figure 3-3).

Summarizing, the multi-scalar configuration of the Panama Canal Watershed Integrated Watershed Management regime begins with the local communities organized into Community Based Organizations (Community Based Organizations). Another scale is composed by the Watershed Committees to which members of the Community Based Organizationss belong. A higher scale is constituted by the Consultative Committees, in which several Watershed Committees join local and regional government entities to find solutions to pressing socio-environmental issues. Finally, the higher scale of governance is the Interinstitutional Committee of the Watershed (the CICH), to which national level government entities, such as ministries, and the ACP belong.

METHODS

My research addresses two central questions of the study of hybrid governance regimes from a political ecology perspective: 1) what are current aspects of this integrated management regime that signal a truly multi-stakeholder influence over policy, social and environmental outcomes, and what are still some challenges to achieve this?, and 2) what are the prevailing power dynamics among the main actors that may prevent or promote a more equal distribution of power?

To approach these questions I focused the research at two levels of analysis, which allowed me to look in detail at the interactions among the main actors of this governance regime: the local communities and the Panama Canal Authority. The first level was institutional and the second one at the level of individual actors. At the institutional level I analyzed the structure, functioning, and interactions among actors of the Integrated Watershed Governance regime constituted in Watershed Committees, Consultative Councils, and the ACP/CICH. Individually based interviews with members of the Watershed Committees and with ACP staff formed the second level of analysis, which allowed more in-depth communication with the actors when they are not interacting at the institutions. In addition, individual interviews gave me information about socio-economic status, perceptions, and attitudes toward the governance regime in place.

This study is based on sub-watersheds, since this is the basic level of this environmental governance regime. The work was conducted with the watershed committees of the following river sub-watersheds: Chilibre and Chilibrillo, in the Eastern side of the Canal, and Trinidad and Ciri Grande in the Western side (Figure 3-4). These four rivers were chosen as samples because the communities in these areas represent a good contrast between rural and peri-urban communities. The first two rivers are located along the Transismica road, thus the land is greatly urbanized, with most of the population working in Panama City or Colon. On the other hand, the rivers Trinidad and Ciri Grande are surrounded by land used for cattle ranching, subsistence, swidden agriculture, commercial coffee, palmito, pineapple, and poultry operations.

To address the main questions of this research I employed a mix of quantitative and qualitative methods. I conducted semi-structured interviews with Watershed Committee members, in-depth key informant interviews and participant observation at Watershed Committee and Consultative Council meetings. I also used the results of a survey administered by the consulting firm: Tetratech, in 2010. This agency had been contracted to assess the human capital present in the Watershed Committees from the Eastern side of the Watershed, thus many of their results were informative for my questions. This multi-method approach is referred to as "triangulation" and allows for the corroborating of results (Fontana and Frey, 1994). The employment of a mixed-methods approach has been called upon for studying and understanding newer forms of governance such as multi-stakeholder or hybrid environmental governance regimes (UNDP 2002, *cit.* Batterbury and Fernando, 2006). A conjunction of methods allow rich data to be obtained, such as accounts of how formal structures of governance are seen, used, ignored or modified by the different actors involved in them (Baterbury and Fernando, 2006).

SEMI-STRUCTURED INTERVIEWS — I conducted semi structured-interviews to gather information about Watershed Committee members. I conducted non-probability purposive sampling (Bernard, 1994), based on participation and attendance in Watershed Committee meetings and activities, to select the interviewees. This sampling was deemed appropriate for the purpose of the study, since more active members structure and define the functioning of the Committees and can frame the interaction of the communities with other actors.

During the months of July and August 2010, I conducted a total of 25 face-to-face semi-structured interviews with active members of Watershed Committees. Fourteen were completed in the sub-watersheds of the rivers Chilibre and Chilibrillo, on the East side of the Panama Canal Watershed, and 11 in the sub-watersheds of Ciri-Grande and Trinidad, on the West. I conducted 60% of the interviews during Watershed Committee meetings, and 40% in people's homes and during Consultative Councils. In addition, the consulting firm, Tetratech, administered 73 survey questionnaires in Chilibre and Chilibrillo during a capacity building workshop in which I participated.

The semi-structured interview was drafted following a livelihood conceptual approach. The concept of livelihoods is defined as "comprising people, their capabilities and their means of living (e.g. food, income and assets) " (Chambers and Conway, 1991). The interview questionnaire contained, both, quantitative and qualitative questions (Appendix 3-1). Quantitative questions were geared toward assessing the socio-economic profile of interviewees so as to characterize their livelihoods based on their natural, social, economic, human and physical assets (Scoones, 1998).

The qualitative questions were geared toward assessing positive aspects and challenges of the environmental governance structure in place as perceived by the communities. Questions addressed the role and functioning of the Watershed

Committees and their relations to the ACP and to local government actors, community visions for the future of the watershed and the governance regime, and socio-environmental awareness. In addition, open-ended questions were geared toward finding prevailing discourses that would inform me about power dynamics, and struggles between community members and other actors (especially the ACP). Discourses are “story lines” by which actors create a narrative of the “social reality” based on how they see it or on common understandings among actors, which allows them to make “alliances” in order to gain more power for their position (Hajer, 1995). By prevailing discourses I mean those narratives on common themes that appeared repeatedly on the interviews. I identified the common themes and coded responses based on those (see Data Analysis section). Semi-structured interviews lasted 30-60 minutes. Interviews were hand-written on prepared questionnaires and transcribed.

KEY INFORMANT INTERVIEWS — My key informants were two active members of the Watershed Committees of Chilibre and Chilibrillo, one member of Ciri Grande and Trinidad Consultative Council, three ACP field staffs and two actors at higher decision-making spheres within the ACP/CICH: the secretary general of the CICH (Tomas Fernandez) and the director of the Social Team (Amelia Sanjur).

Key informant interviews were conducted on a one-to-one basis, and were open-ended to leave room for the respondent to vary its response (Margoluis and Salfsky, 1998). These interviews lasted between one and two hours, and I recorded and transcribed all of them. Key informant interviews allowed me to gain in-depth understanding about different actors perceptions and understanding about the governance structure and function of the Watershed Integrated Management Regime. In addition, key informant responses contained the main narratives each actor (communities and ACP) utilized to push forward their own agenda within the framework of the Panama Canal Watershed Integrated Watershed Regime.

PARTICIPANT OBSERVATION — I conducted participant observations during Watershed Committee and Consultative Council meetings. During meetings I was able to meet people, record how many people, and who attended the meetings. In addition I documented activities conducted, decision-making processes, and hierarchies among actors. In this way, through participant observation I registered contested issues and challenges at each governance scale that did not come through in the interviews. Thus data from participant observation at meetings allowed me to enrich and cross-check the results of the semi-structured and key informant interviews. I participated in seven Watershed Committee meetings, three in the West and four in the East, and in three Consultative Council meetings, as well as in two capacity building workshops. I recorded the meetings and wrote notes on activities conducted, actors' interactions and issues raised.

DATA ANALYSIS — Qualitative responses were coded and then grouped based on the following hypothesis driven categories: *respondents context* (e.g. membership in community based organizations and status on the Committee)*, perspectives about the watershed and the community, environmental awareness,* and *environmental governance.* Coding was conducted following the methodology suggested by Huberman and Miles, (1994) to derive meaning and understanding of qualitative data.

The approach begins by noting patterns and themes to cluster responses by conceptual grouping, then to count the answers in each group to see what is there and make contrasts and comparisons between observations.

I analyzed responses to open-ended questions in the semi-structured and key informant interviews for recurrent narratives held by the different actors, which I organized based on similarities. This allowed me to find areas of agreement and disagreement among actors, which highlighted current power struggles. In addition, it allowed me to see differences and similarities between opinions about governance in the Panama Canal Watershed and realities on the ground, that determined which narrative, and thus which actor determined actions on the ground.

Quantitative data on socio-economic variables were analyzed employing t-tests to compare between the peri-urban and the rural Watershed Committee members. All quantitative analyses were conducted using the R statistics software (R-Development-Core-Team, 2009).

RESULTS AND DISCUSSION

HYBRID ENVIRONMENTAL GOVERNANCE IN THE PANAMA CANAL WATERSHED: POSITIVE ASPECTS AND CHALLENGES — During my fieldwork, the governance plan drafted in the DSGHIR was being implemented through a strong focus on capacity building and by promoting community members participation in highlighting environmental and social issues to the local authorities. The focus on capacity building is at the core of ACPs strategy. They believe a key aspect in the adequate functioning and long-term sustainability of this governance structure lies in the recognition, by community members, of the importance of this process, and of environmental problems in the Watershed (Fernandez, T., CICH secretary, June 28 2010).

The ACP has been providing the Watershed Committees with technical and capacity building support so they become more organized, increase their environmental awareness and start "owning" their Management and Action plans for the conservation of the water resource in their sub-watershed (Gomez, ACP staff, August 2011). The ACP views this strengthening process as something continuous; it has been a process that began 10 years ago and has not stopped since. This focus on capacity building is a key component of the narrative of decentralized governance (Lemos and Agrawal, 2006), but also one that aims to "depoliticize" government development interventions (Matthews, personal communication). Via the capacity trainings the ACP tries to increase the efficacy of government responses to priority areas of socio-environmental concern for the community:

> *"The idea is not to duplicate efforts and also to help the communities learn how to prioritize the problems to be solved, so as to render a more efficient outcome. For example, the community might want another classroom in their school, but under a closer look one sees that they do not need one given the number of students, so the CICH tries to make the community understand that it is not a priority and they should focus their efforts around other issues that are more pressing"* (Fernandez, T., CICH secretary, June 28 2010).

A staff member of the ACP considers these capacity building efforts to be very positive since there are currently groups in the watershed who understand the concept of watershed, who are conscious about the environment and who can now recruit more people to the process (Gomez, ACP staff, key interview, August 2011). The concept of “watershed” can be something rather new to many inhabitants of the Panama Canal Watershed (Carse, 2012). Authors Agrawal and Lemos (2007) believe this to be a successful governance strategy because it focuses more on changing environmental attitudes through education and less on changing behavior based on economic incentives.

My interview results corroborate Gomez view that this effort on capacity building has been effective at raising environmental awareness among the participants. Interviewees had a very positive attitude and perception toward the formation of the Committees and the knowledge acquired in the capacity building workshops. Most (68%) answers related to the importance of being organized and the knowledge acquired through the workshops. In the words of an interviewee:

> *“I have learned a lot about the environment. I have learned to respect things I did not do before such as trees”* (Chilibrillo, Watershed Committees member, August 2010).

When people were asked about changes they had seen in the watershed through time, 66% agreed that environmental quality had diminished, especially in relation to forest cover. The vast majority (72%) related watershed conservation with the protection of water sources and forest cover. Both sides of the watershed agreed that in order to protect the quantity and quality of the water that runs to the Canal, the forest cover must be protected. When interviewees were asked about the land uses they would like to see in the Panama Canal Watershed responses showed a high degree of environmental education and awareness. The best use mentioned by 65% of the interviewees was ameliorating current agriculture uses through the reduction in agrochemicals and the introduction of agroforestry systems. It is interesting that only 15% of the interviewees, and all of them from the Eastern side, mentioned forests for strict conservation uses as an option. This shows that most people want to see projects that are win-win situations, where conservation and economic needs are met.

Communities' active participation in raising socio-environmental concerns to local authorities was accomplished by the cross-scalar nature of the governance structure in place. Beginning with the local, sub-watershed scale, the creation of the local Watershed Committees

> "*serve as a point of encounter of the different, already existing Community Based Organizations's and serve as a bridge to connect them with local government entities in charge of answering community issues and environmental problems"* (Arauz, A., ACP field staff (at the time of this interview he was a USAID contractor), July 2010).

The most commonly mentioned Community Based Organizationss to which my interviewees belonged were related to the Church in some way or another. In the East, interviewees also belonged to Family Committees (these are organized by a church around social issues such as education or health) and to an organization founded by Committee members called "Community Organization for the Human Sustainable Development (OCDHU, in Spanish)". In the West, members belonged to Unions of Agriculture Producers and to Health Committees.

At the time of this work, the Watershed Committees in the West had been active for six years without interruption, and had well-established, one-year old Consultative Councils. Eastern Committees were in the process of re-activation since their membership had dwindled for the past three years. As I was in the field, the

ACP hired the consultant agency IRG to aid in implementing workshops aimed at reorganizing the Watershed Committees for Chilibre and Chilibrillo and to form the Consultative Council for these two river watersheds.

Reasons for this reduction in membership on the East were attributed mainly to lack of projects (Chilibre interviewee), and lack of people's free time (Gomez, personal communication). My personal observation was that the West had more projects than the East. For example, at the time of the interviews, in August 2010, Watershed Committeess in the West were discussing their participation in at least two different projects (construction of energy-saving stoves, and ACPs payment for environmental services). In the East, I did not document an active project at the time of my data collection (Personal observation). The fact that most people in the Ciri-Trinidad area are self-employed in agriculture or cattle-ranching means they have more flexibility to meet in the Watershed Committees and Consultative Councils. People in the East, who work for a salary, can only meet during nights or weekends (Gomez, interview). I observed the need for strong presence of ACP staff at the meetings in the East so as to maintain the interest and the cohesion of community members in the process.

In the next hierarchical governance level, the Consultative Councils, elected Watershed Committee members are organized in teams by thematic environmental areas. Each working team must present their quarterly achievements to the Council. I was able to observe the development of the Consultative Council in the West over a 1-yr period (Council of the rivers Ciri-Trinidad, July 30 2010 and August 5 2011).

Community members lead the Council the entire time, while government officials and ACP staff listened and presented advancements of projects. This observation meant to me a true ownership of the governance process by the communities. It showed me that the platforms of communication among communities and government actors created by the Watershed Committees and Consultative Councils are achieving the purpose of empowering the communities to speak to their government representatives and, potentially, this will exert more pressure to have their infrastructural and service needs meet.

In addition, within a year, the presentations conducted by community members showed an increased level of awareness about the environmental issues to be solved, and paths to the solution. For example, in Ciri and Trinidad, the team for Environmental Education realized that involvement of communities, as a whole, was needed to reach the Management Plan objectives. Therefore, it had been conducting information campaigns about the Action and Management Plans at all levels of the community, from schools to productive cooperatives. In addition, there appeared to be an increased level of commitment to the process by some local government institutions as observed in their presentations of projects executed. An official of the Ministry of Infrastructure Development, for example, presented all the financial and timeline details for the execution and completion of roads in the area, whereas in 2010, interventions of government officials were limited to informal responses to issues raised by the community. This observation differs from Carse (2012) report on slowness of the Government of Panama in responding to infrastructure needs in the

Panama Canal Watershed related to the change in Government of Panama's perception of the Watershed from an agricultural frontier to an area where forests need to be conserved and enhanced.

THE CHALLENGES — One of the challenges I observed with implementing this governance regime was that local and regional branches of the governmental entities participating in the Consultative Council usually lacked the power to respond to the problems brought up by the communities. A similar problem with a decentralization initiative in Indonesia was observed by Ribot, (1999), where the local authorities take note of the community issues and then these problems should move to the higher level, the ministers at the Permanent Technical Committee of the CICH. Unfortunately, I could not gather information on the extent to which this was happening.

The lack of decision-making power in the local branches of government is still due to the centralization of the public economic resources. This has been called the "challenge of plurality" by Cash *et al.*, (2006), which refers to trying to accommodate the perspectives and agendas of all relevant actors, at the central and local levels, that participate in a hybrid governance regime, but with the central government still trying to maintain control. In the case of the Panama Canal Watershed,

> "*the institutions have their budget given by the state, but it does not specify actions or amounts for the Panama Canal Watershed …Until the State assumes the conservation of the Panama Canal Watershed as a matter of State, the actions by the ACP will be very weak and challenged"* (Gomez J., ACP staff, August 03 2011).

The ACP maintains communication with the Ministers of the various governmental agencies to inform them of what actions their agencies must prioritize for the Watershed. As Fernandez, Secretary General of the CICH, pointed out:

> "*We are trying to sensibilize the institutions around the issue of water: people need water. We also help the institutions channel their funds adequately by showing them what the communities already pointed to as their more pressing issues. We, in the CICH, are not interested in getting votes or achieve a given political position, so we can be more neutral and more objective as to what communities really need" (*June 28 2010).

The quote above speaks of the ACP as a politically neutral government institution, which allows it to approach government agencies with the sole focus being solving pressing socio-environmental issues that affect water conservation in the Panama Canal Watershed, and not guaranteeing votes in the next electoral cycle. The ACP, with its organizational structure inherited from the United States, allows staff to make a career within the agency. Therefore, ACP's staff does not depend on election results to hold their positions and they can be apolitical. On the other hand, staff in government agencies tends to place their actions around issues that are going to mean votes for them in the next election. For example, a basketball court may be built over a water sewage system, if the former means more votes. Cash *et al.,* (2006) calls this issue the problem of temporal-scale mismatch, by which "electoral cycles are too short to meet the long-term goals of environmental planning" (p. 4). The ACP functions as what Cash *et al.,* (2006) call a "boundary or bridging " organization that can talk across all hierarchical governance scales and hold the structure together.

Involving government authorities is currently one of the main challenges the ACP is facing. As noted by Nora Haenn (2005), sustainable development may be too innovative for classic state political structures, thereby only playing a marginal role in political actions. It remains to be seen whether the current sustainable development narrative in the Panama Canal Watershed, truly becomes a dominant discourse, overcoming "the challenges at the intersection of development, environment and governance" (Haenn, 2005: p. 173). Multi-stakeholder governance arrangements do not resolve inter-institutional conflicts over power, mandates, and responsibilities (Li, 1999; Haenn, 2005). In the words of one of ACP's staff members:

> *"The ACP was given as a constitutional mandate the immense task of conserving the water resource in the Panama Canal Watershed in quantity and quality, but was not given the power to draft regulations, laws or other instruments to execute the mandate... What we want to achieve is the understanding that both sides are responsible of solving the issues. That the community cannot wait and expect all to be resolved by the government, but that the government understands the importance of the watershed for all of Panama"* (Gomez, J., ACP staff, August 03 2011).

Getting support from the authorities in the governance process is key for the ACP as most actions to execute the DS-GIRH lie in the hands of other institutions. The ACP only conducts certain types of projects like reforestation, payment for environmental services and capacitation workshops. One issue brought up by Janet Gomez (ACPs staff) is that in some cases there are communities that have not had their basic needs met, lack of potable water for example, but institutions lack the power to address those needs because they do not have the budget. The following quote exemplifies this issue,

> *"A small community needed maintenance of their rural aqueduct. The Health Ministry is the institution in charge of maintaining rural aqueducts; however, they said they lacked the equipment to clean the filters. The Water Management Institute (IDAAN) had the equipment, however, their constitutional mandate states they can only serve populations of over 1500 people, thus this does not include most rural communities. The people were drinking dirty water and the*

institutions could not resolve the issue…" (Gomez, J., ACP staff, August 03 2011).

The above-mentioned challenge relates to the next one I observed. Even though interviewees liked the capacity building emphasis of the ACP, they also expressed frustration. They would like to see more socio-environmental projects in their communities, rather than just capacity building. These communities' still face challenges in meeting their basic infrastructure and service needs and having these needs solved is their main priority. On the East, which is the peri-urban area, almost 16% of the interviewees identified issues with black and gray water management and garbage recollection as their main problems, followed by lack of environmental education. On the West, the rural area, 23% identified the absence of appropriate roads and other infrastructure as their main challenge, basically to transport their products to markets.

Lack of projects was identified by 36% of the interviewees as the main challenge Committees face, because it leads to people losing interest in the governance process. In the words of an interviewee from the East:

> *" People like fast results, if they do not see them, they become frustrated and stop participating"*(Chilibre, Watershed Committees member, August 2010).

> *"We have been for almost 8 years in this process and still not a single project has come to us, that is frustrating…"* (Chilibre, Watershed Committees member, August 2010).

Less than half of the people interviewed (48%) could identify socio-environmental projects recently undertaken in their localities. In addition, of those projects identified, it was not clear to what extent they came as a result of the new governance structures formed by the ACP or if they would have happened regardless.

For example, two main projects identified in areas I studied where, “Cadena Verde”, a project of community-based tree nurseries funded by USAID in the Eastern side of the Panama Canal Watershed, and construction of efficient wood stoves in the houses of people in the West; neither one of these projects came as a result of the formation of the Watershed Committees, nor were they channeled through them but through contracted NGOs.

Another important challenge observed in this multi-scale governance structure is how to move from the local to the regional scale, without losing strength at the local level. Amelia Sanjur (director of ACPs social team, June 2011) expressed how in some regions the regional level has weakened local participation and action. The leaders of the local Watershed Committees become engaged with the Consultative Councils and stop participating in their sub-watersheds. One reason behind this is that the Consultative Council is where they get organized into working teams and interact with officials (Sanjur, June 2011). Prager (2010) explored the challenges in up scaling community-based resource management systems from the local to the regional. The challenges she found are similar to those felt by the ACP regarding how to maintain local communities’ enthusiasm, engagement, voluntary commitment and action; while at the same time connecting with efficient solutions at both regional and local scales. Maintenance of lower units of governance, such as Watershed Committees, in multi-scale governance systems is important, since they usually involve a higher level of trust among their members than higher levels (Marshall, 2008).

PREVAILING NARRATIVES AND POWER STRUGGLES — As discussed in the previous section, environmental governance in the Panama Canal Watershed is framed under the need to "guarantee the quantity and quality of the water resource in the Panama Canal Watershed" which underlies the premise that water could become "scarce" if not managed well. This narrative appears to be shared by all the actors involved in this multi-stakeholder governance regime. However, I observed power struggles between the communities and the ACP related to the implementation of a governance regime whose mission is to create spaces of community participation.

In the following section I elaborate on my observations about the dominant narrative that framed ACP's Integrated Management Plan for the Panama Canal Watershed and how I believe this approach maintains a top-down power hierarchy. Subsequently, I analyze responses of community members to the current status and development of the Integrated Management Plan, which speak to their struggles in obtaining greater participation and power in decision-making and project execution. I relate differences in the degree this power struggle manifested on the ground to socio-economic differences between the peri-urban East and the more rural West.

ACP's SUSTAINABLE DEVELOPMENT NARRATIVE — As the following quote illustrates, the ACP/CICH follows the "win-win" discourse of sustainable development put forward in global development discussions, when addressing the goals of the Integrated Watershed Regime of the Panama Canal Watershed:

"The Integrated Watershed Management Plan gathers all the needs and problems mentioned by the communities living in the watershed. Because, sustainable management of the watershed cannot be found if people lack an adequate quality of life, if they do not have what to eat they are not going to conserve the water resource.

For that reason, this Plan aims at improving the production areas, infrastructure, health, and education of the people in the watershed" (Fernandez, T., CICH secretary, June 28 2010).

The classic form of this discourse promises that sustainable development will allow achieving, both, economic growth and conservation objectives (Wilbanks, 1994; Bassett and Bi Zueli, 2003). A parallel between the globally agreed-upon discourse on sustainable development and ACPs discourse provides the later with authority to teach people how to meet their socio-economic needs and conserve the environment at the same time.

The main narratives held by the ACP parallel the international environmental, and sustainable development discourses of *Green governance* and *Civic environmentalism* described by Bäckstrand and Lövbrand (2006). *Green governance* closely links government with the prevailing scientific understanding of environmental problems and leaves little room for alternative knowledge systems that could come out of the community (Bäckstrand and Lövbrand, 2006). ACP's narrative frames there is a need to "conserve forests in order to conserve water" otherwise it will become scarce. Interestingly, aside from Wadworth in 1978 and Windsor and Rand, I could not find recent scientific documents that made the link between deforestation and water scarcity explicit. McCarthy and Prudham, (2004) stated how environmental narratives of scarcity are highly disciplinary and technocratic; they confer power and an authoritarian mandate to the actor who manages the "scientific" knowledge that determines scarcity to dictate the "good" environmental practices that citizens must follow. In the case of the Panama Canal Watershed, communities participate in drafting the plans and in the Consultative Councils, but all the relevant guidelines and information comes from the ACP.

The *Civic environmentalism* narrative emphasizes improving "environmental multilateralism", by which all the groups who have a stake in a given issue should have a voice in finding solutions. This narrative speaks of a more balanced power structure. ACP's emphasis in community participation parallels this narrative, however, as shown in the previous section, the established governance structure has yet to show increased decision-making power in the communities. This finding confirms Carse (2012) observation that despite ACP increasing community participatory spaces in governance of the Panama Canal Watershed, compared to Noriega's government Forest Law, issues of social justice still need to be resolved to achieve a truly participatory "water culture".

This mixing of top-down versus egalitarian narratives in ACPs discourse of sustainable development can lead to conflict if local communities do not see their socio-economic conditions improve as expected or if they do not see an increase in their participation in projects. Haenn warns against forms of governance that declare themselves as "participatory", yet carry along classic forms of hierarchical power relations because they tend to become authoritarian and the status-quo is maintained (Haenn, 2005). Haenn writes about a conflict in her study site in the Yucatan Peninsula, between local people expectations of sustainable development projects and actual project deliverables. In the Panama Canal Watershed, as I will describe below, there are seeds of frustration in the local people that could also develop into conflict.

In her area of study, as in the Panama Canal Watershed, local communities discontent had to do with “familiar critiques of power differences”, like the location of projects in particular communities and the control of projects. These types of disputes indicate that sustainable development implies significant political arrangements regarding “who is in control, who sets agendas, who allocates resources, who mediates disputes and who sets the rules of the game” (Wilbanks, 1994: p. 544).

COMMUNITY STRUGGLES WITH IMPERATIVE NARRATIVES — As I described in the governance section, in public, the local communities agree with the narratives of sustainable development held by the ACP, however, in private their struggles become apparent. This observation agrees with Matthews, During my interviews, community members expressed frustration over what I see as a mismatch between the imperative narrative put forward by the ACP and community’s realities and expectations. Some of the Watershed Committees community members interviewed expressed frustration about wanting to be more involved as decision-makers and as recipients of funding. The following quotes are clear expressions of these frustrations:

> *“We receive hundreds of capacitation workshops, but then our knowledge is not employed in the execution of projects”* (Chilibrillo, Watershed Committees member).

> “ *We hope to be the recipients of projects that we can then channel to the rest of the community. We want to be informed and involved in decision-making. We are well formed, and with capacity to implement projects, but they (ACP) always bring people from outside”* (Ciri-Grande Watershed Committees member).

They see the Committees as potential structures through which more government resources can be channeled to the community:

"The Committees are spaces of participation through which many projects can be channeled that would help us socially and environmentally" (Chilibre Watershed Committees member).

The expectation of some community members that Watershed Committees obtain the necessary legal status to receive and administer project funds seems to echo Nora Haenn's (2005) observation that in her area of work in Mexico people engaged in projects brought by development agents with the idea of acquiring paid positions. After a strong protest, peasants in her area of work demanded also that government funds be channeled through "campesino organizations", similar to what is happening in the Panama Canal Watershed. However, the willingness of Watershed Committees members to be recipients of funds for projects does not agree with the goals and the mission ACP has for the Committees. In the words of Amelia Sanjur, director of social staff of the ACP:

*"… local watershed committees cannot execute projects… they are supposed to be the link between the established Community Based Organizations and the institutions. If they execute projects they lose their identity, because more than interconnecting actions they will become another Community Based Organizations" (*Sanjur, key interview*).*

Community members believe that if the Watershed Committee's do not execute projects, then they do not understand the role of these arrangements (interviews with Chilibre and Chilibrillo Watershed Committeess members, August 2010). These dissonant views among the actors in the Panama Canal Watershed speak to key political differences. The ACP believes community members should volunteer their time in the Watershed Committees and Consultative Councils, whereas the people want to receive resources and authority. It becomes important to establish an open dialogue between communities and the APC that can allow working towards a solution of these differences.

However, the strength of the local communities struggle with the structure and function of the governance regime was not homogenous between the East and the West. Five interviewees in the East were very vocal about their frustrations, whereas only one person in the West mentioned wanting to see projects channeled through the Watershed Committees. In the East, the community is getting organized to push forward projects in parallel to those of the ACP. For example, those five interviewees from the East told me about a reforestation and tourism initiative they are conducting at the Chilibrillo river-head with funds from a local NGO.

I relate a higher education and socioeconomic status in the East with a more critical view of the actions and leadership of the ACP. The two sides of the watershed were quite different in the socio-economic profile of the Watershed Committees members (Table 3-2). In the East, the majority of interviewees (67%) were born in the interior of the country and immigrated to the periphery of Panama City, whereas in the West most interviewees had been living in the area for at least one generation (64%). Livelihood activities differed significantly between the East and the West. As a rural area, interviewees in the West worked more in agriculture than those in the East (Figure 3-5).

This rural versus peri-urban profile was also evident in the education level of interviewees from each side. Education level was higher in the East than in the West ($t_{20,129}$ = 2.175, P= 0.04172). In the East, 43% of interviewees had completed a college degree, whereas in the West all interviewees had completed some schooling, but either middle school or high school. A higher education along with living near the city influenced the variety of occupations that people in the East had. For example: mechanics, teachers, and carpenters.

The relationship I observed between socio-economic level and political dynamics in the Panama Canal Watershed is summarized well by the following two quotes from key informants:

> *"Some communities that are in the transition from being rural to being peri-urban, but are experiencing this in a context of marginalization, are very difficult to sensibilize towards protecting the natural resources without talking about their increase in quality of life, and without showing tangible results. This is what makes difficult the work in areas such as Chilibre and Chilibrillo"* (Gomez, interview).

> *"In rural areas people tend to have a higher cohesiveness than in urban settings. A low immigration rate in rural areas means people know each other more. The lack of many services and institution support in rural areas means that community members maintain alive the initiative of being their own agents of solving issue. In urban areas people wait for the government to solve their issues"* (Arauz, interview).

These results show that potentially the approach that has worked in a rural area does not necessarily work in a peri-urban setting. When Gomez talks in her quote about "tangible results" she refers to the actual delivery of socio-economic and environmental projects as a result of the formation of the governance bodies and the organization of the community. As I explained in the governance section, people in the East are frustrated by the overall lack of projects and it is not clear if the projects conducted to date have been a direct result of the governance regime in place. The East with its higher population means also that the few projects conducted impact a very small percentage of the people.

CONCLUSIONS

After conducting this work, I believe the hybrid governance structure developing in the Panama Canal Watershed provides and adequate space for community and local government interactions, which can become stronger with time and affect change in the current political decision-making dynamics. Responses from higher-level branches in the government could come as a direct result of pressure from communities organized at local and regional levels and thus be less driven by short-term electoral needs. I believe the strategy taken by the ACP of drafting an overall management plan with the communities and then generating projects from that Plan at the level of sub-watersheds are steps in the right direction. The ACP believes that through constant support of the communities, via the capacitation work, the communities will realize they have spaces where their needs are heard and begin to be agents of their own development.

One key idea in participatory regimes of governance is decentralization; nevertheless, I observed that to date the ACP is playing a strong managerial role in the governance process developing in the Panama Canal Watershed. After 10 years of this process of conformation of Watershed Committees, there still is a missing link as to how or when the ACP can leave the communities to organize on their own. In the report produced by Tetratecht in (2010) they mention how a sustainable component has not been built into the current ACP capacity building plan. Given that ACP staff believes Watershed Committees should not become recipient of funds, it is unclear to me how the long-term permanence of this governance structures can be maintained. Volunteer participation in poor, especially peri-urban, communities is challenged by the requirement of people to satisfy their subsistence needs first.

I believe one way to overcome this challenge may lie in a creative articulation between Watershed Committeess and existent Community Based Organizationss. Community Based Organizationss represent an important focus of local organization and action that pre-dates the formation of Watershed Committeess. Since Community Based Organizationss can have the legal status to be direct recipients of funds, projects that directly involve the community can be channeled through them. The Watershed Committeess could still act as spaces of communication between Community Based Organizationss and government, but at least the members of the Watershed Committeess would feel more involved in projects. Tetratech (2010) reported Community Based Organizationss carry several types of environmental projects, such as reforestation, cleaning of river ways, and environmental education, independently of support from the ACP. There has to be more focus in strengthening these organizations by channeling funds to them, and not only by providing capacity building at the Watershed Committees level.

The ACP uses powerful narratives because they are aligned with international discourses on sustainable development, plus it has a budget to implement capacity building workshops and certain development projects. This translates in a top-down hierarchical dynamic in the prevailing governance structure of the Panama Canal Watershed, in which the ACP is at the top and the communities at the bottom. The communities are given a space to voice their concerns about socio-environmental issues in their localities but not control over projects or funding. However, people are organizing themselves to push forward their agenda in parallel to that one of the ACP. These findings point towards certain community groups getting organized to resist the "status-quo" and move forward their agenda side to side that one of the ACP.

FIGURES:

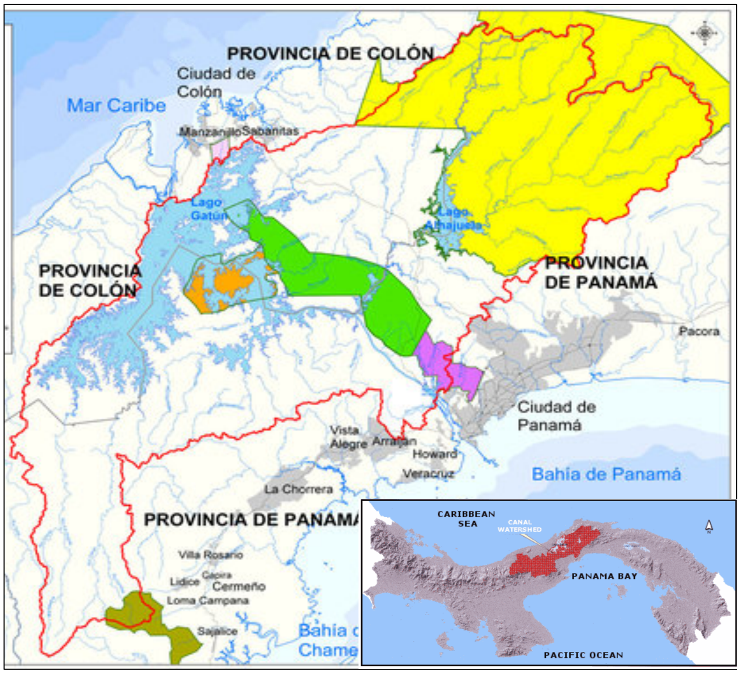


Figure 3-1. General map of Panama showing the location of the Panama Canal Watershed. (Modified from www.panama-guide.com and www.zonu.com on January 4, 2012).

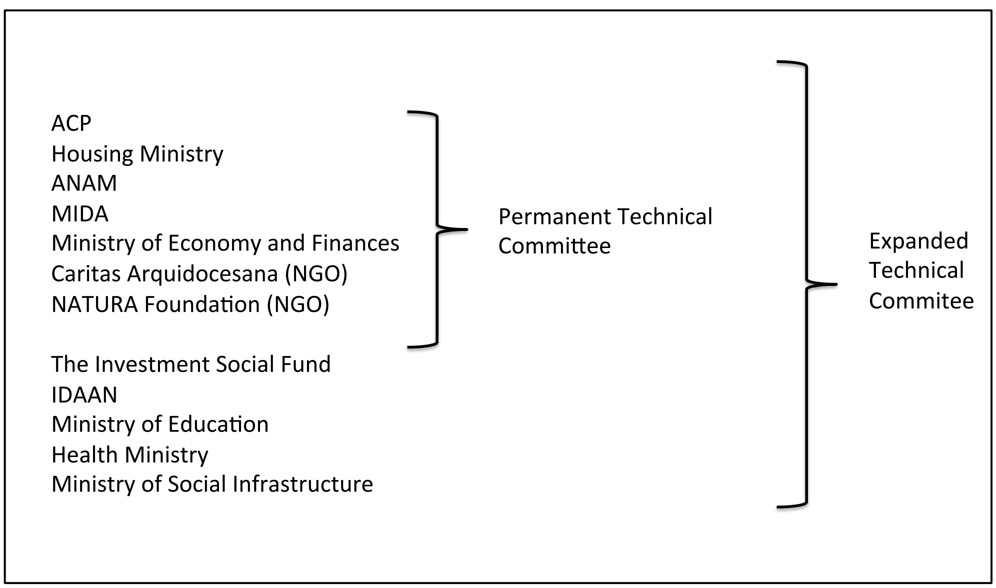


Figure 3-2. Member institutions of the CICH.

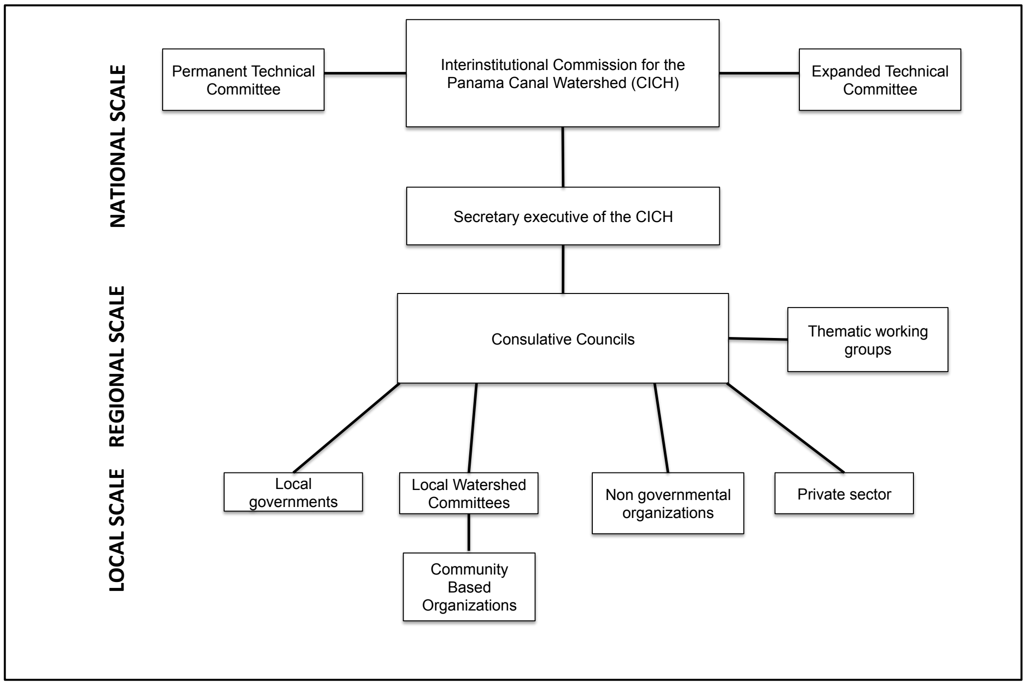


Figure 3-3. Diagram of the governance structure for the Integrated Management of the Panama Canal Watershed. Figure modified from the DS-GHIR document (CICH, 2008)

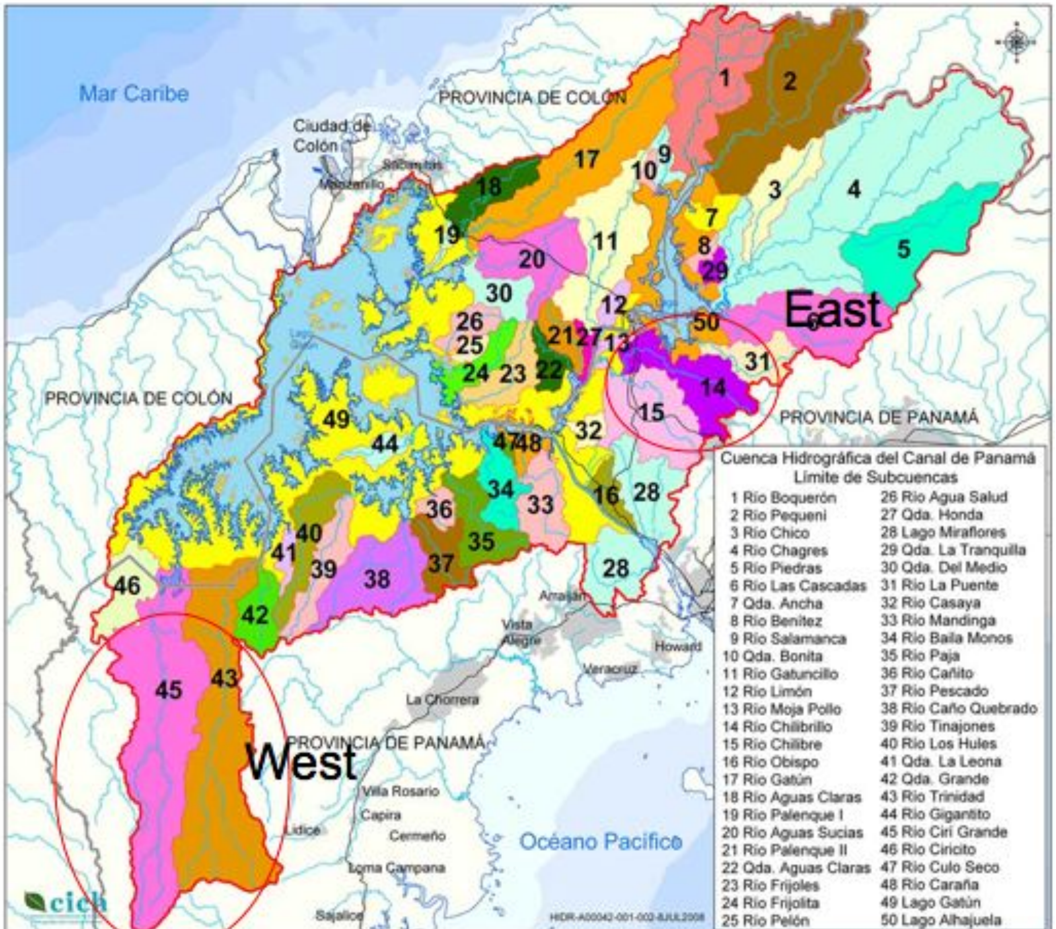


Figure 3-4. Location of the four study sites, which are the sub-watersheds of rivers Trinidad and Ciri Grande in the West (numbers 43 and 45), and rivers Chilibre and Chilibrillo in the East (numbers 14 and 15) (Picture modified from the CICH web page)

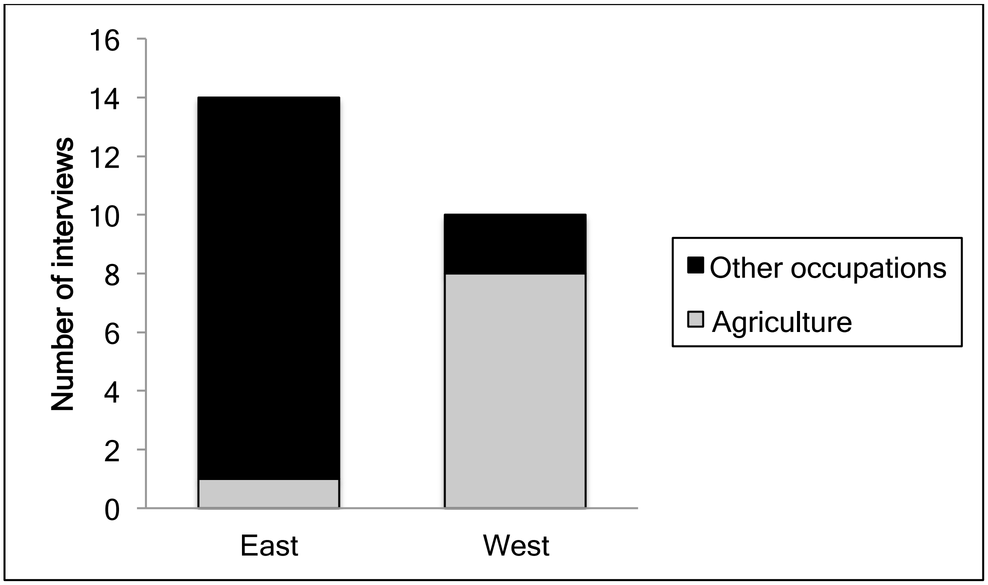


Figure 3-5. Number of interviewees dedicated to agriculture on each of the sides of the Panama Canal Watershed.

TABLES:

Table 3-1. Acronyms employed in the text.

Acronym	Explanation
ACP	Panama Canal Authority
CICH	Interinstitutional Commission for the Panama Canal Watershed
ANAM	National Environmental Authority
INRENARE	Natural Resources Institute
MIDA	Ministry of Agrarian Development
USAID	United States Aid Agency
IDAAN	Water Management Institute

Table 3-2. Summary of main socio-economic differences among interviewees from the East versus the West.

Socio-economic variable	East	West
Birth place	Interior provinces	West side of the Panama Canal Watershed
Higher education level	College	Middle and High school
Main livelihood activity	Manual labor and teaching	Agriculture
Source of income	Salaries	Self-employed

APPENDICES

Appendix 3-1. Semi-structured interview

Interviewer:

Watershed Committee Membership of Interviewee:

Name of Community of Interviewee:

Place of Interview:

Date:

Livelihoods

I. Human capital

1.1 How many people live in your household? *Cuanta gente vive en su casa?*

1.2 Are all family? If not ask about the relations among house members. *Son todos familia? Si no, Cual es la relación entre las personas que habitan este hogar?*

1.3 How many children do you have? *Cuantos hijos tiene?*

1.4 Where you born in this area? *Naciste en esta área? If not*

1.4.1 Where does your ancestors or you come from? *De donde viniste? De donde vinieron tus ancestros?*

1.4.2 What land use activities did your ancestors perform? *Que actividades realizaban sus ancestros?*

1.4.3 How long have you lived here? *Hace cuanto vive aquí?*

II. Ethno-ecology:

2.1 In the time you have lived in this area what are the main changes to the watershed environment you have seen? *En el tiempo que ha habitado en esta zona ha observado cambios en el ambiente de la cuenca? Cuales?*

2.2 What do you understand for Watershed conservation? *Que entiende usted por conservación de la cuenca?*

2.3 What would you like the land uses in the watershed to be? *Que le gustaría que fuesen los usos de la tierra en la cuenca?*

2.4 Do you think it is important to conserve forests? Why or why not? *Cree ud que es importante conservar bosques? Porque si o porque no?*

III. Economic capital

3.1 What do you do for a living? *En que trabaja ud?*

3.2 What do other household members do for living? *En que trabajan los demás miembros del hogar?*

3.3 What is the level of education of the members of your household? *Cual es el nivel educativo de los miembros de su familia?*

3.4 Do your children attend school? *Sus hijos asisten a la escuela actualmente? If not Why? Porque no?*

3.5 How many household members currently provide the house with either income or resources from their work? *Cuantos miembros de la familia contribuyen a la casa con sus ingresos?*

3.6 Are there secondary income-generating activities? *Hay actividades de ingresos secundarias ?*

3.7 What are the main challenges your household face to generate a livelihood? *Cuales son los principales retos que su familia enfrenta para generar ingresos?*

VI Material capital

4.1 Is this house yours, belong to other family member or rented? *Es esta casa propia? Si no De quien es? Es alquilada?*

4.2 Do you have access to land? *Tiene acceso a tierra? If yes*

4.2.1 Do you use it? *La usa?*
Do you have documents of that land? *Se apoya en documentación de la tierra?*

4.2.3 Do you rent land? *Renta tierra?*
4.2.4 Do you have crops or animals? *Tiene animales of cultivos? If yes, how many? Cuantos*

4.2.5 Do you have trees planted in your land? *Tiene arboles sembrados en su tierra?*

4.2.6 *Si. Cuales? Y con que propósito?*

4.2.7 Would you like to plant more trees in your land? *Te gustaría sembrar mas arboles en tu tierra? Por que?*

4.2.8 What kinds of material assets do you have? *Que herramientas tiene para su trabajo?*

4.2.9 Who works the land? *Quien trabaja la tierra suya?*

4.2.10 How much help do you get? *Cuanto le ayudan (horas, actividades)?*

4.2.11 Do you pay the people who help you? *Les paga a la gente que le ayuda?*

V Social capital:

5.1 To what organizations do you or other family members belong: *A que organizaciones comunitarias pertenece ud o su familia?*

Church *Iglesia*
Cooperative *Cooperativa*
Social clubs *Clubs socials o deportivos*
Community based organizations *Organizaciones comunitarias (describir)*
Volunteers groups *Voluntariados (describir)*
Other *Otros*

5.2 Do you help other members in your community? *Ayuda ud a otros miembros de la comunidad? If yes, how? Como?*

5.3 Do you help with community issues? *Such as repairing a road Ayuda ud. con problemas de la comunidad? Ejemplo: reparar una carretera*

5.4 What are the major challenges in your community? *Cuales son los mayores retos de la comunidad?*

VI. Relations with governance entities

6.1 What are the government entities that you have interacted with? Or In your idea what are the government entities more involved with your community and with the watershed in general? *En tu opinión, cuales entes gubernamentales están mas involucrados en tu comunidad?*

6.2 *Cuales están involucrados con el manejo de la cuenca?*

6.3 What types of projects have they conducted in the past and recently? *Que proyectos se han llevado a cabo en el pasado? Y recientemente?*

6.4 Do you think the projects they conducted helped the community? *Piensas que los proyectos llevados a cabo han ayudado a la comunidad?*

Not at all *No*
A little bit *Un poquito*
A lot *Mucho*

Why? *Por que?*

6.5 What types of projects would you like to see developed in your area? *Que tipo de proyectos te gustaría que se llevaran a cabo?*

6.6 How do you rate the conformation of watershed committees: *Te ha gustado la formación de los Comités de Cuenca? Por que?*

6.7 What is your position within this watershed committee? *Cual es tu posición dentro del Comité?*

6.8 How is the participation of the committee members: *Como es la participación de los demás miembros del comité en general?*

Good *Buena*
Bad *Mala*
Average *Promedio*

Why? *Por que?*

6.9 What activities does your committee conducts: *Que actividades realiza tu comité?*

On a regular basis: *Regularmente*
Eventually *Eventualmente*

6.10 What are the major conflicts that your committee faces? *Cuales son los principales retos en tu comite?*

6.11 What do you want to change within your committee *Que te gustaría cambiar dentro del comite?*

6.12 What do you want to change regarding the relation between the governance entities and the committees *Que te gustaría cambiar con respecto a la relacion entre los entes gubernamentales y el comité?*

LITERATURE CITED

Agrawal, A. and C. C. Gibson. 1999. Enchantment and disenchantment: The role of community in natural resource conservation. World Development **27**:629-649.

Agrawal, A. and M. C. Lemos. 2007. A greener revolution in the making? Environmental governance in the 21st century. Environment **49**.

ANAM. 2004. Informe del estado del ambiente. GEO Panama. 175 p.

Bäckstrand, K. and E. Lövbrand. 2006. Planting trees to mitigate climate change: Contested discourses of ecological modernization, green governmentality and civic environmentalism. Global Environmental Politics **6**:50-75.

Bassett, T. and K. Bi Zueli. 2003. Environmental discourses and the Ivorian Savanna. Annals of the Association of American Geographers **90**:67-95.

Batterbury, S. P. J. and J. L. Fernando. 2006. Rescaling governance and the impacts of political and environmental decentralization: an introduction. World Development **34**:1851-1863.

Bernard, R. 1994. Research methods in anthropology: Quantitative and qualitative approaches. Sage Publications, Walnut Creek. pp.

Blaikie, P. 1985. The political economy of soil erosion in developing countries. Longman, New York. pp.

Blaikie, P. and H. Brookfield. 1987. Land degradation and society. Methue, London. 296 pp.

Bulkeley, H. 2005. Reconfiguring environmental governance: Towards a politics of scales and networks. Political Geography **24**:875-902.

Busch, P. O., H. Jorgens, and K. Tews. 2005. The global diffusion of regulatory instruments: The making of a new international environmental regime. Annals of the American Academy of Political and Social Science **598**:146-167.

Carse, A. 2012. Nature as infrastructure: Making and managing the Panama Canal Watershed. Social Studies of Science:1-25.

Cash, D. W., W. N. Adger, F. Berkes, P. Garden, L. Lebel, P. Olsson, L. Pritchard, and O. Young. 2006. Scale and cross-scale dynamics: Governance and information in a multilevel world. Ecology and Society **11**.

Castree, N. 2003. Commodifying what nature? Progress in Human Geography **27**:273-297.

Chambers, R. and G. Conway. 1991. Sustainable rural livelihoods: practical concepts for the 21st century. Discussion Paper 296.*in* I. f. D. S. (IDS), editor., Brighton, U.K.

CICH. 2007. Fondo para la conservacion y recuperacion de la Cuenca Hidrografica del Canal de Panama. Informe de proyectos.

CICHa. 2008. Plan de desarrollo sostenible y gestion integrada de los recursos hidricos de la Cuenca Hidrografica del Canal de Panama. Borrador Final.115 pp.

CICHb. 2008. Plan de Accion Inmediata II: para el desarrollo humano, apoyo a la produccion y manejo ambiental de la Cuenca Hidrografica del Canal de Panama. Panama.

Condit, R., D. Robinson, R. Ibañez, S. Aguilar, A. Sanjur, R. Martinez, R. Stallard, T. Garcia, G. Angehr, L. Petit, J. Wright, T. R. Robinson, and S. Heckadon. 2001. The Status of the Panama Canal Watershed and its biodiversity at the beginning of the 21st century. Bioscience **51**:389-398.

Escobar, A. 1995. Encountering development: The making and unmaking of the third world. Princeton University Press, New Jersey. 312 pp.

Escobar, A. 1999. After nature: Steps to an antiessentialist Political Ecology. Current Anthropology **40**:1-30.

Fontana, A. and J. H. Frey. 1994. Interviewing: The art of science. Sage, Thousand Oaks, California. 256 pp.

Graham, J., B. Amos, and T. Plumptre. 2003. Principles for good governance in the 21st century. Policy Brief 15. Institute on Governance, Ontario.

Haenn, N. 2005. Fields of power, forests of discontent. The University of Arizona Press, Tucson. 229 pp.

Hajer, M. A. 1995. Discourse analysis. Pages 42-72 The politics of environmental discourse. Oxford University Press, Oxford.

Hannigan, J. 2006. Environmental sociology. Second edition edition. Routledge, London and New York. 194 pp.

Huberman, M. and M. Miles. 1994. Data management and analysis methods. Handbook of qualitative research. . Sage, Thousand Oaks, California. 729 pp.

Hyden, G., J. Court, and K. Mease. 2004. Making sense of governance: empirical evidence from 16 devloping countries. Lynne Rienner, Boulder. 262 pp.

IRG. 2002. Institutional support for sustainable environmental management of the Panama Canal Watershed. 51

Lemos, M. C. and A. Agrawal. 2006. Environmental Governance. Annual Review of Environmental Resources **31**:297-325.

Li, T. M. 1999. Compromising power: Development, culture, and rule in Indonesia. Cultural Anthropology **14**:295-322.

Margoluis, R. and N. Salfsky. 1998. Measures of success: Designing, managing and monitoring conservation and development projects. Island Press. 362 pp.

Matthews, A. S. 2008. State making, knowledge, and ignorance: translation and concealment in Mexican Forestry Institutions. American Anthropologist **110**:484-494.

McCarthy, J. and S. Prudham. 2004. Neoliberal nature and the nature of neoliberalism. Geoforum **35**:275-283.

McKay, A. 1984. Colonizacion de tierras nuevas en Panama. Pgs 45-60. In: Heckadon-Moreno, S y A. McKay (Eds). Colonizacion y destruccion de bosques en Panama. Asociacion Panamegna de Antropologia. Panama. 174 pp

.

Morris Carrera, J. A. and J. D. Q. Mendoza. 2002. Los actores sociales en el proyecto de ampliacion del canal y el desarrollo economico social en la llamada cuenca occidental. Tesis. Universidad de Panama. Facultad de Humanidades. Escuela de Sociologia. 162 pp.

Papadopoulos, Y. 2003. Cooperative forms of governance: Problems of democratic accountability in complex environments. European Journal of Political Research **42**:473-501.

Peet, R. and M. J. Watts. 2004. Liberation ecologies. Routledge editors, New York, London. 444 pp.

Pinzon, L. and J. Estuarin. 1986. Vigilancia de los bosques. In: La cuenca del canal de Panama: Actas de los seminaries-talleres (Heckadon, S (Ed.). Panama. 380 pp.

Polanyi, K. 2001. The great transformation. Third edition edition. Beacon Press, Boston. 317 pp.

R-Development-Core-Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical omputing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Ribot, J. C. 1999. Decentralisation, participation and accountability in sahelian forestry: Legal instruments of political-administrative control. Africa **69**:23-65.

Robbins, P. 2004. Political ecology: A critical introduction. Blackwell Publishing, Ltd., Malden, M.A. 298 pp.

Scoones, I. 1998. Sustainable rural livelihoods: a framework for analysis. Institute for Development Studies (IDS), Brighton, UK.

United Nations Development Program. 1997. Governance for sustainable human development: a UNDP policy document. Chapter 1: Good governance and sustainable human development. New York.

United States Agency for International Development. 2005. Evaluation of USAID's strategic objective for the Panama Canal Watershed 2000-2005. Final Report. USAID.

Wilbanks, T. J. 1994. Sustainable devlopment in geographic perspective. Annals of the Association of American Geographers **84**:541-556.

Windsor, D. and A. S. Rand. 1986. Cambios climaticos en los registros de lluvia en Panama y Costa Rica. *.in* Heckadon and Espinosa, editors. Agonia de la naturaleza, Panama.

CONCLUSIONS

The three studies conducted for my dissertation addressed two aspects of community interactions related to forest restoration and environmental governance in the Panama Canal Watershed. The first two studies (Chapters 1 and 2) assessed the value of phylogenetic ecology as a framework to understand community assembly and species interactions in forest restoration. The third study (Chapter 3) assessed the impacts of a hybrid (multi-stakeholder) governance regime implemented by the Panamanian Government with the goal of achieving sustainable development of the Panama Canal Watershed.

In the first two studies, I found the inclusion of phylogenetic relationships in forest restoration to be a useful framework for understanding plant species performance and community assembly. In the first study, I found that plants that recruited naturally under tree plantations were more distantly related to both the overstory tree species and to each other than would be expected from the available species. The composition of understory recruits was strikingly similar under several species of legume overstory trees, dominated by species distantly related to each other. This overdispersion trend, however, was driven primarily by a high abundance of Piperaceae, an ancestral family clade, rather than from negative interactions among close relatives. On the other hand, there was a random phylogenetic structure between non-legume overstory trees and the plants that recruited into the understory; but the understory species were more closely related to each other (phylogenetically clustered) than expected by chance. Such clustering is expected in response to challenging factors for natural recruitment, such as grass regrowth, beneath non-legumes leading to the presence of cosmopolitan species.

The second study showed that the performance of enrichment planted tree seedlings beneath an establish tree canopy improves if the seedling species is not of the same species as the overstory tree. It is worth noting that in designing this experiment I was limited to seedling species that were available in local nurseries. This limitation led to few closely related species pairs, such as seedling species in the same genus as the overstory tree. Because negative interactions are stronger among close relatives(Gilbert and Webb, 2007, and the present study), including more close relatives may have provided a greater ability to detect a continuous increase in performance with phylogenetic distance. In addition, predictions of community assembly processes based on the analysis of phylogenetic structure can be strengthen by looking at the conservatism of a few key functional traits (Losos, 2008; Mayfield and Levine, 2010; Flynn *et al.*, 2011; Baraloto *et al.*, 2012), and by using models to link trait and phylogenetic data (e.g., Pavoine *et al.*, 2011). Assessments of traits may be too expensive and time consuming for many projects; but current initiatives to develop free, online data bases of plant traits show a promising resolution of this issue (Kattge *et al.*, 2011).

Restoration of forests in the Panama Canal Watershed is a priority of the Panama Canal Authority, which is the Panamanian government entity in charge of guaranteeing water quantity and quality for Canal operations. The Panama Canal Authority implements many of the research findings of forest restoration studies in on-the-ground forest restoration projects. This interest is key for the application of novel tools, such as phylogenetic ecology, in improving tropical forest restoration.

To achieve their mission of protecting the water resources in the Panama Canal Watershed, the Panama Canal Authority implemented a multi-stakeholder environmental governance regime, which involves the participation of local actors in reforestation for water conservation, and in sustainable development activities. I found the governance regime is creating important spaces for environmental education and communication between the communities and government actors. The Panama Canal Authority holds a strong win-win discourse, typical of sustainable development agendas, regarding the vision of the governance regime. However, tangible results were mostly lacking. The local communities expressed frustration with the lack of projects and quality of life improvements to date, and the Panama Canal Authority struggles to achieve greater collaboration from other government institutions that are in charge of solving pressing social issues in the Watershed.

Moving forward I recommend the Panama Canal Authority should develop a strategy to channel an increased number of projects through the local communities to achieve both reforestation and sustainable development. Such an approach would guarantee the long-term existence of the current multi-stakeholder governance regime.

LITERATURE CITED

Baraloto, C., O. J. Hardy, C. E. T. Paine, K. G. Dexter, C. Cruaud, L. T. Dunning, M. A. Gonzalez, J. F. Molino, D. Sabatier, V. Savolainen, and J. Chave. 2012. Using functional traits and phylogenetic trees to examine the assembly of tropical tree communities. Journal of Ecology **100**:690-701.

Flynn, D. F. B., N. Mirotchnick, M. Jain, M. I. Palmer, and S. Naeem. 2011. Functional and phylogenetic diversity as predictors of biodiversity-ecosystem-function relationships. Ecology **92**:1573-1581.

Gilbert, G. S. and C. O. Webb. 2007. Phylogenetic signal in plant pathogen-host range. Proceedings of the National Academy of Sciences of the United States of America **104**:4979-4983.

Kattge, J. and S. Diaz and S. Lavorel and C. Prentice and P. Leadley and G. Bonisch and E. Garnier and M. Westoby and P. B. Reich and I. J. Wright and J. H. C. Cornelissen and C. Violle and S. P. Harrison and P. M. van Bodegom and M. Reichstein and B. J. Enquist and N. A. Soudzilovskaia and D. D. Ackerly and M. Anand and O. Atkin and M. Bahn and T. R. Baker and D. Baldocchi and R. Bekker and C. C. Blanco and B. Blonder and W. J. Bond and R. Bradstock and D. E. Bunker and F. Casanoves and J. Cavender-Bares and J. Q. Chambers and F. S. Chapin and J. Chave and D. Coomes and W. K. Cornwell and J. M. Craine and B. H. Dobrin and L. Duarte and W. Durka and J. Elser and G. Esser and M. Estiarte and W. F. Fagan and J. Fang and F. Fernandez-Mendez and A. Fidelis and B. Finegan and O. Flores and H. Ford and D. Frank and G. T. Freschet and N. M. Fyllas and R. V. Gallagher and W. A. Green and A. G. Gutierrez and T. Hickler and S. I. Higgins and J. G. Hodgson and A. Jalili and S. Jansen and C. A. Joly and A. J. Kerkhoff and D. Kirkup and K. Kitajima and M. Kleyer and S. Klotz and J. M. H. Knops and K. Kramer and I. Kuhn and H. Kurokawa and D. Laughlin and T. D. Lee and M. Leishman and F. Lens and T. Lenz and S. L. Lewis and J. Lloyd and J. Llusia and F. Louault and S. Ma and M. D. Mahecha and P. Manning and T. Massad and B. E. Medlyn and J. Messier and A. T. Moles and S. C. Muller and K. Nadrowski and S. Naeem and U. Niinemets and S. Nollert and A. Nuske and R. Ogaya and J. Oleksyn and V. G. Onipchenko and Y. Onoda and J. Ordonez and G. Overbeck and W. A. Ozinga and S. Patino and S. Paula and J. G. Pausas and J. Penuelas and O. L. Phillips and V. Pillar and H. Poorter and L. Poorter and P. Poschlod and A. Prinzing and R. Proulx and A. Rammig and S. Reinsch and B. Reu and L. Sack and B. Salgado-Negre and J. Sardans and S. Shiodera and B. Shipley and A. Siefert and E. Sosinski and J. F. Soussana and E. Swaine and N. Swenson and K. Thompson and P. Thornton and M.

Waldram and E. Weiher and M. White and S. White and S. J. Wright and B. Yguel and S. Zaehle and A. E. Zanne and C. Wirth. 2011. TRY - a global database of plant traits. Global Change Biology **17**:2905-2935.

Losos, J. B. 2008. Phylogenetic niche conservatism, phylogenetic signal and the relationship between phylogenetic relatedness and ecological similarity among species. Ecology Letters **11**:995-1003.

Mayfield, M. M. and J. M. Levine. 2010. Opposing effects of competitive exclusion on the phylogenetic structure of communities. Ecology Letters **13**:1085-1093.

Pavoine, S., E. Vela, S. Gachet, G. de Belair, and M. B. Bonsall. 2011. Linking patterns in phylogeny, traits, abiotic variables and space: a novel approach to linking environmental filtering and plant community assembly. Journal of Ecology **99**:165-175.