UNIVERSIDADE FEDERAL DE PERNAMBUCO

CENTRO DE CIÊNCIAS BIOLÓGICAS

PROGRAMA DE PÓS-GRADUAÇÃO EM BIOLOGIA VEGETAL

KÁTIA FERNANDA RITO PEREIRA

EFEITO DAS PERTURBAÇÕES ANTRÓPICAS SOBRE POPULAÇÕES DE EUPHORBIACEAE EM ÁREAS DE CAATINGA, NORDESTE DO BRASIL

RECIFE

2012

KÁTIA FERNANDA RITO PEREIRA

EFEITO DAS PERTURBAÇÕES ANTRÓPICAS SOBRE POPULAÇÕES DE EUPHORBIACEAE EM ÁREAS DE CAATINGA, NORDESTE DO BRASIL

Dissertação apresentada ao Programa de Pós-Graduação em Biologia Vegetal da Universidade Federal de Pernambuco como um dos requisitos para obtenção do título de Mestre em Biologia Vegetal, na área de concentração Ecologia Vegetal e linha de pesquisa Ecologia de Populações e Comunidades Vegetais.

Orientadora: Inara Roberta Leal

RECIFE

2012

Catalogação na fonte
Elaine Barroso
CRB 1728

Pereira, Kátia Fernanda Rito
Efeito das perturbações antrópicas sobre populações de Euphorbiaceae em áreas de Caatinga, Nordeste do Brasil/ – Recife: O Autor, 2012.

72 folhas : il., fig., tab.
Orientadora: Inara Roberta Leal
Dissertação(mestrado) – Universidade Federal de Pernambuco, Centro de Ciências Biológicas, Biologia Vegetal, 2012.
Inclui bibliografia e anexo

1. Euphorbiaceae 2. Caatinga I. Leal, Inara Roberta (orientadora) II. Título

583.69 CDD (22.ed.) UFPE/CCB- 2014- 286

KÁTIA FERNANDA RITO PEREIRA

EFEITO DAS PERTURBAÇÕES ANTRÓPICAS SOBRE POPULAÇÕES DE EUPHORBIACEAE EM ÁREAS DE CAATINGA, NORDESTE DO BRASIL

APROVADO EM 15/02/2012

BANCA EXAMINADORA:

Dra. INARA ROBERTA LEAL (Orientadora)-UFPE

Dr. PAULO ENRIQUE CARDOSO PEIXOTO - UEFS

Dr. FELIPE PIMENTEL LOPES DE MELO - UFPE

RECIFE

2012

“DA FELICIDADE:

Quantas vezes a gente, em busca da ventura,

Procede tal e qual o avozinho infeliz:

Em vão, por toda parte, os óculos procura

Tendo-os na ponta do nariz!”

Mário Quintana.

Àquela que mesmo sem entender muito bem o que eu fazia, sempre esteve ao meu lado, minha mãe, Justina Rito.

Dedico.

AGRADECIMENTOS

A Deus, por iluminar meu caminho, me dar a saúde e o discernimento para que eu pudesse seguir sempre em frente.

À minha família, em especial aos meus pais Justina Rito e José Pereira que se dedicaram tanto para que eu alcançasse meus objetivos.

À minha orientadora, Inara Leal, por todos estes anos de convivência e aprendizado, pelas oportunidades e pela amizade.

Aos meus companheiros de campo Laura Leal, Gabriela Burle e José Domingos (Zezinho), pela tão preciosa ajuda em campo, pelas longas viagens e aventuras na Manhosa (Toyota), pelo pão com atum nosso de cada dia, pela amizade, pelo companheirismo em tempos tão difíceis e pelas boas risadas que demos.

Aos meus companheiros de LIPA: Elâine Ribeiro (Florzinha), Fernanda Maria, Walkíria Rejane, Marcos Meiado, Laura leal, Gabriela Burle, Talita Câmara e José Domingos, pela amizade tão preciosa ao longo destes três anos. Orgulho-me demais de fazer parte da história desse laboratório de luta!

A todos os meus amigos, que fazem minha vida mais feliz, com muito mais sentido e que eu sei que posso contar até o fim dos tempos, em especial à: Edson Pinho, Carolina Malafaia, Túlio Diego, Nelson Lima e Talita Câmara.

A Edgar Silva, pelo amor, pela paciência, pela cumplicidade, pelo companheirismo em todos os momentos e por ter feito, em muitos destes momentos, as coisas ficarem menos pesadas de carregar. Agradeço também, pela ajuda no trabalho de campo (como nosso motorista), que foi essencial para finalização do trabalho, e pelos pitacos intelectuais sempre pertinentes.

Gostaria de agradecer novamente e de forma especial a Gabriela Burle e Laura Leal, que foram muito mais que amigas e companheiras durante estes anos. Obrigada pela compreensão, por todos os momentos que partilhamos, pelos sorrisos e lágrimas.

Aos moradores dos sítios de Parnamirim, que nos receberam de braços abertos para realização das entrevistas. Obrigada pela acolhida, pela simplicidade e pelos valores compartilhados.

A todos da Estação de Agricultura Irrigada de Parnamirim em especial a S. Flávio, S. Eurico, S. Tica e D. Lica, pelo apoio logístico, pela acolhida, pela ajuda e por todo o carinho.

Ao Centro de Pesquisas Ambientais do Nordeste (CEPAN) pelo apoio logístico.

Ao Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) pelo financiamento do projeto e concessão da minha bolsa de mestrado.

À todos que contribuíram de alguma forma para a realização deste trabalho.

LISTA DE FIGURAS

LISTA DE TABELAS

SUMÁRIO

APRESENTAÇÃO

As populações vegetais apresentam um comportamento dinâmico em resposta a nascimentos e mortes de indivíduos e este comportamento é definido por diferentes estratégias de vida que garantem a sobrevivência e reprodução em ambientes distintos. O estudo da estrutura de populações vegetais fornece informações sobre as estratégias ecológicas das espécies e ajuda no entendimento de como variações temporais e espaciais podem influenciar o recrutamento, a mortalidade e a dinâmica de sucessão dessas espécies em ecossistemas com diferentes características. Atualmente, um grande desafio para os ecólogos é identificar fatores que regem o comportamento dinâmico das populações e assim, predizer como mudanças ambientais afetam sua viabilidade (BULLOCK *et al.*, 1996; BRUNA, 2003; MANDUJANO *et al*., 2007).

Populações e comunidades vegetais podem ser afetadas tanto por distúrbios ambientais naturais como por distúrbios de origem antrópica (COMITA *et al*., 2010). A alteração de habitat pelas pressões antrópicas é hoje o principal fator responsável por modificações na estrutura de comunidades e, conseqüentemente, na prestação de serviços ecológicos de muitos ecossistemas em todo o planeta (SALA *et al*., 2000). Isso tem se agravado porque em muitos ambientes as perturbações antrópicas tem causado a hiperproliferação de espécies adaptadas a perturbação, desencadeando um processo de homogeneização biótica (MICKNEY & LOCKWOOD, 1999; LÔBO *et al*., 2011).

O processo de degradação de paisagens naturais da Caatinga tem acelerado nas últimas décadas, principalmente por meio das perturbações antrópicas crônicas. As perturbações antrópicas crônicas se caracterizam pela persistência e frequência de retirada de pequenas quantidades de biomassa da vegetação, seja de recursos madeireiros como também recursos não madeireiros. Isso porque a Caatinga tem um longo histórico de ocupação em que, em geral, os moradores subsistem dos recursos florestais. Porém, não se conhece ainda muito bem as conseqüências da degradação destas paisagens para a perda da biodiversidade, muito menos para a estruturação das populações e comunidades vegetais (CASTELLETTI *et al*., 2003; LEAL *et al*., 2005). Estudar como as espécies vegetais em áreas de Caatinga podem se comportar frente a esses crescentes distúrbios fornece importantes subsídios para compreensão das consequências das ações antrópicas na manutenção da biodiversidade nesse ecossistema. Assim, este estudo se propôs a avaliar como espécies de Euphorbiaceae, uma das famílias mais ricas da Caatinga e composta por várias espécies pioneiras, respondem a perturbações antrópicas crônicas. Este trabalho é composto por uma fundamentação teórica e por um capítulo estruturado em forma de artigo científico a ser enviado ao periódico *Environmental Conservation*.

FUNDAMENTAÇÃO TEÓRICA

Respostas vegetacionais à perturbação antrópica

As atividades humanas têm alterado de forma intensa os ambientes naturais e a biota do planeta. A modificação de ambientes naturais pela ação humana tem ocorrido principalmente devido à exploração não sustentável de recursos naturais e à expansão das áreas urbanas (CHAPIN III *et al*., 2000; CHAPIN III, 2003). Como consequência dessas atividades, grandes áreas de vegetação pristina estão sendo completamente removidas, severamente modificadas ou transformadas em conjuntos de pequenos fragmentos (FOLEY *et al*., 2005; SAUNDERS *et al*., 1991). Atualmente, a área florestada no mundo todo corresponde a apenas 31% da área total (FAO, 2010). Cerca de 13 milhões de hectares de floresta no mundo foram convertidos, por ano, para outros usos ou perdidos por causas naturais entre 2001 e 2010, em comparação a 16 milhões de hectares/ano no período de 1991-2000 (FAO, 2011). Embora tenha ocorrido esta diminuição, a taxa global de desflorestamento permanece bastante alta (FAO, 2011), fazendo com que esta ainda seja a maior ameaça a diversidade global (SALA *et al*., 2000).

A retirada de cobertura vegetal promove a remoção direta de diversas espécies. Contudo, as ações antrópicas também alteram fatores físicos do ambiente como temperatura, luminosidade, umidade e disponibilidade de nutrientes no solo (SANTOS *et al*., 2009; GALINDO, 2007). Estas alterações abióticas afetam a distribuição de espécies nos remanescentes florestais, uma vez que espécies vegetais e animais sensíveis a essas novas condições impostas pelo ambiente antropizado serão removidas e substituídas por espécies mais resistentes (SILVA *et al*., 2007; MANDUJANO *et al*., 2007). Além dessas mudanças abióticas e bióticas, as perturbações antrópicas também tendem a reduzir a área do habitat, simplificar a flora e a fauna abrigada pelas áreas remanescentes, diminuindo a qualidade do habitat (ARROYO-RODRÍGUEZ & MANDUJANO, 2006). Por fim, todas estas alterações afetam negativamente as funções do ecossistema como a ciclagem de nutrientes, regime de chuvas e sucessão ecológica (MILCHUNAS & LAUENROTH, 1993; FLEISCHNER, 1994; CURTIN, 2002; WILSON, 1994; HONGO *et al*., 1995; NEIL *et al.*, 1995).

De forma geral, espécies que possuem baixas taxas de crescimento individual e populacional, alta mortalidade durante as fases juvenis e baixas taxas de recrutamento são aquelas que têm maior dificuldade em permanecer em um habitat modificado antropicamente. Estas espécies têm grande dificuldade em recuperar suas populações e persistirem após um evento de perturbação (SCHMALZEL *et al*., 1995; CONTRERAS & VALVERDE, 2002; ESPARZA-OLGUÍN *et al*., 2002, 2005; ALVAREZ *et al*., 2004; MANDUJANO *et al*., 2007). Frente a eventos de perturbação, essas espécies apresentam rápidas mudanças em sua estrutura e distribuição populacional e algumas dessas respostas a esses eventos podem ser visualizadas principalmente através de estágios de vida predominantes, fecundidade e sobrevivência (SILVA *et al*., 2007; MANDUJANO *et al*., 2007; BULLOCK *et al.*, 1996; RODRIGUES *et al.*, 2000). Ureta & Martorell (2009), avaliaram o efeito do distúrbio antrópico em duas espécies de cactos (*Mammillaria dixanthocentron* e *Mammillaria hernandezii*) em região semi-árida do México. Estes autores encontraram que reduções na sobrevivência e reprodução e alta mortalidade de adultos em áreas de intenso distúrbio resultaram em alterações na taxa de crescimento populacional.

Por outro lado, há também espécies que se beneficiam com as mudanças do ambiente após eventos de perturbação. Dentre elas podemos destacar espécies vegetais invasoras e ruderais (FREEDMAN *et al*., 1996; PAKEMAN 2004). O que faz com que estes grupos de espécies se beneficiem em habitats perturbados, aumentando suas abundâncias, são características fisiológicas e ecológicas que as permitem colonizar os ambientes perturbados com baixa cobertura vegetal e condições microclimáticas extremas (HOBBS & HUENNEK, 1992; PYSEK *et al.*, 2002; REJMÁNEK *et al.*, 2005). Dentre estas características estão: sistemas de polinização e dispersão pouco especializados, grande produção de sementes de pequeno tamanho, alta germinabilidade, crescimento rápido e reprodução clonal (REJMÁNEK & RICHARDSON, 1996; PRINZING *et al*., 2002; SUTHERLAND, 2004; REJMÁNEK *et al*., 2005). As perturbações fazem com que as espécies com este tipo de estratégia proliferem-se e o aumento de suas abundâncias pode ocasionar a homogeneização da biota destes ambientes perturbados (MICKNEY & LOCKWOOD, 1999). Santos *et al.* (2008), em estudo realizado na floresta Atlântica nordestina, observou que espécies de árvores pioneiras representaram mais de 80% das espécies com diâmetro à altura do peito ≥10 cm em pequenos fragmentos e bordas de grandes áreas de floresta. Em florestas tropicais úmidas, a hiper-proliferação de pioneiras atrelada à mortalidade de grandes árvores contribui para a simplificação da flora (LAURANCE *et al*., 1997; NASCIMENTO & LAURANCE, 2004).

Florestas secas e suas ameaças

Florestas tropicais secas são ecossistemas característicos de regiões áridas e semi-áridas marcadas por sazonalidade pronunciada com a ocorrência de muitos meses de seca (MOONEY *et al*., 1995). Nestes ambientes, a vegetação é tipicamente dominada por árvores decíduas, a média anual de temperatura está acima dos 25°C, a precipitação anual está em torno de 300 e 900 mm e nos meses de seca a precipitação não excede os 100 mm (SÁNCHEZ-AZOFEIFA *et al*., 2005). De acordo com Murphy & Lugo (1986), 42% das florestas tropicais e subtropicais são florestas secas. Miles *et al.* (2006)

estimaram que a área remanescente de florestas secas em todo o mundo era de 1.048,700 km^2 , incluindo Caatinga e Cerrado. Desta área, 54,2% encontram-se na América do Sul, 12,3% nas Américas do norte e central, 13,1% na África, 16,4% na Eurásia e 3,8% na Austrália, parte insular da Ásia e sudeste asiático (MILES *et al.*, 2006). Porém, sua atual distribuição é apenas uma fração da cobertura original que foi convertida principalmente em campos agricultáveis e pastos (FAO, 2007).

As mudanças no uso de terra ocorridas nestes ambientes áridos estão atreladas às interações complexas entre sistemas naturais e sociais (LAMBIN *et al*., 2001, 2003). As principais ameaças reportadas para florestas secas estão relacionadas à alta densidade populacional em áreas naturais (MILES *et al*., 2006). Estas populações geram mudanças no uso do solo e também tem grande influência na introdução e propagação de espécies invasoras (KÜHN & KLOTZ, 2006). Isso ocorre porque nas áreas de clima seco a menor estatura da vegetação, o clima mais adequado para a criação de animais e a disponibilidade de forragem natural facilitam a implantação de agricultura e a criação de animais de forma extensiva (MURPHY & LUGO, 1986; REID *et al*., 2008). Por isso, de maneira geral, as principais mudanças no uso do solo para estes ambientes envolvem atividades como a agricultura (MOFFATT *et al*., 2004), a extração de madeira (PRESS, 2006) e a criação extensiva da caprinos e bovinos (JACKSON *et al*., 2003; PAKEMAN, 2004; ZHAO *et al*., 2007).

As perturbações antrópicas podem ser classificadas como agudas ou crônicas (SINGH, 1998). As perturbações agudas consistem na total descaracterização de uma área por corte raso da vegetação; já as do tipo crônicas ocorrem como uma atividade constante que modifica o ambiente de maneira gradual, não descaracterizando o ambiente de maneira drástica (SINGH, 1998; MARTORELL & PETERS, 2005). Trabalhos recentes apontam que, em ambientes áridos e semi-áridos, os quais abrigam os remanescentes de florestas secas, as perturbações antrópicas mais comuns são as crônicas (MATORELL & PETERS, 2008; MATORELL & PETERS, 2005). Estas são exemplificadas pela atividade de extração seletiva de madeira e criação extensiva de animais (MATORELL & PETERS, 2008; MATORELL & PETERS, 2005). Devido aos ambientes secos possuírem baixa produtividade e, por isso, lenta recuperação, as modificações decorrentes das perturbações crônicas não são completamente recuperadas antes que um distúrbio subseqüente aconteça. Dessa maneira, os efeitos tornam-se cumulativos e a recuperação total do ambiente não acontece (NILSSON & GRELSSON, 1995). É importante que a análise dos efeitos das modificações provocadas pelas perturbações crônicas seja realizada em uma escala contínua, uma vez que uma análise dicotômica não permite avaliar os diferentes graus de perturbação que o ambiente possui (WATT, 1988).

A degradação de ambientes naturais está intimamente ligada às mudanças sociais, políticas e econômicas nos âmbitos nacional e internacional, mas de uma maneira não menos importante e impactante, está ligada também às mudanças em pequena escala como a oferta do mercado de trabalho local e o ciclo de vida de famílias rurais (CALVO-ALVARADO *et al*., 2009). A utilização de serviços e recursos de ambientes secos não é apenas inevitável como também indispensável para o desenvolvimento de atividades econômicas e sociais. Porém, é importante identificar o grau de sustentabilidade destas práticas e que práticas oferecem risco para a manutenção da integridade estrutural e funcional dos ambientes naturais (MAASS *et al.*, 2010).

A Caatinga e seu atual estado de conservação

A Caatinga é um mosaico vegetacional caracterizado pela presença de arbustos espinhentos e trechos de florestas secas (LEAL *et al*., 2005). Possui uma área original de cerca de 86.411 km² e estende-se por todos estados do nordeste brasileiro e parte de Minas Gerais (2%), sendo menos representativa no estado do Maranhão (1%; LEAL *et al*., 2005; MMA/IBAMA, 2011; IBGE, 1985; GIULLIETI *et al*., 2004). Este ecossistema possui uma diversidade de mais de 2.000 espécies de plantas vasculares, peixes, répteis, anfíbios, aves e mamíferos e grande número de endemismos (de 7% em aves a 57% em peixes; LEAL *et al*., 2005). As fisionomias vegetais da Caatinga são diversas e estendem-se por diversas formações geológicas de bacias sedimentares, montanhas e platôs (IBGE, 1985). Em uma classificação amplamente aceita até hoje, Andrade-Lima (1981) reconheceu 12 fitofisionomias baseadas na integração entre o clima e o solo da região.

Durante muito tempo, alguns autores reportaram a Caatinga como um ecossistema pobre e com poucos táxons endêmicos (RIZZINI 1963, 1979; ANDRADE-LIMA, 1982). Desde o Workshop da Caatinga, realizado em 2000 em Petrolina, a Caatinga tem sido reconhecida como um ambiente rico em endemismos e passou a ser considerada uma área prioritária para conservação (GIULIETTI *et al*., 2002; PRADO, 2003; QUEIROZ, 2006). No entanto, em estudo recente realizado por Santos *et al*. (2011), observou-se que mesmo depois de mais de uma década do início destes debates, este ecossistema permanece negligenciado pelas ações governamentais de preservação e pelos esforços científicos dos grupos de pesquisas das instituições situadas em áreas sob influência do ecossistema. Conseqüentemente, isso torna os avanços científicos e de preservação para este ambiente ainda bastante limitados.

Nas Américas, o Brasil é o segundo país com maior porcentagem de florestas secas degradadas por ações antrópicas (PORTILLO-QUINTERO *et al*., 2010). Quando comparadas as formações arbustivas de Campos rupestres, Llanos, Chacos, savanas de Beni, Cerrado e Caatinga, a Caatinga é o terceiro ecossistema mais ameaçado (PORTILLO-QUINTERO *et al*., 2010). Dentre os ecossistemas brasileiros, a Caatinga é um dos mais ameaçados e alterados pela ação antrópica, principalmente pelo desmatamento, apresentando extensas áreas degradadas, com solos sob intenso processo de desertificação (CASTELLETTI *et al.,* 2003). As atividades de agricultura itinerante ao longo da história geraram uma ocupação territorial desordenada e impactante, o que causou uma redução significativa da biodiversidade regional (MMA, 2002). Em 1993, as atividades agrícolas ocupavam quase 28% da área total da Caatinga (MMA, 1998). Em Pernambuco, as áreas de Caatinga degradadas ultrapassam 25% da área total, sendo 16% destas áreas classificadas como áreas com nível de degradação severo (SÁ *et al.*, 2003). Contrastantemente, apenas 7,4% da área total de Caatinga encontra-se protegida através de unidades de conservação. Destes, apenas 1% é de áreas de proteção integral, os outros 6,4% são protegidos como áreas de uso sustentável (MMA/IBAMA, 2011).

Diante das muitas formas de degradação que a Caatinga experimenta, como a extração de madeira, criação de estradas, criação extensiva de gado e agricultura (Costa et al. 2002), alguns autores vêm buscando estimar quanto ainda resta deste ecossistema. Para isso, eles têm utilizado diferentes abordagens e cada uma delas tem apresentado diferentes resultados para o estado de conservação do ecossistema, a depender do tipo de perturbação que é utilizado como base para a análise. Castelletti *et al*. (2003) considerando apenas as áreas cobertas por atividades agrícolas, estimaram que 27,5% (201.786 km²) da Caatinga se encontra modificada. Se somado às áreas agricultáveis e ao impacto das estradas, a área alterada pelo homem varia de 30,4% (223.100 km²) a 51,7% (379.565 km²) dependendo da largura da zona de efeito da estrada adotada (CASTELLETTI *et al*., 2003). Já baseado em critérios de intensidade de exploração e nível de manejo do solo, Sá *et al*. (2004) concluiu que 66% da Caatinga é degradada, incluindo desde áreas pouco degradadas (7,07%) a severamente degradadas (38,42%). Devido a estas abordagens diferentes, ainda não há uma estimativa adequada sobre o quanto da vegetação da Caatinga já foi alterada (CASTELLETTI *et al*., 2003; Oliveira, 2011) Estimativas mais recentes, e sem a determinação da fonte de perturbação, mostram que a região apresentava mais de 50% de sua área alterada pelo homem, aproximadamente 441.117,88 km², até o ano de 2009 (MMA/IBAMA, 2011). Porém, todas estas análises avaliam a Caatinga sem considerar as diferentes formações vegetacionais existentes no ecossistema. Isto torna ainda mais defasado o conhecimento sobre o atual estado de degradação da Caatinga e torna impossível a mensuração do montante de biodiversidade que já foi perdida.

REFERÊNCIAS BIBLIOGRÁFICAS

ANDRADE-LIMA, D. The caatinga dominium. **Revista Brasileira de Botânica**, v.4, p. 149-153. 1981.

ANDRADE-LIMA, D. Present day forest refuges in northeastern Brazil. *In*: PRANCE, G.T. (ed.) **Biological Diversification in the Tropics**. Columbia University Press, New York. p. 245. 1982.

ARROYO-RODRÍGUEZ, V.; MANDUJANO, S. Forest Fragmentation Modifies Habitat Qualityfor *Alouatta palliate.* **International Journal of Primatology**, v. 27, n.4, p. 1079-1096. 2006.

BULLOCK, J. M.; SILVERTOWN, J.; HILL, B. C. Plant demographic responses to environmental vatiations: Distinguishing between effects on age structure and effects on age-specific vital rates. **Journal of ecology**, v. 84, p.733-743. 1996.

BRUNA, E. M. Are plant populations in fragmented habitats recruitment limited? Tests with an Amazonian herb. **Ecology**, v.84, n.4, p. 932-947. 2003.

CALVO-ALVARADO, J.; MCLENNAN, B.; SÁNCHEZ-AZOFEIFA,A.; GARVIN, T. Deforestation and forest restoration in Guanacaste, Costa Rica: Putting conservation policies in context. **Forest Ecology and Management**, v. 258, p. 931–940. 2009.

CASTELLETTI, C.H.M.; SANTOS, A.M.M.; TABARELLI M.; SILVA, J.M.C. Quanto ainda resta da Caatinga? *In*: LEAL, I.R.; TABARELLI, M., SILVA, J.M.C. (eds.). **Ecologia e conservação da Caatinga**. Editora Universitária da UFPE, Recife, pp. 719-734. 2003.

CHAPIN III, F.S.; ZAVALETA, E.S.; EVINER, V.T.; ET AL. Consequences of changing biodiversity. **Nature**, v. 405, p. 234-242. 2000.

CHAPIN III, F.S. Effects of plant traits on ecosystem and regional processes: a conceptual framework for predicting the consequences of global changes. **Annals of Botany**, v. 91, p. 455-463. 2003.

COMITA, L. S.; THOMPSON, J.; URIARTE, M.; JONCKHEERE, I.; CANHAM, C.D.; ZIMMERMAN, J.K. Interactive effects of land use history and natural disturbance on seedling dynamics in a subtropical forest. **Ecological Applications**, v. 20, n.5, p.1270–1284. 2010.

CONTRERAS, C.; VALVERDE, T. Evaluation of the conservation status of a rare cactus (*Mammillaria crucigera*) through the analysis of its population dynamics. **Journal of Arid Environment**, v. 51, p. 89–102. 2002.

CURTIN, G.C. Livestock grazing, rest and restoration in arid landscapes. **Conservation Biology**, v. 16, p. 840–842. 2002.

ESPARZA-OLGUÍN, L.; VALVERDE, T; VILCHIS-ANAYA, E. Demographic analysis of a rare columnar cactus (*Neobuxbaumia macrocephala*) in the Tehuacan Valley, Mexico. **Biological Conservation,** v. 103, p. 349–359. 2002.

FLEISCHNER, T.L. Ecological cost of livestock grazing in Western North America. **Conservation Biology**, v.8, p. 629–644. 1994.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS - FAO. State of the world's forests 2007. **FAO**, Rome, Italy. 2007.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS - FAO. Global Forest Resource Assessment 2010: Key findings. **FAO**, Rome, Italy. 2010.

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS - FAO. State of the world's forests 2011. **FAO,** Rome, Italy. 2011.

FOLEY, J.A.; DEFRIES, R.; ASNER, G.P. et al. Global consequences of land use. **Science,** v. 309, p.570–574. 2005.

FREEDMAN, B.; LOVE, S.; O'NEIL, B. Tree species composi- tion, structure, and carbon storage in stands of urban forest of varying character in Halifax, Nova Scotia. **The Canadian Field-Naturalist**, v. 110, p. 675–682. 1996.

GALINDO, I.C.L. Relações solo-vegetação em áreas sob processo de desertificação no estado de Pernambuco. Tese, **Universidade Federal Rural de Pernambuco**. 2007.

GIULIETTI, A. M.; BOCAGE-NETA, A. L.; CASTRO, A. A. J. F.; ET AL. Diagnóstico de vegetação do bioma Caatinga. *In*: SILVA, J.M.C.; TABARELLI, M.; FONSECA, M. T.; LINS, L.V. Biodiversidade da Caatinga: áreas e ações prioritárias para a conservação. **Ministério do Meio Ambiente**. Brasília. p.48-90. 2004.

GIULIETTI, A.M.; HARLEY, R.M.; QUEIROZ, L.P.; BARBOSA, M.R.V.; BOCAGE, A.L.; FIGUEIREDO, M.A. Plantas endêmicas da caatinga. *In*: SAMPAIO, E.V.S.B.; GIULIETTI, A.M.; VIRGÍNIO, J.; GAMARRA-ROJAS, C.F.L. (eds). **Vegetação e flora das caatingas**. APNE/CNiP, Recife-PE. pp. 103-115. 2002.

HOBBS, R. J.; HUENNEKE, L. F. Disturbance, diversity and invasion: implications for conservation. **Conservation Biology**, v. 6, p.324-337. 1992.

HONGO, A.; MATSUMOTO, S.; TAKAHASHI, H.; ZOU, H.; CHENG, J.; JIA, H.; ZHAO, Z. Effect of exclosure and topography on rehabilitation of overgrazed shrub-steppe in the loess plateau of Northwest China. **Restoration Ecology**, v. 3, p.18–25. 1995.

IBGE - Atlas Nacional do Brasil: Região Nordeste. Rio de Janeiro: IBGE. 1985.

JACKSON, E.C.; KROGH, S.N.; WHITFORD, W.G. Desertification and biopedturbation in the northern Chihuahuan Desert. **Journal of Arid Environment**, v. 53, p.1–14. 2003.

KÜHN, I; KLOTZ, S. Urbanization and homogenization-Comparing the floras of urban and rural areas in Germany. **Biological Conservation,** v.127, p. 292-300. 2006.

LAMBIN, E.F.; GEIST, H.J.; LEPERS, F. Dynamics of land-use and land-cover change in tropical regions. **Annual Review Environment and Resources**, v. 28, p. 205–241. 2003.

LAURANCE, W. F., S. G.; LAURANCE, L.V.; FERREIRA, J.; RANKIN-DE M´ ERONA; GASCON, C.; LOVEJOY, T. E. Biomass collapse in Amazonian forest fragments. **Science**, v. 278, p. 1117–1118. 1997.

LEAL, I.R.; SILVA, J.M.C.; TABARELLI, M.; LACHER JR, T. Changing the course of biodiversity conservation in the Caatinga of northeastern Brazil. **Conservation Biology**, v. 19, n. 3, p. 701-706. 2005.

LÔBO, D.; LEÃO, T.; MELO, F.P.L.; SANTOS, A.M.M. ; TABARELLI, M. Forest fragmentation drives Atlantic forest of northeastern Brazil to biotic homogenization. **Diversity and Distributions**, v. 17, p. 287-296. 2011.

MAASS, M.; BÚRQUEZ, A.; TREJO, I.; VALENZUELA, D.; GONZÁLEZ, M.A.; RODRÍGUEZ, M.; ARIAS, H. Amenazas. *In*: Ceballos G, Martínez L, García A, Espinoza E, Creel JB, Dirzo R (eds.). **Diversidad, amenazas y áreas prioritárias para La conservación de las selvas secas Del Pacífico de México**. Fondo de Cultura Económica, México, 2010. pp. 321-346

MANDUJANO, M. C.; GOLUBOV, J. & HUENNEKE, L. F. Effect of reproductive modes and environmental heterogeneity in the population dynamics of a geographically widespread clonal desert cactus. **Population Ecology**, v.49, p.141–153. 2007.

MARTORELL, C.; PETERS, E. The measurement of chronic disturbance and its effects on the threatened cactus Mammillaria pectinifera. **Biological Conservation**, v. 124, p. 199–207. 2005.

MARTORELL, C.; PETERS, E. M. Disturbance-Response Analysis: a Method for Rapid Assessment of the Threat to Species in Disturbed Areas. **Conservation Biology**, v. 23, p. 377–387. 2008.

MCKINNEY, L. M.; LOCKWOOD, J. L. Biotic homogenization: a few winners replacing many losers in the next mass extinction. **Trends in Ecology and Evolution**, v. 14, p. 450-453. 1999.

MILCHUNAS, D.G.; LAUENROTH, K.W. Quantitative effects of grazing on vegetation and soil over a global range of environments. **Ecological Monographs,** v. 63, p. 327–366. 1993.

MILES, L.; NEWTON, A.; DEFRIES, R.; RAVILIOUS, C.; MAY, I.; BLYTH, S.; KAPOS, V.; GORDON, J. A global overview of the conservation status of tropical dry forests. **Journal of Biogeography**, v. 33, p. 491–505. 2006.

MMA- Ministério do Meio Ambiente / IBAMA - Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. **Monitoramento do desmatamento nos biomas brasileiros por satélite acordo de cooperação técnica MMA/IBAMA: Monitoramento do bioma Caatinga 2008-2009.** Brasília. 2011.

MMA - Ministério do Meio Ambiente. Primeiro relatório nacional para a Convenção Sobre Diversidade Biológica: Brasil. **MMA.** Brasília. 1998.

MMA - Ministério do Meio Ambiente. Biodiversidade Brasileira: Avaliação e identificação de áreas prioritárias para conservação, utilização sustentável e repartição de benefícios da biodiversidade brasileira. **Série Biodiversidade n°5**. Brasília. 2002.

MOONEY, H.A.; BULLOCK, S.H.; MEDINA, E. Introduction, *In:* Bullock, S.H., Mooney, H.A., Medina, E. (Eds.), **Seasonally Dry Tropical Forests.** Cambridge University Press, Cambridge, p. 146–194. 1995.

MURPHY, P.G.; LUGO, A.E. Ecology of Tropical dry forest. **Annual Review of Ecology and Systematic**, v. 17, p. 67-88. 1986.

NASCIMENTO, H.E.M.; LAURANCE, W. F. Biomass dynamics in Amazonian forest fragments. **Ecological Applications**, v.14, p.127–138. 2004.

NEIL, E.P.; FROEND, R.H.; LADD, P.G. Grazing in remnant woodland vegetation: changes in species composition and life form groups. **Journal of Vegetation Science**, v. 6, p.121–130. 1995.

NILSSON, C.; GRELSSON, G. The fragility of ecosystems: a review. **Journal of Applied Ecology**, v. 32, p.677–692. 1995.

OLIVEIRA, O.F. Caatinga of Northeastern Brazil: Vegetation and Floristic Aspects. *In*: RIET-CORREA, F.; PFISTER, J.; SCHILD, A.L.; WIERENGA, T. (eds.). **Poisoning by Plants, Mycotoxins, and Related Toxins**. CABI International, London. pp. 2-24. 2011.

PAKEMAN, R.J. Consistency of plant species and trait responses to grazing along a productivity gradient: a multi-site analysis. **Journal of Ecology**, v. 92, p. 893–905. 2004.

PORTILLO-QUINTERO, CA; SÁNCHEZ-AZOFEIFA, G.A. Extent and conservation of tropical dry forests in the Americas. **Biological Conservation**. v. 143, p. 144–155. 2010.

PRADO, D.E. As Caatingas da América do Sul. *In*: LEAL, I.R.; TABARELLI, M.; SILVA, J.M.C. Ecologia e Conservação da Caatinga (orgs). Editora **Universitária da UFPE**, Recife-PE. pp. 3-74. 2003.

PRINZING, A.; DURKA, W.; KLOTZ, S.; BRANDL, R. Which species become aliens? **Evolutionary Ecology Research**, v. 4, p.385-405. 2002

PYSEK, P.; JAROSIK, V.; KUCERA, T. Patterns of invasion in temperate nature reserves. **Biological Conservation**, vol. 104, p.13-24, 2002.

QUEIROZ, L.P. The Brazilian Caatinga: phytogeographical patterns inferred from distribution data of the Leguminosae. *In*: PENNINGTON, R.T.; LEWIS, G.P.; RATTER, J.A. **Neotropical Savannas and Seasonally Dry Forests** (eds). CRC Press/Taylor & Francis Group, Boca Raton. pp. 121-157. 2006.

REJMÁNEK, M.; RICHARDSON, D.M. What attributes make some plant species more invasive? **Advances in Invasion Ecology**, v. 77, p.1655-1661. 1996.

REJMANÉK, M.; RICHARDSON, D. M.; PYSEK, P. Plant ivasion and invisibility of plant communities. In: VAN DER MAAREL, E. **Vegetation Ecology**. Blackwell Publishing, Oxford. pp. 332-355. 2005.

REID, R. S.; GALVIN, K. A.; KRUSKA, R. S. Global significance of extensive grazing lands and pastoral societies: an introduction. *In*: GALVIN, K. A.; REID, R. S.; BEHNKE JR, R. H.; HOBBS, N. T. (orgs). **Fragmentation in Semi-Arid and Arid Landscapes: Consequences for Human and Natural Systems**. Springer. Dordrecht, The Netherlands. pp.413. 2008.

RIZZINI, C.T. Nota prévia sobre a divisão fitogeográfica do Brasil. **Revista Brasileira de Geografia**, v. 25, n. 1, p. 3-64. 1963.

RIZZINI, C.T. Tratado de Fitogeografia do Brasil. Hucitec/Universidade de São Paulo, São Paulo. 747 pp. 1979.

SÁ, I. B.; RICHÉ, G. R.; FOTIUS, G. A. As paisagens e o processo de degradação do semi-árido nordestino. *In*: SILVA, J. M. C.; TABARELLI,M.; FONSECA,M. T.; LINS, L. V. (orgs). **Biodiversidade da Caatinga: áreas prioritárias para conservação.** Ministério do Meio Ambiente: Universidade Federal de Pernambuco. Brasília. 15-37. 2004.

SALA, O.E.; CHAPIN III, F.S.; ARMESTO, J.J. et al. Global Biodiversity Scenarios for the Year 2100. **Science**, v. 287, p. 1770-1774. 2000.

SÁNCHEZ-AZOFEIFA, G.A.; QUESADA, M.; RODRIGUEZ, J.P; et al. Research priorities for Neotropical dry forests. **Biotropica**, v. 37 (4), p. 477–485. 2005.

SANTOS, B. A., C. A. PERES, M. A. OLIVEIRA, A. GRILLO, C. P. ALVES-COSTA, AND M. TABARELLI. Drastic erosion in functional attributes of tree assemblages in Atlantic forest fragments of northeastern Brazil. **Biological Conservation**, v.141, p. 249–260. 2008.

SANTOS, JC; LEAL, IR.; ALMEIDA-CORTEZ, JS.; FERNANDES, GW; TABARELLI, M. Caatinga: the scientific negligence experienced by a dry tropical forest. **Tropical Conservation Science**, v. 4, n. 3, p. 276-286. 2011.

SANTOS, M.F.A.V.; GUERRA, T.N.F.; SOTERO, M.C.; SANTOS, J.I.N. Diversidade e densidade de espécies vegetais da Caatinga com diferentes graus de degradação no município de floresta, Pernambuco, Brasil. **Rodriguésia,** v. 60, n.2, p. 389-402. 2009.

SAUNDERS, D.A.; HOBBS, R.J.; MARGULES, C.R. Biological consequences of ecosystem fragmentation: a review. **Conservation Biology**, v. 5, p.18–32. 1991.

SCHMALZEL, R.; REICHENBACHER, F.; RUNTMAN, S. 1995. Demographic study of the rare *Coryphantha robinsorum* (Cactaceae) in southeastern Arizona. **Madroñ**, v. 42, p. 332-348.

SILVA, P. S. D.; LEAL, I. R.; WIRTH, R.; TABARELLI, M. Harvesting of *Protium heptaphyllum* Aublet (March.) seeds (Burseraceae) by the leaf-cuting ant *Atta sexdens* L. promotes seed aggregation and seedling mortality. **Revista Brasileira de Botânica,** v.30, p.553-560. 2007.

SIGNH, S.P. Chronic disturbance, a principal cause of environmental degradation in developing countries. **Environmental Conservation**, v. 25, n.1, p.1-2. 1998.

SUTHERLAND, S. What makes a weed a weed: life history traits of native and exotic plants in the USA. **Oecologia**, v. 141, p.24-39. 2004.

URETA, C.; MARTORELL, C. Identifying the impacts of chronic anthropogenic disturbance on two threatened cacti to provide guidelines for population-dynamics restoration. **Biological Conservation,** v. 142, p. 1992–2001. 2009.

WATT, A. D. Measuring disturbance in tropical forests: a critique of the use of species-abundance models and indicator measures in general. **Journal of Applied Ecology**, v. 35, p. 467-469. 1988.

WILSON, H.D. Regeneration of native forest on Hinewai reserve, Banks Peninsula. **New Zealand Journal of Botany**, v. 32, p. 373–383. 1994.

ZHAO, W.Y.; LIA, J.L., QIB, J.G. Changes in vegetation diversity and structure in response to heavy grazing pressure in the northern Tianshan Mountains, China. **Journal of Arid Environments**, v.68, p. 465–479. 2007.

MANUSCRITO

Plant responses to chronic anthropogenic disturbances in the Caatinga vegetation: from species proliferation to biotic homogenization

Kátia Fernanda Rito[1],·Marcelo Tabarelli[2] and Inara R. Leal[2]*

[1]Programa de Pós-Graduação em Biologia Vegetal, Universidade Federal de Pernambuco, Av. Prof. Moraes Rego, s/ no., 50670-901, Recife-PE, Brazil

[2]Departamento de Botânica, Universidade Federal de Pernambuco, Av. Prof. Moraes Rego, s/ no., 50670-901, Recife-PE, Brazil

*Corresponding author: irleal@ufpe.br

SUMMARY

Chronic anthropogenic disturbances (CAD) have posed tangible threats to biodiversity-relevant tropical biotas but community- and ecosystem-level impacts still remain neglected. Here we address a 152-km^2 Caatinga landscape in northeast Brazil in order to investigate how Euphorbiaceae species and these seasonally-dry tropical plant assemblages respond to a gradient of chronic anthropogenic disturbances (CAD). Woody plant species were surveyed across 26 0.06-ha plots spatially independent exposed to CAD. Euphorbiaceae species accounted for 78.9% of all plants and 21.5 % of all species, with some species achieving up to 283 individuals per 0.06ha or 92% of all recorded plants. At plot scale, Euphorbiaceae total abundance and relative abundance did not correlate to disturbance level, but total and relative richness were higher in very high-disturbed plots. Among these frequent species, *Jatropha mollissima* abundance experienced a 6-fold increment across the CAD gradient, largely responding to increased similarity among intensively disturbed plots. Finally, the indicator species analysis underscored seven species for three groups of disturbance intensity: low, moderate and very high. In the Caatiga vegetation CAD may result in plant-community homogenization as Euphorbiaceae-dominated plant assemblages emerge. Such assemblages are possible due to the persistence (at least at local level) of several species in parallel to the proliferation of others (i.e. ruderals) as disturbance intensifies.

Key-words: Caatinga, Euphorbiaceae, chronic disturbances, land use, biotic homogenization.

INTRODUCTION

Habitat loss and fragmentation (i.e. acute human disturbance) has drastically altered the availability and quality of tropical forest habitats, particularly the permanent elimination of old-growth stands with negative impacts on tropical biodiversity persistence in human-modified landscapes (Foley *et al.* 2005; Hansen *et al.* 2013; Laurance *et al.* 2014). At demographic/population level, we already know that such acute disturbances may provoke reductions in terms of population number, size and range, what may culminate in local or even regional extinctions as documented across all the tropics, multiple taxa and trophic levels, from predators to plants (Laurance *et al.* 2001). Other species, however, may experience a contrasting trajectory relative to population size and range (i.e. the winner species sensu McKinney & Lockwood 1999). Moreover, both winner and losers tend belong to particular ecological groups, suggesting that biodiversity erosion in human-modified landscapes is not a random process (Laurance *et al.* 2006).

In contrast to acute, chronic human disturbances (sensu Singh 1998) are more subtle because it usually refers to regular, frequent and long-term removal of small amounts of biomass. In the case of forests, we refer to the collection of firewood, fodder and other non-timber forest products (NTFP), and biomass removal via livestock (Singh et al. 1984). Depending on its regime, chronic disturbances can impose negative effects from population (recruitment failure, local extinction and proliferation) to ecosystem level as it can drive shifts on soil, hydrology and microclimate conditions (Mishra *et al.* 2004; Portilla-Alonso & Martorell 2011). We shall mention demographic shifts experienced by some cactus species in Mexico (see C. Martorell and colaborators) and the replacement of Himalayan forests by shrub-dominated vegetation (Mehta *et al.*

2008) as illustrative cases. Usually resulting from rural population trying to meet basic patterns of livelihood via exploitation of forest/vegetation resources, chronic disturbance are not expected to be negligible or cease in the presence of environmental regulations (Shahabuddin & Prasad 2004; Kumar & Shahabuddin 2005; Karanth & DeFries 2010); they also threat the ecological integrity of protected areas (Kumar & Shahabuddin 2005).

Caatinga is a mosaic of seasonally dry tropical forest and scrub vegetation (Pennington *et al.* 2000) that occupies ca. 800,000 km^2 of northeastern Brazil (17% of territory extension, Portillo-Quintero & Sánchez-Azofeifa 2010). This semiarid biota has been occupied since mid-sixteenth century and currently home over 23 million people (11.8% of the Brazilian population), one of the most populated semiarid regions globally, with 26.03 hab/km^2 (Ab'Sáber 1999; Medeiros *et al.* 2012). Cattle-raising, wood extraction and subsistence agriculture activities have impose a continuum of degradation varying from biomass reduction to complete desertification (Leal *et al.* 2005; MMA & IBAMA 2010). To worse this scenario of high human pressure, strictly protected areas encompass less than 1% of Caatinga cover (Leal *et al.* 2005). Finally, the role played by chronic disturbances on vegetation and plant community structure has been just eventually examined (Sánchez-Azofeifa et al. 2005; Santos et al. 2011), which limit our ability to propose conservation guidelines and regulations (Leal *et al.* 2005; Lôbo *et al.* 2011).

Here we address Euphorbiaceae species and woody plant communities in a 152-km^2 Caatinga landscape in order to examine potential effects imposed by chronic anthropogenic disturbances (CAD), particularly firewood collection and browsing by livestock. We adopted the Euphorbiaceae species as a biological model as they refers to high diverse group in the Caatinga biota (Silva *et al.* 2003), particularly in human disturbed sites (Araújo *et al.* 2006). First, we offer family-level related scores across a set of plots covering a CAD gradient. Second, we examine species individual responses to the CAD gradient and correlate them to levels of cross-plot taxonomic similarity; we also report disturbance-level indicator species. Finally, we speculate about potential mechanisms responsible for our uncovered patterns and address theoretical implications on the CAD context.

METHODS

Study site

This study was carried out in a continuous patch of Caatinga vegetation near Parnamirim city (8°5'S; 39°34'W; 393 m asl) in Pernambuco state, NE Brazil. The climate is semi-arid with most of the 550 mm mean annual rainfall falling between January and May (IBGE 1985). The wet season is highly variable in its length, with the dry season lasting for 7-11 months (Nimer 1972; Prado 2003). The predominant soils are non-calcic brown soil, regosols, planosols and podzolic yellow soils (EMBRAPA 2001). The vegetation is mostly scrub, but includes patches of seasonally dry tropical forest (Sampaio 1995; Prado 2003).

Anthropogenic disturbance measure

We established 26 0.06-ha plots (each 30 x 20 m; separated by at least 2 km) over an area of approximately 152 km^2, with 15 sites on regosols and 11 on non-calcic brown soils. The habitat structure of Caatinga vegetation (especially the lack of a well-developed ground layer) combined with the chronic rather than acute nature of disturbance (see below), meant that reliable quantification of level of disturbance based on habitat characteristics was not possible. We then used surrogates of intensity of resource use to characterize the levels of disturbance from multiple factors based on 34 semi-structured interviews with local people. This measurement of multi-factor disturbance was adapted from previous studies by Martorell and Peters (2005) and Martorell and Peters (2009) on semiarid ecosystems from Mexico, and is detailed in Leal et al.(2014) . The major disturbances were identified as grazing by stock (goats and cattle), firewood collection, and hunting (Leal *et al.* 2014). Their intensity was inversely related to proximity to rural properties or to the city of Parnamirim (Leal *et al.* 2014). Through the interviews, we collected information on the number of people living in, and the number of stock managed by, each property.

We used five metrics to characterize the level of anthropogenic disturbance in each study area: (1) distance to Parnamirim; (2) distance to nearest farm; (3) distance to nearest road; (4) number of stock (goats and cattle combined) managed by farms within 2 km; and (5) number of people living in farms within 2 km. All spatial analyses were conducted using satellite imagery and ARCGIS software, with distances measured from the centres of sites. We classify sites into four categories of anthropogenic disturbance. For the three distance metrics, categories ranged from 1 (highest distances values) to four (lowest distance values), and, for numbers of stock and people, from 1 (lowest) to 4 (highest). We summed the values of each metric to obtain an overall disturbance score for each site, with the higher the score, the higher the disturbance. We used breakpoints in the frequency distribution of disturbance scores to classify sites into four categories of level of anthropogenic disturbance (for more details see Leal et al 2014).

Plant species surveys

Euphorbiaceae species is a monophyletic group, which have referred in the literature as common component of Caatinga degraded areas (Albuquerque *et al.* 2005; Andrade *et al.* 2005; Carneiro-Torres *et al.* 2011), thereby offering a interesting opportunity to address chronic anthropogenic disturbances (hereafter CAD). In each plot we marked and identified all woody individuals with diameter at soil level ≥ 3 cm and total height ≥ 1m (Rodal et al. 1992). We calculated the total Euphorbiaceae relative abundance and richness in each plot. In addition, we calculated the relative abundance for Euphorbiaceae species that were present in at least 50 percent of sites. As soil type did not influence Euphorbiaceae species richness and abundance, we remove it from analysis. We then used one-way ANOVA to evaluate the disturbance effect in these response variables. Normality of the residuals and homogeneity of variances were verified through Shapiro-Wilk and Levene tests, respectivelly. Response variables were log(10) transformed or arcsine-square root transformed (in case of percentage data) when they did not attend the assumptions of tests.

We used community abundance data to compute pairwise Bray-Curtis similarity matrix between sites. Based in Bray-Curtis similarity, we conducted an analysis of similarity (ANOSIM) and calculated the average of similarity percentage (SIMPER) between sites in the same anthropogenic disturbance level. We realized SIMPER analysis to identify plant species contributing mostly to similarity within each level. Afterward, we performed a non-metric multidimensional scaling (NMDS) ordination of all 26 sites using Bray-Curtis dissimilarity matrix of species composition (Krebs 1999). To avoid any bias resulting from highly abundant species and differences in samples sizes, the species abundance data were square root-transformed. To examine if there is a relationship between the floristic similarity and the changes in Euphorbiaceae group, we plotted the first NMDS axis against (1) Euphorbiaceae relative richness, (2) relative abundance of specie contributing mostly to similarity within groups, and (3) species benefitted by disturbance. Finally, we used the compositional community data to realize an indicator species analysis (sensu Dufrêne & Legendre 1997). All the analyses were performed in the software Primer 6.0 and R package.

RESULTS

A total of 5554 plant individuals, distributed among 51 species and 18 families, were recorded across the 26 plots. Euphorbiaceae accounted for 4383 individuals (167.88 ± 61.88, mean ± SD), followed by Fabaceae (732 indivíduals) and Apocynaceae (98 individuals). Euphorbiaceae plants were distributed into 11 species from six genera; *Croton* (88.8% of individuals), *Jatropha* (5.1%) and *Cnidoscolus* (4.1%) were the most abundant genera. Euphorbiaceae accounted for 78.9% of all plants and 21.5 % of all species, with some species achieving up to 283 individuals per 0.06 ha or 92% of all recorded plants.

Despite such contribution, Euphorbiaceae total abundance (168.6 ± 62.9; $F_{(3,19)} = 0.859$, $p = 0.479$) and relative abundance (77.9% ± 10.51; $F_{(3,19)} = 0.479$, $p = 0.7$) were not affected by disturbance level. However, the Euphorbiaceae total and relative richness were higher in very high-disturbed plots ($F_{(3,19)} = 5.396$, $p < 0.001$; $F_{(3,19)} = 4.531$, $p = 0.015$, respectively; Fig.1), with five species being recorded in more than 50% of all plots: *Croton blanchetianus, Croton heliotropiifolius, Jatropha molissima, Cnidoscolus quercifolius,* and *Sapium glandulosum.* Among these frequent species, *Jatropha mollissima* abundance correlated positively with disturbance level (both in absolute and relative), while the other four species did not exhibit any trend (Tables 1 and 2). Precisely, *J. molissima* abundance experienced a 6-fold increment, largely responding to increased similarity among intensively disturbed plots (Table 3).

ANOSIM test detected an effect of anthropogenic disturbance on floristic similarity (R= 0.129, p=0.037; low *versus* very high p = 0.029). Moreover, the floristic similarity among sites increased with the anthropogenic disturbance level (Table 3) and a detailed analysis of SIMPER, detected *Croton blanchetianus* as common species across the entire disturbance gradient, largely contributing for patterns of species similarity among sites (Table 3). It is important to highlight that, in very high-disturbed sites, from the eight species that contribute mostly to similarity among sites, five were Euphorbiaceae, responsible for 76.48% of species contribution to similarity (Table 3). We did not observe a relationship between the first NMDS axis and the Euphorbiaceae relative richness (R^2= 0.005, df = 1, p = 0.725) and the *J. molissima* relative abundance (R^2=0.0003,df = 1, p = 0.927). However, we observed a relationship between *C. blanchetianus* relative abundance and first NMDS axis (R^2= 0.6837, df = 1, p < 0.0001; Fig. 2). Finally, the indicator species analysis underscored seven species for three groups of disturbance intensity: low, moderate and very high (Table 4). Two Euphorbiaceae species were pointed out as indicators: *Cnidoscolus vitifolius* as indicator of areas with moderate anthropogenic disturbance jointly others four species belongs other diverse families, while *Jatropha mollissima* was the only indicator species of very high disturbed areas (Table 4).

DISCUSSION

Our findings suggest that (1) Euphorbiaceae species represent a dominant element across Caatinga disturbed stands, (2) although they refer to a monophyletic group, species do not respond linearly to CAD gradients, at least in terms of species abundance; (3) exception to this pattern refers to species responding positively and dominating plant assemblages in intensively disturbed sites, (4) with potential proliferating species, Euphorbiaceae species richness may increase at habitat level but it drops at habitat or landscape spatial level (i.e. reduced beta diversity), supporting increasing community-level taxonomic similarity as disturbance increases.

Chronic disturbances have been reported in the literature to be as much degrading as acute forms of disturbance such as habitat loss and fragmentation (Singh 1998). It may be particularly true across socioecological contexts marked by the presence of dense and poor rural populations with livelihood largely dependent on the direct exploitation of natural resources including firewood, fodder, and other NTFPs, which result in continuous biomass extraction (Kumar & Shahabuddin 2005). I refer to environmental-dependent human communities (sensu Millennium Ecosystem Assessment 2005) as seen today across many regions covered by forests and savannas (Davidar *et al.* 2010; Gaoue *et al.* 2013; Blackie *et al.* 2014). Despite potential degradation driven by CAD, few ecosystems have been examined, with most studies addressing effects on plant population level, particularly exploited species (Shahabuddin & Prasad 2004). As a package of imposed to targeted ecosystems, CAD and is expected to affect targeted species (direct effects), but frequently produce community- and ecosystem level effects by creating physically stressing environments (Sagar & Singh 2003) with evolutionary and ecological impacts mediated by disturbance intensity (Ureta *et al.* 2012). Although most plant responses are not linear across disturbance gradients, a common effect refer to shifts on vital rates leading to population decline or collapse (Vetaas 2000), while some species experience increased recruitment, population growth and density (Martorell *et al.* 2012). Thereby, intermediate levels of CAD can result in higher levels of species diversity (i.e. by mixing species of different successional status; Kumar & Ram 2005). However as disturbance intensity exceeds some thresholds, trees are replaced by shrubs (in the case of forests), vegetation biomass and structure collapse, plant communities become impoverished and may experiment increasing levels of invasion (Mishra *et al.* 2004; Mehta *et al.* 2008). Such trajectories experienced by temperate and tropical dry forests in India suggest that CAD my drive targeted vegetations towards transitional plant assemblages between two extremes: old-growth forest and shrub-dominated vegetation (Singh *et al.* 1984; Mehta *et al.* 2008).

Our results reinforce the notion that some species are able to benefit from CAD, as anecdotally reported for Euphorbiaceae species in the Caatinga vegetation. Furthermore, we offer evidence that such benefit may contribute to the emergence of impoverished and taxonomically similar plant assemblages at landscape level; i.e. a congruent set of signal indicating plant community homogenization partially due to proliferation of particular taxa in response to increasing disturbance. Proliferation of few adapted species and increased species dominance at community level represent an expected response in the case disturbance increments physical stress and environmental filtering (Tilman & Lehman 2001). However it is the first time that proliferation has been demonstrated to be correlated to biotic homogenization as an integrated CAD effect. In the context of anthropogenic disturbances, benefiting species have been referred as weedy (Tilman & Lehman 2001), ruderal (Martorell *et al.* 2012), ecological winners or proliferating species (Tabarelli *et al.* 2012), including both exotic and native species, with much more species assigned as losers than winners (McKinney & Lockwood 1999; Tabarelli *et al.* 2010).

Like species extinction in tropical human-modified landscapes, species proliferation is not a random process since some plant traits or life-history strategies can confer either vulnerability or increased fitness in particular disturbance scenarios (Laurance *et al.* 2001; Tabarelli *et al.* 2008). A well documented example refers to some small-seeded, pioneer plant species proliferating across human-modified landscapes in the Atlantic forest region (Lôbo *et al.* 2011). Although the reduced number of species examined in this study does not allow us to identify plant traits correlated with species persistence or proliferation in response to disturbance, it is worth mention potential traits exhibited by our winners. *Jatropha molissima* has a low quality wood ─ low density wood (0.29g/cm^3; Vitorio 2013) ─ and because of this it is not used by local human communities as firewood and for fence constructions, as observed in our set of interviews. Moreover, the low wood density implies in high water reserve that may be used to production of fruits and leaves (Borchert 1980; Rivera et al. 2002) and consequently to contribute for plant maintenance in disturbed areas. *J. molissima* also bears flowers along the whole year, it is self-compatible and in natural conditions the percentage of fruit production is 85% (Santos et al. 2005). Thus, a high reproductive success and a low use pressure would contribute for its proliferation as documented here.

On the other hand, *C. blanchetianus* seems to be favored by (1) resprouting ability, (2) production of viable seeds per agamospermy (Araujo 1998), and (3) this specie is also able and presents low foraging value for goats sheep and cattle, the main herbivores in Caatinga (Cândido 1998; Moreira et al. 2006; Santana et al. 2011) achieving10-45 thousand individuals per hectare in successional areas (Carvalho *et al.* 2001). Note that in the Caatinga vegetation slash-and-burn agriculture leading to soil degradation, firewood collecting, and overgrazing have been reported to the main degrading drivers (Leal *et al.* 2005). In this ecological context, sprouting ability, unpalatable foliage represent key trait (Bond & Midgley 2001). Apparently, Euphorbiaceae species bear more than a single trait-package conferring low vulnerability or increased capacity to benefit from certain levels of CAD, what is consistent to the both species and family level scores exhibited across our CAD gradient.

The Caatinga vegetation has experienced increasing levels of human disturbances since the first European settlements in the 15th century as the alarming rates of human-driven soil aridization and desertification confirm (Leal *et al.* 2005). Like other tropical biotas with significant conservation value, Caatinga will continue to experience immense the immense challenges posed by poverty, increasing human population and can climate change what makes imperative to conservation objectives and human needs (Karanth & DeFries 2010). Here we offer evidence for a plant-community homogenization driven by CAD as Euphorbiaceae-dominated plant assemblages emerge, probably as transitional assemblages. Such assemblages are possible due to the persistence (at least at local level) of several species in parallel to both the proliferation of others (i.e. ruderals) as disturbance intensifies. As proposed, biotic homogenization also benefits from the extirpation of disturbance-sensitive taxa (McKinney & Lockwood 1999), but it was not documented among Euphorbiaceae species in our setup. This phenomenon add new insights and confirm CAD potential for degradation; it also reinforces that notion that biotic homogenization is a more generalized response to human disturbances as previously advocated (Tabarelli *et al.* 2012). As a first description based on a “natural experiment”, much more information is to address the generality of the patterns documented here as well as the underlying mechanism supporting species proliferation and biotic homogenization in the case we intend offer guidelines for conciliating human livelihood and ecosystem integrity.

ACKNOWLEDGMENTS

This study was supported by the Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco (FACEPE process 04-2.05/08) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) provided a master's scholarship to K.F. Rito. We would like to thank the Estação de Agricultura Irrigada de Parnamirim (UFRPE) and Centro de Pesquisas Ambientais do Nordeste (CEPAN) for logistic support and L.C. Leal, G. Burle, and J.D. Ribeiro Neto for their help in the field work.

REFERENCES

Ab'Sáber, A. N. (1999) Dossiê Nordeste seco. *Estudos avançados* **13**(36): 1999.

Albuquerque, U. P. d., Andrade, L. d. H. C. & Silva, A. C. O. d. (2005) Use of plant resources in a seasonal dry forest (Northeastern Brazil). *Acta Botanica Brasilica* **19**: 27-38.

Andrade, L. d., Pereira, I. M., Leite, U. T. & Barbosa, M. R. V. (2005) Análise da cobertura de duas fitofisionomias de caatinga, com diferentes históricos de uso, no município de São João do Cariri, estado da Paraíba. *Cerne* **11**(3): 253-262.

Araujo, E. L. (1998) Aspectos da dinamica populacional de duas especies em floresta tropical seca (Caatinga), nordeste do Brasil. In: Campinas: Universidade Estadual de Campinas.

Araújo, F. S. d., Martins, S. V., Meira Neto, J. A. A., Lani, J. L. & Pires, I. E. (2006) Estrutura da vegetação arbustivo-arbórea colonizadora de uma área degradada por mineração de caulim, Brás Pires, MG. *Revista Árvore* **30**: 107-116.

Assessment, M. E. (2005) *Ecosystems and human well-being*. Island Press Washington, DC.

Blackie, R., Baldauf, C., Gautier, D., Gumbo, D., Kassa, H., Parthasarathy, N., Paumgarten, F., Sola, P., Pulla, S., Waeber, P. & Sunderland, T. C. H. (2014) Tropical dry forests: The state of global knowledge and recommendations for future research. In: *CIFOR Discussion Paper* pp. 1-30. Bogor: Center for International Forestry Research (CIFOR).

Bond, W. J. & Midgley, J. J. (2001) Ecology of sprouting in woody plants: the persistence niche. *Trends in Ecology & Evolution* **16**(1): 45-51.

Borchert, R. (1980) Phenology and Ecophysiology of Tropical Trees: Erythrina Poeppigiana O. F. Cook. *Ecology* **61**(5): 1065-1074.

Cândido, M. (1998) Caatinga-importante recurso forrageiro do Nordeste Brasileiro (In Portuguese.) In: Viçosa: Universidade Federal de Viçosa.

Carneiro-Torres, D., Cordeiro, I., Giulietti, A., Berry, P. & Riina, R. (2011) Three new species of Croton (Euphorbiaceae s.s.) from the Brazilian Caatinga. *Brittonia* **63**(1): 122-132.

Carvalho, F. C., Araújo Filho, J. A., Garcia, R., Pereira Filho, J. M. & Albuquerque, V. M. (2001) Efeito do corte da parte aérea na sobrevivência do marmeleiro (Croton sonderianus Müll. Arg.). *Revista Brasileira de Zootecnia* **30**(03): 930-934.

Davidar, P., Sahoo, S., Mammen, P. C., Acharya, P., Puyravaud, J.-P., Arjunan, M., Garrigues, J. P. & Roessingh, K. (2010) Assessing the extent and causes of forest degradation in India: Where do we stand? *Biological Conservation* **143**(12): 2937-2944.

Dufrêne, M. & Legendre, P. (1997) Species assemblages and indicator species: the need for a flexible asymmetrical approach *Ecological Monographs* **67**(3): 345-366.

EMBRAPA. (2001) *Mapa exploratório de solos do município de Parnamirim, PE.* Recife: Empresa Brasileira de Pesquisa Agropecuária - Embrapa Solos UEP

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C., Gibbs, H. K., Helkowski, J. H., Holloway, T., Howard, E. A., Kucharik, C. J., Monfreda, C., Patz, J. A., Prentice, I. C., Ramankutty, N. & Snyder, P. K. (2005) Global Consequences of Land Use. *Science* **309**(5734): 570-574.

Gaoue, O. G., Horvitz, C. C., Ticktin, T., Steiner, U. K. & Tuljapurkar, S. (2013) Defoliation and bark harvesting affect life-history traits of a tropical tree. *Journal of Ecology* **101**(6): 1563-1571.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O. & Townshend, J. R. G. (2013) High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science* **342**(6160): 850-853.

IBGE. (1985) *Atlas Nacional do Brasil: Região Nordeste. IBGE- Instituto Brasileiro de Geografia Estatística*. Rio de Janeiro.

Karanth, K. K. & DeFries, R. (2010) Conservation and management in human-dominated landscapes: Case studies from India. *Biological Conservation* **143**(12): 2865-2869.

Krebs, C. J. (1999) *Ecological methodology*. California: Benjamin/Cummings Menlo Park.

Kumar, A. & Ram, J. (2005) Anthropogenic disturbances and plant biodiversity in forests of Uttaranchal, central Himalaya. *Biodiversity & Conservation* **14**(2): 309-331.

Kumar, R. & Shahabuddin, G. (2005) Effects of biomass extraction on vegetation structure, diversity and composition of forests in Sariska Tiger Reserve, India. *Environmental Conservation* **32**(03): 248-259.

Laurance, W. F., Cochrane, M. A., Bergen, S., Fearnside, P. M., Delamônica, P., Barber, C., D'Angelo, S. & Fernandes, T. (2001) The Future of the Brazilian Amazon. *Science* **291**(5503): 438-439.

Laurance, W. F., Nascimento, H. E. M., Laurance, S. G., Andrade, A. C., Fearnside, P. M., Ribeiro, J. E. L. & Capretz, R. L. (2006) Rain forest fragmentation and the proliferation of successional trees *Ecology* **87**(2): 469-482.

Laurance, W. F., Sayer, J. & Cassman, K. G. (2014) Agricultural expansion and its impacts on tropical nature. *Trends in Ecology & Evolution* **29**(2): 107-116.

Leal, I. R., Da Silva, J. M. C., Tabarelli, M. & Lacher, T. E. (2005) Changing the Course of Biodiversity Conservation in the Caatinga of Northeastern Brazil. *Conservation Biology* **19**(3): 701-706.

Leal, L., Andersen, A. & Leal, I. (2014) Anthropogenic disturbance reduces seed-dispersal services for myrmecochorous plants in the Brazilian Caatinga. *Oecologia* **174**(1): 173-181.

Lôbo, D., Leão, T., Melo, F. P. L., Santos, A. M. M. & Tabarelli, M. (2011) Forest fragmentation drives Atlantic forest of northeastern Brazil to biotic homogenization. *Diversity and Distributions* **17**(2): 287-296.

Martorell, C., Garcillán, P. & Casillas, F. (2012) Ruderality in extreme-desert cacti? Population effects of chronic anthropogenic disturbance on Echinocereus lindsayi. *Population Ecology* **54**(2): 335-346.

Martorell, C. & Peters, E. M. (2005) The measurement of chronic disturbance and its effects on the threatened cactus *Mammillaria pectinifera*. *Biological Conservation* **124**(2): 199-207.

Martorell, C. & Peters, E. M. (2009) Disturbance-Response Analysis: a Method for Rapid Assessment of the Threat to Species in Disturbed Areas. *Conservation Biology* **23**(2): 377-387.

McKinney, M. L. & Lockwood, J. L. (1999) Biotic homogenization: a few winners replacing many losers in the next mass extinction. *Trends in Ecology & Evolution* **14**(11): 450-453.

Medeiros, S. d. S., Cavalcante, A. d. M. B., Perez Marin, A. M., Tinôco, L. B. d. M., Hernan Salcedo, I. & Pinto, T. F. (2012) Sinopse do censo demográfico para o semiárido brasileiro.

Mehta, V. K., Sullivan, P. J., Walter, M. T., Krishnaswamy, J. & DeGloria, S. D. (2008) Impacts of disturbance on soil properties in a dry tropical forest in Southern India. *Ecohydrology* **1**(2): 161-175.

Mishra, B. P., Tripathi, O. P., Tripathi, R. S. & Pandey, H. N. (2004) Effects of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, northeast India. *Biodiversity & Conservation* **13**(2): 421-436.

MMA & IBAMA. (2010) Monitoramento do desmatamento nos biomas brasileiros por satélite. Acordo de cooperação técnica MMA/IBAMA. Monitoramento do Bioma Caatinga 2002 a 2008.

Moreira, J. N., LIRA, M. A., Santos, M. V. F., Ferreira, M. d. A., Araújo, G. G. L., Ferreira, R. L. C. & Silva, G. (2006) Caracterização da vegetação de Caatinga e da dieta de novilhos no Sertão de Pernambuco. *Pesquisa Agropecuária Brasileira* **41**(11): 1643-1651.

Nimer, E. (1972) Climatologia da região Nordeste do Brasil. Introdução à climatologia dinâmica. *Revista Brasileira de Geografia* **34**: 3-51.

Pennington, T. R., Prado, D. E. & Pendry, C. A. (2000) Neotropical seasonally dry forests and Quaternary vegetation changes. *Journal of Biogeography* **27**(2): 261-273.

Portilla-Alonso, R. M. & Martorell, C. (2011) Demographic consequences of chronic anthropogenic disturbance on three populations of the endangered globose cactus Coryphantha werdermannii. *Journal of Arid Environments* **75**(6): 509-515.

Portillo-Quintero, C. A. & Sánchez-Azofeifa, G. A. (2010) Extent and conservation of tropical dry forests in the Americas. *Biological Conservation* **143**(1): 144-155.

Prado, D. E. (2003) As caatingas da América do Sul. In: *Ecologia e conservação da Caatinga*, eds. I. R. Leal, M. Tabarelli & J. M. C. Silva, pp. 3-73. Recife: Editora Universitária da UFPE.

Rivera, G., Elliott, S., Caldas, L., Nicolossi, G., Coradin, V. & Borchert, R. (2002) Increasing day-length induces spring flushing of tropical dry forest trees in the absence of rain. *Trees* **16**(7): 445-456.

Rodal, M. J. N., Sampaio, E. V. & Figueiredo, M. A. (1992) *Manual sobre métodos de estudo florístico e fitossociológico: ecossistema caatinga*. Brasília: Sociedade Botânica do Brasil.

Sagar, R. & Singh, J. S. (2003) Predominant phenotypic traits of disturbed tropical dry deciduous forest vegetation in northern India. *Community Ecology* **4**(1): 63-71.

Sampaio, E. (1995) *Overview of the Brazilian caatinga.* . Cambridge (RU). Cambridge University Press.

Sánchez-Azofeifa, G. A., Quesada, M., Rodríguez, J. P., Nassar, J. M., Stoner, K. E., Castillo, A., Garvin, T., Zent, E. L., Calvo-Alvarado, J. C., Kalacska, M. E. R., Fajardo, L., Gamon, J. A. & Cuevas-Reyes, P. (2005) Research Priorities for Neotropical Dry Forests. *Biotropica* **37**(4): 477-485.

Santana, D., Lira, M. & Santos, M. (2011) Caracterização da caatinga e da dieta de novilhos fistulados, na época chuvosa, no semiárido de Pernambuco. *Revista Brasileira de Zootecnia* **40**(1): 69-78.

Santos, J. C., Leal, I. R., Almeida-Cortez, J. S., Fernandes, G. W. & Tabarelli, M. (2011) Caatinga: the scientific negligence experienced by a dry tropical forest. *Tropical Conservation Science* **4**(3): 276-286.

Santos, M. J., Machado, I. C. & Lopes, A. V. (2005) Biologia reprodutiva de duas espécies de Jatropha L.(Euphorbiaceae) em Caatinga, Nordeste do Brasil. *Revista Brasileira de Botânica* **28**(2): 361-373.

Shahabuddin, G. & Prasad, S. (2004) Assessing Ecological Sustainability of Non-Timber Forest Produce Extraction: The Indian Scenario. *Conservation and Society* **2**(2): 235-250.

Silva, R. A. d., Santos, A. M. M. & Tabarelli, M. (2003) Riqueza de plantas lenhosas em cinco unidades de paisagem da Caatinga. In: *Ecologia e Conservação da Caatinga*, ed. A.-C. J. Leal I R, Santos J C, pp. 337-366. Recife: Editora Universitária da UFPE.

Singh, J., Pandey, U. & Tiwari, A. (1984) Man and forests: a central Himalayan case study. *AMBIO: A Journal of the Human Environment* **13**(2): 80-87.

Singh, S. P. (1998) Chronic disturbance, a principal cause of environmental degradation in developing countries. *Environmental Conservation* **25**(01): 1-2.

Tabarelli, M., Aguiar, A. V., GirÃO, L. C., Peres, C. A. & Lopes, A. V. (2010) Effects of Pioneer Tree Species Hyperabundance on Forest Fragments in Northeastern Brazil

Efectos de la Hiperabundancia de Especies de Árboles Pioneros sobre Fragmentos de Bosque en el Noreste de Brasil. *Conservation Biology* **24**(6): 1654-1663.

Tabarelli, M., Lopes, A. V. & Peres, C. A. (2008) Edge-effects Drive Tropical Forest Fragments Towards an Early-Successional System. *Biotropica* **40**(6): 657-661.

Tabarelli, M., Peres, C. A. & Melo, F. P. L. (2012) The ‘few winners and many losers’ paradigm revisited: Emerging prospects for tropical forest biodiversity. *Biological Conservation* **155**(0): 136-140.

Tilman, D. & Lehman, C. (2001) Human-caused environmental change: Impacts on plant diversity and evolution. *Proceedings of the National Academy of Sciences* **98**(10): 5433-5440.

Ureta, C., Martorell, C., Hortal, J. & Fornoni, J. (2012) Assessing extinction risks under the combined effects of climate change and human disturbance through the analysis of life-history plasticity. *Perspectives in Plant Ecology, Evolution and Systematics* **14**(6): 393-401.

Vetaas, O. (2000) The effect of environmental factors on the regeneration of Quercus semecarpifolia Sm. in Central Himalaya, Nepal. *Plant Ecology* **146**(2): 137-144.

Vitorio, L. A. P. (2013) Densidade da madeira de espécies da Caatinga. In: Campina Grande: Universidade Estadual da Paraíba.

Table 1 Total abundance (individuals/0.1 ha) of five Euphorbiaceae woddy species (mean ± SD) in 0.1 ha plots in different anthropogenic disturbance levels at Caatinga continuous patches, at Parnamirim City, northeast of Brazil.*

	Disturbance level				Two-way ANOVA			
					Disturbance		Soil	
	Low (n=6)	Moderate (n=6)	High (n=6)	Very high (n=8)	F	p	F	P
Croton blanchetianus	90.7 ± 90.2	126.0 ± 54.9	99.7 ± 98.7	134.6 ± 69.0	1.67	0.21	0.21	0.65
Croton heliotropiifolius	88.3 ± 116.6	17.2 ± 33.1	32.2 ± 35.0	12.0 ± 20.2	1.08	0.38	0.02	0.89
Jatropha molissima	2.3 ± 2.9^{a}	3.5 ± 3.0^{ab}	3.5 ± 5.3^{ab}	8.1 ± 2.9^{b}	3.91	**0.02**	1.39	0.25
Cnidoscolus quercifolius	5.0 ± 4.6	2.8 ± 3.7	5.3 ± 3.1	5.0 ± 2.9	1.57	0.23	1.46	0.24
Sapium glandulosum	0.0 ± 0.0	1.8 ± 4.0	2.5 ± 2.8	3.3 ± 4.5	2.45	0.10	4.42	0.05

*Value in bold denotes significant difference.

Table 2 Relative abundance (%) of five Euphobiaceae woody species (mean ± SD) in 0.1 ha plots in different anthropogenic disturbance levels at Caatinga continuous patches, at Parnamirim City, northeast of Brazil.*

Species	Disturbance level				Two-way ANOVA			
					Disturbance		Soil	
	Low (n=6)	Moderate (n=6)	High (n=6)	Very high (n=8)	F	p	F	p
Croton blanchetianus	38.1 ± 35.8	57.1 ± 14.7	47.4 ± 31.3	63.2 ± 18.9	1.41	0.27	1.21	0.29
Croton heliotropiifolius	27.9 ± 34.9	7.9 ± 13.4	22.0 ± 21.7	7.3 ± 11.4	1.26	0.32	0.60	0.45
Jatropha molissima	0.8 ± 1.1[a]	1.5 ± 1.2[ab]	2.0 ± 3.3[ab]	4.2 ± 1.5[b]	4.35	**0.02**	0.48	0.50
Cnidoscolus quercifolius	2.3 ± 2.8	1.6 ± 2.2	3.1 ± 1.4	2.7 ± 1.8	1.81	0.18	3.97	0.06
Sapium glandulosum	0 ± 0	1.3 ± 2.8	1.7 ± 1.8	2.5 ± 4.0	2.31	0.11	4.31	0.05

*Data in percentage. Value in bold denotes significant difference.

Table 3 The percent contribution of species most strongly contributing to similarity between sites within anthropogenic disturbance groups, based on SIMPER analysis. *

Low (35.9)		**Moderate (48.29)**		**High (50.14)**		**Very high (54.20)**	
Species	**Contrib (%)**	**Species**	**Contrib (%)**	**Species**	**Contrib (%)**	**Species**	**Contrib (%)**
Croton blanchetianus Müll.Arg.	27.19	*Croton blanchetianus* Müll.Arg.	46.18	*Croton blanchetianus* Müll.Arg.	33.84	*Croton blanchetianus* Müll.Arg.	48.67
Croton heliotropiifolius Kunth	14.29	*Senegalia polyphylla* (DC.) Britton & Rose	8.13	*Croton heliotropiifolius* Kunth	13.72	*Jatropha mollissima* (Pohl) Baill.	13.15
Poincianella pyramidalis (Tul.) L.P. Queiroz	11.43	*Anadenanthera colubrina* (Vell.) Brenan	7.36	*Poincianella pyramidalis* (Tul.) L.P. Queiroz	11.83	*Cnidoscolus quercifolius* Pohl	9.31
Aspidosperma pyrifolium Mart.	9.69	*Piptadenia stipulacea* (Benth.) Ducke	5.74	*Cnidoscolus quercifolius* Pohl	10.3	*Poincianella pyramidali*s (Tul.) L.P. Queiroz	8.7
Cnidoscolus quercifolius Pohl	8.17	*Jatropha mollissima* (Pohl) Baill.	5.09	*Sapium glandulosum* (L.) Morong	5.01	*Croton heliotropiifolius* Kunth	2.82
Fraunhofera multiflora Mart.	5.55	*Aspidosperma pyrifolium* Mart.	4.06	*Aspidosperma pyrifolium* Mart.	3.41	*Amburana cearensis* (Allemao) A.C.Sm.	2.63
Mimosa tenuiflora (Willd.) Poir.	4.08	*Croton heliotropiifolius* Kunth	3.75	*Jatropha mollissima* (Pohl) Baill.	3.2	*Sapium glandulosum* (L.) Morong	2.53
Piptadenia stipulacea (Benth.) Ducke	3.42	*Cnidoscolus vitifolius* (Mill.) Pohl	3.31	*Fraunhofera multiflora* Mart.	3.17	*Erythroxylum* sp.	2.22
Pilosocereus gounellei subsp. *gounellei*	3	*Cnidoscolus quercifolius* Pohl	2.6	*Anadenanthera colubrina* (Vell.) Brenan	2.49		
Jatropha mollissima (Pohl) Baill.	2.29	*Cynophalla hastata* (Jacq.) J . Presl	1.82	*Myracrodruon urundeuva* Allemão	2.42		
Bauhinia cheilantha (Bong.) Steud.	1.65	*Mimosa tenuiflora* (Willd.) Poir.	1.55	*Piptadenia stipulacea* (Benth.) Ducke	2.18		
		Myracrodruon urundeuva Allemão	1.2				
Cum(%)	*90.75*		*90.78*		*91.57*		*90.02*

*Bold values *in parenthesis* indicated the level of similarity within groups. Contrib (%) = percentage of the total similarity among sites within anthropogenic disturbance level that are explained by variation in the abundance of each listed plant species; Cum(%) = cumulative percentage of species contribution to similarity.

Table 4 Result of Indicator species analysis for different anthropogenic disturbance levels at Caatinga continuous patch, at Parnamirim City, northeast of Brazil. *

Specie	Group	Indval	p	Frequence
Pilosocereus gounellei	1	0.6666667	0.0030	4
Anadenanthera colubrina	2	0.6197183	0.0064	15
Colicodendron yco	2	0.5000000	0.0230	3
Cynophala hastata	2	0.4750000	0.0291	4
Cnidoscolus vitifolius	2	0.4482759	0.0254	6
Guapira graciliflora	2	0.4375000	0.0464	4
Jatropha molissima	4	0.4653938	0.0091	20

*Group represents different disturbance levels. 1= Low, 2=Moderate, 4=Very High. Indval represents the indicator value and to express species importance in communities within groups, is a index given by specificity and fidelity (for more details see Dufrêne and Legendre [1997]). Values of $p \leq 0.05$ indicates significancy and Frequence the number of times that the species was present in sites within a certain level of disturbance.

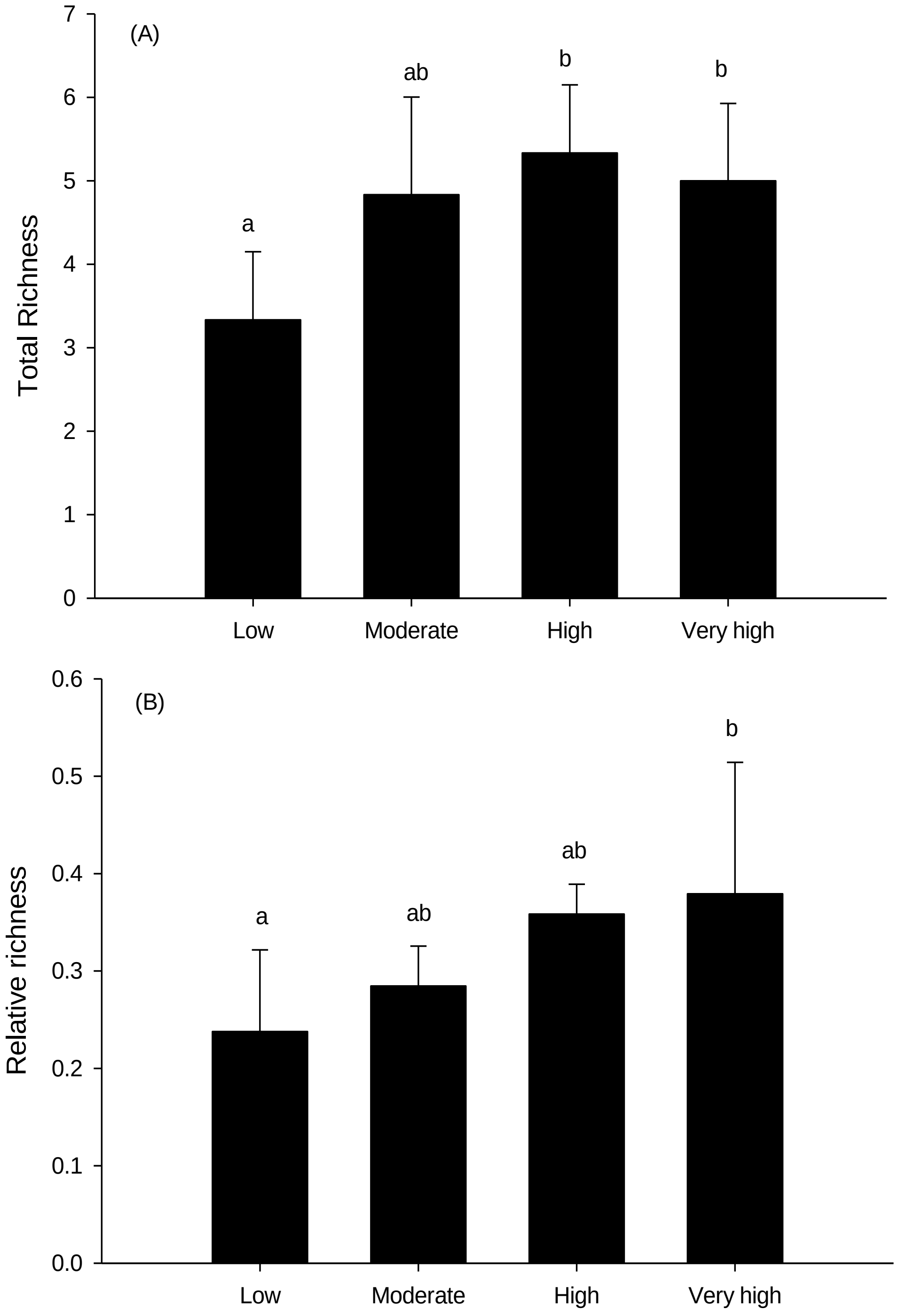

Fig. 1 Euphorbiaceae total richness (A) and relative richness (B) comparisons among different anthropogenic disturbance levels at Caatinga continuous patch, at Parnamirim City, northeast of Brazil. Significant differences in post hoc comparisons (Tukey test) are indicated by different letters. Error bars indicate standard deviation.

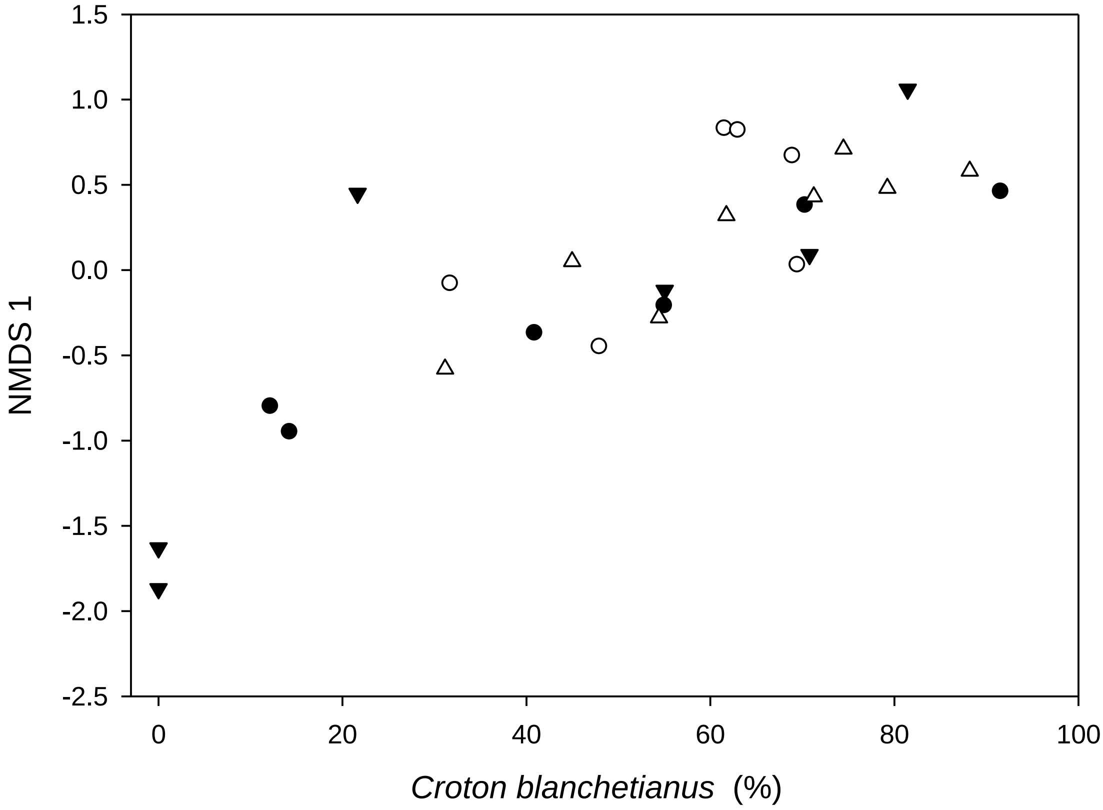

Fig. 2 Relation between *Croton blanchetianus* abundance in sites at different levels of anthropogenic disturbance and the nonmetric multidimensional scaling (NMDS) ordination (axis 1) of 26 sites on the basis of their floristic similarity at Caatinga continuous patch, Parnamirim City, northeast of Brazil. Black triangles= low disturbance; open circles=moderate disturbance; black circles= high disturbance; open triangles=very high disturbance.

RESUMO

Distúrbios antrópicos crônicos tem implicado em ameaças reais à biodiversidade das biotas tropicais, mas seus impactos tanto no nível de comunidade quanto de ecossistema permanecem negligenciados. Este estudo foi realizado em uma área de 152 km^2 de Caatinga no nordeste do Brasil no intuito de investigar como espécies de Euphobiaceae e assembléias de plantas em florestas tropicais secas respondem às perturbações antrópicas crônicas. Foram amostrados todos indivíduos adultos de espécies de plantas lenhosas em 26 parcelas espacialmente independentes de 0,06ha. Todas estas parcelas estavam expostas, em diferentes níveis, às perturbações antrópicas crônicas. Euphorbiaceae representou 78.9% de todas as plantas amostradas e 21.5 % de todas as espécies, com algumas espécies alcançando 238 indivíduos por 0,06ha ou 92% de todas as plantas amostradas. Na escala da parcela, a abundância total e abundância relativa de Euphorbiaceae não foi correlacionada com o nível de perturbação, mas a riqueza total e relativa da família foi maior em parcelas com níveis muito altos de perturbação. Dentre as espécies mais frequentes, houve um incremento de seis vezes na abundância de *Jatropha mollissima* ao longo dos níveis de perturbação, em grande parte respondendo ao aumento na similaridade entre parcelas intensamente perturbadas. Por fim, a análise de espécies indicadoras ressaltou sete espécies para três grupos de intensidade de distúrbio: baixo, moderado e muito alto. Na Caatinga as perturbações antrópicas crônicas podem resultar em homogeneização da comunidade de plantas, com assembleias dominadas por Euphorbiaceae. Tal organização de comunidade é possível devido a persistência (pelo menos ao nível local) e proliferação de apenas um grupo de espécies à medida que o distúrbio aumenta.

Palavras-chave: Caatinga, Euphorbiaceae, distúrbios crônicos, uso de terra, homogeneização biótica

ANEXO

CAMBRIDGE | Instructions for Contributors

Environmental Conservation

The main criteria for acceptance of submissions to *Environmental Conservation* are originality, scientific rigour, international interdisciplinary appeal to the readership and acceptability of style. Papers must not have been published previously, nor be under consideration for publication elsewhere. *Environmental Conservation* employs an interactive processing and editing procedure. We receive many more submissions than we have space to publish and the final authority in all matter relating to publication lies with the Editor.

Submission of Manuscripts

All material to be considered for publication in *Environmental Conservation* must be submitted in electronic format via the journal's online submission system at the Journal's ScholarOne site at http://mc.manuscriptcentral.com/envcon. New authors should create an account prior to submitting a manuscript for consideration. Submissions should be typewritten, double-spaced, on A4 or US letter paper, and supplied electronically as Word or rich-text files. PDF files cannot be considered.

Submissions of the following types are accepted for review in the Journal:

- Subject Reviews (<10 000 words including legends and references)
- Research Papers (<8000 words including legends and references)
- Reports (<4000 words including legends and references)
- Comments (<1500 words including any legends and references)

Articles received by the Journal will undergo a pre-screening process to increase the efficiency of the publication process. Papers that are considered to be of minor importance to the readership of the Journal are not reviewed and any papers with format problems are returned for revision. Papers selected for review are sent out to three referees, who agree to undertake the refereeing within a short period of time.

Licence and Permissions

Upon receipt of accepted manuscripts at Cambridge University Press authors will be invited to complete a copyright licence to publish form. The corresponding author is required to assign the copyright of any paper published to the Foundation for Environmental Conservation. Work submitted for publication must be original, previously unpublished, and not under consideration for publication elsewhere. If previously published figures, tables, or parts of text are to be included, the copyright-holder's permission must have been obtained prior to submission. This must include the right to reproduce and publish electronically. The author bears the responsibility for checking whether material submitted is subject to copyright or ownership rights, e.g. photographs, illustrations and data. Where use is so restricted, the Editors and the Publisher must be informed with the submission of the material.

Preparation of Manuscripts

General

Papers must be clearly written in English. A recent issue of the journal from Volume 38 onwards should be consulted for style. Units, symbols and related matters are based on the CBE Manual *Scientific Style and Format* (6th Edition, 1994, ISBN 0-521-47154-0).

Text should be prepared in Word or rich-text format in a common 12-point font such as Arial. All pages should be numbered and should be line numbered to ease the review process. The first (title) page must include author names (capitals) and full addresses where the work was carried out. The corresponding author should provide an email address. Current addresses, where different, should also be given, and a word count (including references and legends) provided. The second page of Research Papers, Reports and Subject Reviews requires a Summary that is concise and informative, succinctly expressing the context, purpose, approach, findings and implications of the study. There should be no references or unexplained abbreviations. Avoid phrases such as 'are described', 'will be discussed', etc. Comments do not have a Summary, but please remember that all submissions require an additional Abstract at submission, which is used in the review process. Research papers and Reports will normally have such sections as: Introduction; Methods; Results; Discussion; Acknowledgements; References; and Figure Legends. The Methods section should include essential details of study area, analyses and sources of data. Each Table and Figure should be loaded as a separate file; format details are provided below. A subject review should have sections appropriate to the topic addressed, but any methods (e.g. selection of sources, statistical analyses) should be detailed in a separate section. Please note that **footnotes** are **not** used in the *Environmental Conservation*.

Spelling and Language Editing

Before submitting your manuscript you may wish to have it edited for language, particularly if English is not your first language. Authors are liable for all costs associated with such services. Spelling should conform to *The Concise Oxford Dictionar*y, 10th edition or later. Scientific names of genera, species and subspecies, but not of higher groups should be italicized. Foreign words should be italicized at their first mention, where they also must be defined and explained, but thereafter may be written in normal typeface.

Units and Abbreviations

The International System of units (SI) is to be used. Units, symbols and related matters are based on the CBE Manual *Scientific Style and Format* (6th Edition, 1994, ISBN 0-521-47154-0). Acronyms and abbreviations are generally in upper case and should be expanded at the first mention. All currencies should at first mention have a US$ exchange rate (e.g. '£1 = US$1.20, January 2011).

References

All references to cited literature should be given in alphabetical order on a new page at the end of the paper. Where a Reference is not to a recognized periodical or substantive book, but rather to an official document, internal technical or consultancy report, greater flexibility may be exercised. The chief criterion for correct referencing is that a reader be provided with the information necessary to find the item cited. References should also be given to international treaties (UNTS number). Unnecessary references should be omitted. Each reference should contain some or all of the following:

• Author surnames with initials (no spaces between initials)

• Year of publication

• Title of paper (roman) or book (italic)

• Journal name (italic)

• Volume number (bold)

• First and last page numbers

For example:

• van der Voet, E., Kleijn, R. & de Haes, U. (1996) Nitrogen pollution in the European Union- origin and proposed solutions. *Environmental Conservation* **23**: 120-132.

In a book reference the edition, chapter(s), place of publication and name of publisher should be given:

• Myers, N. (1995) Tropical deforestation: population, poverty and biodiversity. In: *The*

Economics and Ecology of Biodiversity Decline: the Forces Driving Global Change, ed. T.M. Swanson, pp. 111-22. Cambridge, UK: Cambridge University Press.

Within the text citations are given by name of author and year of publication, for example:

• 'This has been observed elsewhere (Bloggs 2006; Smith 2008; Smith *et al.* 2009)' or

• 'This phenomenon was first described by Smith and Bloggs (1992) after a previous study in the region by Clark *et al.* (1990)'

References to material available on the World Wide Web can be given only if the information is available on an official site and without charge to readers. The format for citations is as follows:

• Beckleheimer, J. (2010) How do you cite URLs in a bibliography? [www document]. URL

http://www.nrlssc.navy.mil/meta/bibliography.html

Submitted and otherwise unpublished papers should be mentioned in the text only (e.g. 'K. Brown & N.V.C. Polunin, unpublished data 2010', or 'T.J. Willis, personal communication 2011'). Where an author, or the same group of authors, has written more than one paper in the same year, these should be distinguished by the letters *a, b, c,* etc., in the order in which they are mentioned in the text. Do not use such terms as Op. cit. or Ibid.

Figures

Environmental Conservation is pleased to announce that all figures submitted to the journal in colour will, where justified, be published in colour online at no cost. If you do not wish for your figures to be published online in colour, please submit your figures in black & white. All figures will be printed (i.e. hard copy) in black & white unless a fee is paid. If you request colour figures in the printed version, you will be contacted by

CCC-Rightslink who are acting on our behalf to collect Author Charges. Please follow their instructions in order to avoid any delay in the publication of your article.

Please make sure the figure legends are understandable for both the colour, and the black & white version of your figure. The maximum number of Figures will normally be four. Figures should be supplied in an electronic format at a suitable size for printing with the following resolutions:

Line artwork

Format: tif or eps

Colour mode: black and white (also known as 1-bit)

Resolution: 1200 dpi

Combination artwork (line/tone)

Format: tif or eps

Colour mode: greyscale (also known as 8-bit)

Resolution: 800 dpi

Black and white halftone artwork

Format: tif

Colour mode: greyscale (also known as 8-bit)

Resolution: 300 dpi

Colour halftone artwork

Format: tif

Colour mode: CMYK colour

Resolution: 300 dpi

Figures should be referred to in the text and numbered consecutively (e.g. Fig. 1). They should be supplied separately from the main body of the text, with their approximate final positions marked within the main text. Each figure should be submitted electronically as a separate file.

Figures should not be framed and as simple as possible. Avoid fine lines, stippling and unusual symbols, which cannot be reproduced satisfactorily when reduced to one (84mm) or two-column width (175mm). Where various shadings are used within a figure please ensure that it is easy to differentiate between them. Line charts, bar charts and pie charts should be two-dimensional. Labels on Figures should be brief and explained in the legend. Preferred symbols are open and filled circles, boxes and triangles, and these should be used consistently between Figures and as near as possible to 9 point when reproduced in the final journal.

Figure legends should be in a list separate from the Figures at the end of the main text. They should make the Figure comprehensible without reference to the main text. If abbreviations or symbols are used in the figures they should be explained in the figure legend, if they have not been explained in a key. Maps must have scales and photographs should include an indication of scale. Figures reproduced from other sources should be fully acknowledged in the legend, and permission for their reproduction in both written and electronic format should be sought before use.

Tables

Tables should be submitted in preferably MS Word or Excel format, and presented one per file, complete with heading. They should be uploaded separately from the main body of the text, with their approximate final positions indicated in the text. Tables should be suitable for production on a single journal page or less. Table captions should be brief and ensure the Table is comprehensible without reference to the text. They should incorporate any scale, key or symbols,etc. necessary to interpret the information. The maximum number of Tables will normally be four.

Supplementary Material

There will normally be one of the following reasons for you to be supplying supplementary material to accompany the online version of your article:

1. You wish to link to additional information which due to its nature does not lend itself to print media (examples- full data sets, movie or sounds files etc…).

2. The Editor of the Journal has requested that you extract certain information from the original article in order to allow for space constraints of the print version.

3. You have requested additional material to be available to accompany an article that does not normally allow such material to be included (example – tables to accompany a correspondence article). N.B. Please note that no copyediting or quality assurance measures will be undertaken on supplementary material (other than to ensure that the file is intact). The authors therefore warrant that the supplementary material that they submit is in a suitable format for publication in this manner. The material shall be published online in exactly the form that it is supplied.

Submission

Please follow the following instructions to supply supplementary material to accompany the online version of your article:

1. Each supplementary file must be supplied as a separate file. Do not supply this material as part of the file destined for publication in the print journal.

2. Each supplementary file must have a clear title (eg, Figure S1).

3. Provide a text summary for each file of no more than 50 words. The summary should describe the contents of the file. Descriptions of individual figures or tables should be provided if these items are submitted as separate files. If a group of figures is submitted together in one file, the description should indicate how many figures are contained within

the file and provide a general description of what the figures collectively show.

4. The file type and file size in parentheses.

5. Ensure that each piece of supplementary material is clearly referred to at least once in the print version of the paper at an appropriate point in the text, using the format ‘Table S1’ (for Tables), ‘Figure S2’ (for Figures), with other relevant materials (for example questionnaires, programming code) cited as ‘Appendix S1’, and is also listed at the end of the paper before the reference section.

6. A statement must be added before the acknowledgments section of the manuscript, an example is shown below:

Supplementary material

For supplementary material accompanying this paper, visit http://www.journals.cambridge.org/ENC

7. Supplementary Materials like the paper itself will not be alterable once the paper has been accepted, and authors will not be sent proofs of this material. The authors should understand that they bear whole responsibility for this content.

Format and file size

• File sizes should be as small as possible in order to ensure that users can download them quickly.

• Images should be a maximum size of 640 x 480 pixels at a resolution of 72 pixels per inch.

• Authors should limit the number of files to under ten, with a total size not normally exceeding 3 MB. Sound/movie files may be up to 10 MB per file; colour PDFs/PowerPoint may be up to 5 MB per file; all other general file types may be up to 2 MB per file but most files should be much smaller.

• We accept files in any of the following formats (if in doubt please enquire first): MS Worddocument (.doc) , Adobe Acrobat (.pdf), Plain ASCII text (.txt), Rich Text Format (.rtf), WordPerfect document (.wpd), HTML document (.htm), MS Excel spreadsheet (.xls), GIF image (.gif), JPEG image (.jpg), TIFF image (.tif), MS PowerPoint slide (.ppt), QuickTime movie (.mov), Audio file (.wav), Audio file (.mp3), MPEG/MPG animation (.mpg) If your file sizes exceed these limits or if you cannot submit in these formats, please seek advice from the editor handling your manuscript.

Open Access Publication in Environmental Conservation

Cambridge Open Option allows authors the option to make their articles freely available to everyone, immediately on publication. This service reflects Cambridge's commitment to further the dissemination of published academic information.

The programme allows authors to make their article freely available in exchange for a one-off charge paid either by the authors themselves or by their associated funding body. This fee covers the costs associated with the publication process from peer review, through copyediting and typesetting, up to and including the hosting of the definitive version of the published article online.

Payment of this one-off fee entitles permanent archiving both by Cambridge University Press and by the author; however, it also enables anyone else to view, search and download an article for personal and non-commercial use. The only condition for this is that the author and original source are properly acknowledged.

The Cambridge Open Option is only offered to authors upon acceptance of an article for publication and as such has no influence on the peer review or acceptance procedure. The paper will continue to be made available in both print and online versions, but will be made freely available to anyone with Internet links via our online platform, Cambridge Journals Online. In addition, such papers will have copyright assigned under a Creative Commons Attribution licence, which enables sharing and adaptation, providing attribution is given. All articles will continue to be handled in the normal manner with peer-review, professional production and online distribution in Cambridge Journals Online. Articles will also be included in the relevant Abstracting & Indexing services and in CrossRef, and can have supplementary content (text, video or audio) added to their online versions. Cambridge will also deposit the article in any relevant repositories on the author's behalf, where that is a condition of the funding body.

The Cambridge Open Option is now available to authors of articles in Environmental Conservation at the standard Cambridge rate of **£1695/$2700** per article. Requests to take up the Cambridge Open Option will be subject to approval by the Editors of the Journal. For more information on Open Access and Cambridge Journals, please follow this link.

Required Statements

Acknowledgements

You may acknowledge individuals or organizations that provided advice, support (non-financial). Formal financial support and funding should be listed in the following section.

Financial support

Please provide details of the sources of financial support for all authors, including grant numbers.For example, "This work was supported by the Medical research Council (grant number XXXXXXX)". Multiple grant numbers should be separated by a comma and space, and where research was funded by more than one agency the different agencies should be separated by a semi-colon, with "and" before the final funder. Grants held by different authors should be identified as belonging to individual authors by the authors' initials. For example, "This work was supported by the Wellcome Trust

(A.B., grant numbers XXXX, YYYY), (C.D., grant number ZZZZ); the Natural Environment Research Council (E.F., grant number FFFF); and the National Institutes of Health (A.B., grant number GGGG), (E.F., grant number HHHH)". Where no specific funding has been provided for research, please provide the following statement: "This research received no specific grant from any funding agency, commercial or not-for-profit sectors."

Conflict of interest

Please provide details of all known financial, professional and personal relationships with the potential to bias the work. Where no known conflicts of interest exist, please include the following statement: "None."

Ethical standards

Where research involves human and/or animal experimentation, the following statements should be included (as applicable): "The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008." and "The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional guides on the care and use of laboratory animals."

Tracking Your Submission

Your paper will be acknowledged by email on receipt. A reference number will be allocated which you should use in all correspondence and for tracking an electronic submission on ScholarOne. All submissions approved for peer review are seen by at least two reviewers. The journal makes every effort to ensure that reviewers report swiftly. As soon as the Editor has reached a decision on your paper you will be notified by e-mail. Appeals on any decisions made by the Editors must be made within a month of the decision. Authors of papers supported by reviews can expect normally to have their paper returned to them, with comments of both reviewers and Editor. The revised manuscript should be submitted as directed with an accompanying letter detailing how substantive points raised have been addressed. After acceptance, the copy-editor and publisher deal with all matters relating to printing. Proofs and offprint order forms will be sent to corresponding authors. If authors are to be away from their correspondence address during the ten weeks after acceptance, they must have arrangements in place for queries from the copyeditor to be addressed promptly, and the proofs to be carefully read and swiftly returned. Please address any further queries concerning publication to:

Professor N.V.C. Polunin,

Editor,

envcons@ncl.ac.uk

(Revised 01/09/14)