

<b>Institution: The University of Edinburgh</b>
<b>Unit of Assessment: B7 – Earth Systems and Environmental Sciences</b>
<b>Title of case study: DEVELOPMENT OF ENVIRONMENTAL SERVICES IN BELIZE</b>
<p><b>1. Summary of the impact</b></p> <p><b>Impacts:</b> I) Improved provision of environmental services in Belize, including the creation of plant reference collections / databases and the training of conservation professionals and students.          II) Land-management policy formation by the Government of Belize and NGOs.</p> <p><b>Significance and reach:</b> Over the period 2009 – July 2013 there has been a step-change in the quality of biodiversity monitoring carried out by NGOs and the Government of Belize; including the latter being better able to meet international reporting requirements. Over the same period, 40 conservation professionals have been trained in Belize.</p> <p><b>Underpinned by:</b> Research into savanna plant diversity, led by the University of Edinburgh (1996 - 2012).</p>
<p><b>2. Underpinning research</b>          Numbered references refer to research outputs in Section 3.</p> <p><b>Key researchers</b>          The start and end dates of continuous employment in the School of GeoSciences, University of Edinburgh, are shown along with the most recent / current position of each researcher.</p> <p>Stuart, Lecturer in Geography (1988 onwards)          Furley, Professor of Biogeography (1962 - 2001; Professor Emeritus: 2001 onwards)          Cameron, PDRA (2009 - 2011)</p> <p><b>Research overview and context</b>          The savannas of Belize are an important source of plant biodiversity locally and within the Neotropics, as they contain a unique mix of species from both North and South America, as described in work co-authored by Furley [1]. However, the botany of the lowland savannas of Belize was relatively unexplored until 1996 when an expedition led by Stuart, Furley and Bridgewater, a tropical ecologist at the Royal Botanical Gardens Edinburgh (RBGE), discovered a unique diversity of plant species in this region [2,3]. In work published in 2005, Stuart demonstrated the potential of optical satellite data to map savannas in the country's largest private protected area [4]. Following this, a Royal Geographical Society/ IBG/ Gilchrist Educational Trust award allowed Stuart to examine the feasibility of mapping savanna habitats in detail by using both radar and optical satellite data. Positive results in one area underpinned a successful proposal to DEFRA's Darwin Initiative to conduct the first comprehensive mapping and botanical assessment of savannas in Belize. This project, undertaken in collaboration between Stuart, Furley and Cameron at Edinburgh with the botanical expertise of colleagues at the RBGE, including Bridgewater, Haston (Curator) and Goodwin (Botanist) and consortium partners in Belize, including the University of Belize (UB), the Government of Belize and Belize Botanic Gardens, has enhanced understanding of the distribution of rare and threatened plant species, assessed the condition of remaining savanna areas, and estimated how much has been converted to other uses.</p> <p><b>Key research findings that underpin the subsequent impact</b>          The Darwin Initiative mapping of the country's remaining savanna areas, published in 2011, established a new 2010 baseline for national conservation planning and local protected area management [5]. This work revealed that over 10% of savanna areas in the country had been lost within the last 20 years [5]. The new mapping also guided a systematic, nationwide programme of plant collecting into parts of the country where there had been little previous exploration. During this work (2009-2012), Goodwin and Lopez of UB worked with Stuart and Furley to catalogue over</p>

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10,000 plant specimens. As a result of these surveys, 54 plant species were found for the first time in Belize [6]. Savannas were shown to contain approximately 33% of the total floristic diversity of the country and, importantly, 43% of all national endemic species [6]. The findings from this research have challenged the popular impression of savannas as areas of low biodiversity and established the importance of this ecosystem for the plant diversity of Belize. These new data were combined with existing historical collections which the project collated from herbaria around the world to produce the first (published in 2013) comprehensive botanical checklist of the savanna flora of Belize and have also been assimilated into the Flora Meso-Americana project, the definitive source of reference data for the identification of plants throughout Mexico and Central America [6].

### 3. References to the research

Comments in bold on individual outputs give information on the quality of the underpinning research and may include the number of citations (Scopus, up to September 2013) and/or the 2012 Thomson Reuters Journal Impact Factor (JIF). The starred outputs best indicate this quality.

#### [1] Peer-reviewed journal article

J. C. Lenthall, S. Bridgewater and P. A. Furley (1999) A phytogeographic analysis of the woody elements of New World savannas, *Edinburgh Journal of Botany* 56(2), 293-305, DOI: 10.1017/S0960428600001153

#### [2] Peer-reviewed journal article

Bridgewater, S., Ibáñez A, Ratter J. A. and Furley, P. (2002) 'Vegetation Classification and Floristics of the Savannas and Associated Wetlands of the Rio Bravo Conservation and Management Area, Belize', *Edinburgh Journal of Botany* 59 (3), 421–442, DOI: 10.1017/S0960428602000252

#### [3]\* Peer-reviewed journal article, 20 citations, JIF: 2.8

Murray, M., R., Zisman, S., A., Furley, P. A., Munro, D. M., Gibson, J., Ratter, J. A., Bridgewater, S., Minty, C. D., Place, C. J. (2003) 'The Mangroves of Belize. Distribution, Composition and Classification', *Forest Ecology and Management* 174, 265–279, DOI: 10.1016/S0378-1127(02)00036-1

#### [4]\* Peer-reviewed journal article, >10 citations, JIF: 4.9

Stuart, N., Barratt, T., and Place, C. (2006) 'Classifying the Neotropical Savannas of Belize using Remote Sensing aided by Ground Survey', *Journal of Biogeography*, 33, 476–490, DOI: 10.1111/j.1365-2699.2005.01436.x

#### [5] Technical Report providing the Savanna ecosystems map

Cameron, I.D, Stuart, N., Goodwin, Z. (2011) Savanna Ecosystems Map. Technical report to DEFRA for Darwin Initiative Grant 17-022 'Conservation of the lowland savanna of Belize', <http://tinyurl.com/B7-4-S3-5B>

#### [6]\* Peer-reviewed monograph establishing the first comprehensive reference collection for savanna plant diversity in Belize

Goodwin, Z.A., Lopez, G., Stuart, N., Bridgewater, S.G., Haston, E., Furley, P.A. and Harris, D.J. (2013) 'A Checklist of the Vascular Plants of the Lowland Savannas of Belize, Central America', *Phytotaxa*, 101 (1): 1-119, DOI: 10.11646/phytotaxa.101.1.1

A further metric of research quality is given by the peer-reviewed grants that have contributed to the preceding outputs and/or the pathway to impact, which include:

- 'Conservation of the lowland savannas of Belize' (2009 - 2012), sponsor: DEFRA Darwin Initiative 17-022, value: £287k, awarded to Stuart with 6 consortium partners. Website: <http://tinyurl.com/B7-4-S3-GRANT1>, 2012 final report: <http://tinyurl.com/B7-4-S3-REPORT1>.
- 'Radar remote sensing of neotropical savannas' (2006), Royal Geographical Society/ IBG/ Gilchrist Educational Trust, value £15k, awarded to Stuart. This grant provided the proof of concept necessary for the Darwin award application.

#### 4. Details of the impact

Lettered references relate to corroboration sources in Section 5.

##### Improved provision of environmental services in Belize

**Pathway:** Darwin Initiative grants require that the research should create information and resources that will have lasting impact in the host country. The project described here directly influenced the creation in late 2009 of a new Environmental Research Institute (ERI) at the UB (<http://www.eriub.org/>), including research funding from the project enabling the appointment of foundation staff, as corroborated in a letter from the Terrestrial Science Director of the ERI [A]. The created plant reference collections and identification services run by the Ministry of Natural Resources and a database of savanna plants are now used by both the Belizean government and NGOs in environmental monitoring and land management. In 2012, Belize Tropical Forest Studies used the mapping produced by the Darwin Initiative to revise the National Ecosystems Map of Belize, which now forms part of UNESCO's land cover map for Central America, as corroborated in a letter from the Director of Belize Tropical Forest Studies [B]. Local staff members trained by UK scientists have taken up specialist roles in environmental monitoring / consulting services to government and NGOs.

##### Significance and reach:

- The ERI, the Ministry of Natural Resources and environmental NGOs based in Belize now conduct biodiversity monitoring work of enhanced quality as a result of the comprehensive databases, mapping, plant reference collections (such as updating the Belize National Herbarium in the Forest Department, Belmopan) and well-trained staff that have resulted from the Darwin Initiative research, as stated in letters from the Terrestrial Science Director of the ERI [A] and the Director of Belize Tropical Forest Studies [B]. Corroboration that these research-derived improvements constituted a “step-change in the quality of services for plant identification and biodiversity monitoring” carried out by both NGOs and the Government of Belize is provided in a letter from an independent botanical expert, the Regius Keeper of the RBGE [C]. The then British High Commissioner to Belize can provide corroboration that the Government has been better able to fulfil monitoring and reporting commitments, such as those to the UN, to protect plant diversity [D].
- The embedding of the research into the UNESCO land-cover map (the standard reference for land-use planning / management organisations within Belize) has informed the Government's 2012 National Land Use Policy and Planning Framework, as corroborated in a letter from the Director of Belize Tropical Forest Studies [B]. Further information on the use of the savanna map by Belize Tropical Forest Studies and its integration into policy can be found on pages 2, 4, 7, 13 and 15 of the Grant Final Report cited in Section 3.
- A 2011 consultative workshop organised by the ERI on the findings of the Darwin Initiative work was attended by 30 stakeholders, representing all the key government Ministries and NGOs in Belize and led to a policy briefing to the Ministry of Natural Resources and the National Protected Areas Secretariat [E].
- Since 2009 UK researchers have trained more than 40 Belize-based environmental services professionals (30 person-weeks of training), across the majority of conservation organisations in Belize, as corroborated by the ERI Terrestrial Science Director [A] and ERI annual reports [F].

##### Public engagement with, and understanding of, Belizean biodiversity

**Pathway:** Charitable organisations in Belize, such as Belize Zoo and Belize Botanic Gardens have used the research in public engagement activities. This includes the 2011 establishment of a Savanna Trail and Educational Classroom at the Botanic Gardens [G] and the use by the Zoo of research materials to design interpretative signs and guide books for a \$30k investment into educational facilities [H].

**Significance and reach:** Since 2011, with support from the Ministry of Education, Belize Botanic Gardens have organised school visits by over 1,600 children and 90 teachers to the Savanna Trail

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**[G]**. Furthermore, over 1,000 copies of a children's board game with content traceable to the research have been purchased by primary schools **[G]**. With over 50,000 visitors last year (10,000 of which by schoolchildren), the Zoo is the most popular visitor attraction in Belize and the Darwin Initiative research is now central to the self-sustaining public engagement initiatives at the national Zoo promoting savanna conservation **[H]**.

**5. Sources to corroborate the impact**

Where two web-links are given, the first is the primary source and the second an archived version.

**[A] Factual Statement from the Terrestrial Science Director, Environmental Research Institute (ERI) at the University of Belize**

Corroborates: I) the creation in late 2009 of the ERI was underpinned by Darwin Initiative work, II) the research-led development of databases, mapping, plant reference collections and III) the provision of 30 person-weeks of training to local staff (2009 - 2012). Video testimony is also available (<http://edin.ac/1gDM9aY>, start – 02:10mins).

**[B] Factual Statement from the Director of Belize Tropical Forest Studies**

Corroborates the incorporation of the savanna mapping into the National Ecosystems Map of Belize and the use of this data by NGOs, land managers and the Government of Belize, including having informed the 2012 National Land Use Policy and Planning Framework. Video testimony is also available (<http://edin.ac/19ERB68>, start - 2:37mins).

**[C] Factual Statement from the Regius Keeper of the Royal Botanic Garden, Edinburgh**

Provides independent verification that the botanical data and training provided by the research has led to a “step-change in the quality of the services for plant identification and biodiversity monitoring” carried out by both NGOs and the Government of Belize.

**[D] Former British High Commissioner to Belize**

Can provide corroboration that: I) the research has enhanced the capacity of the Belizean government to undertake statutory monitoring and reporting obligations to international organisations (e.g. the UN) and II) that the project has left a legacy in Belize through the practitioners trained. Video testimony is available (<http://edin.ac/1gDM9aY>, 02:15 - 03:15mins).

**[E] Report on the Science Savanna Meeting April 2011 and the implications for savanna conservation (June 2012)** <http://tinyurl.com/B7-4-S5-XE> or <http://tinyurl.com/B7-4-S5-E> Provides evidence of the outcomes of the Savanna Science Meeting held in Belize in April 2011 (Page 4). Further information on the workshop and resultant policy briefing to the Ministry of Natural Resources can be found on Pages 3, 6, 13, 16 and 22 of the Grant Final Report in Section 3.

**[F] Annual Report of the Environmental Research Institute, University of Belize (August 2009 – July 2010)**

<http://tinyurl.com/B7-4-S5-XF1B> or <http://tinyurl.com/B7-4-S5-F1B> Provides evidence of involvement in the Darwin Lowland Savanna Project and its subsequent influence in the establishment of ERI training programmes for conservation practitioners (Pages 9-13).

**[G] Report on Education and Conservation of Lowland Savanna at Belize Botanic Gardens** <http://tinyurl.com/B7-4-S5-XG1> or <http://tinyurl.com/B7-4-S5-G>

Provides evidence that over the period April 2011 - June 2012 the Darwin Project has funded the creation of the savanna habitat in the Gardens and its research has been used to produce educational materials targeted at primary schools across Belize. Video testimony from the Director of Belize Botanic Gardens is also available (<http://edin.ac/184CsyZ>, 0.15 - 1:17mins).

**[H] Factual Statement from the Director of Belize Zoo**

Provides corroboration that the research has influenced the stated Zoo activities and visitor numbers to the trails. Also provides summary feedback from these visitors about their improved awareness of the savannah after visiting the new trails at the Education Centre. Video testimony is also available (<http://edin.ac/184CsyZ>, 1.18 - 2:04mins).