Darwin Initiative – Final Report

*(To be completed with reference to the Reporting Guidance Notes for Project Leaders (http://darwin.defra.gov.uk/resources/reporting/) - it is expected that this report will be a **maximum** of 20 pages in length, excluding annexes)*

Darwin project information

Project Reference	16-003
Project Title	Tools, training and research for managing eco-hydrology of Cape flora
Host country(ies)	South Africa
UK Contract Holder Institution	Open University
UK Partner Institution(s)	
Host Country Partner Institution(s)	South African National Biodiversity Institute; Cape Nature
Darwin Grant Value	£325,540.05
Start/End dates of Project	01.09.07 / 31.03.11
Project Leader Name	Jonathan Silvertown
Project website:	www.open.ac.uk/fynbos
Report Author(s) and date	Jonathan Silvertown, Yoseph Araya. 14 June 2011

1 Project Background

Fynbos is a key component of South Africa's Cape Floristic Region, a biodiversity hotspot. At present, the region is experiencing increasing demands upon water resources. However there has been little ecohydrological data on keystone fynbos species to assist nature conservation planning.

We established 10 sites across the region and gathered baseline ecohydrological data. We then quantified the dependence of fynbos community structure upon hydrological processes and made advanced species distribution models. We then interpolated how the fynbos flora responds to model perturbation scenarios.

To ensure continuity, we trained local conservation personnel and are disseminating the findings among conservation managers and stakeholders to guide decision-making.

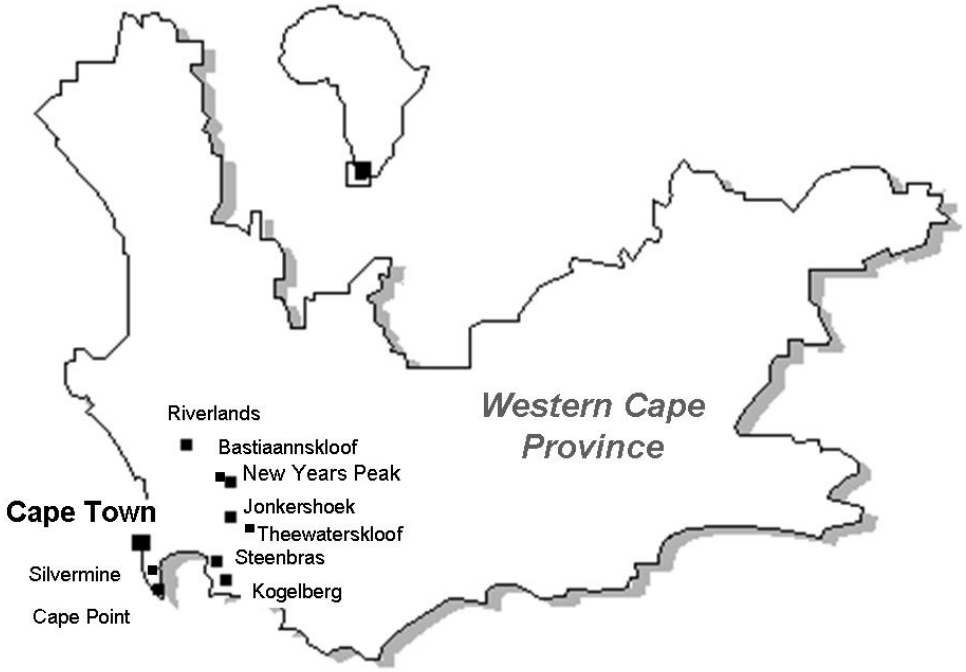

Figure 1. Location of the 10 sites established in the Western Cape Province, South Africa. *Note that there are two sites at Cape Point*.

2 Project support to the Convention on Biological Diversity (CBD)

The project has supported the Convention on Biological Diversity in three main ways. In support of **Article7** (see Annex 3) we have conducted detailed monitoring of the hydrology and flora at ten fynbos sites and deposited the data with partners including the South African Environmental Observation Network who will continue this work in conjunction with our collaborator at the South African National Biodiversity Institute. In support of **Article 12**, we have conducted research towards obtaining a mechanistic understanding of the biodiversity of fynbos, an important threatened community in global biodiversity hotspots. A direct consequence of this is an insight into the important measures that could be undertaken to enable action to help in the conservation / and sustainable management of this habitat. Our work has also involved a large degree of scientific and technical cooperation and training. In support of **Article 13**, we have raised awareness among both public and conservation organisations on the importance/relevance of ecohydrological issues to the Cape. Although we didn't directly work with local CBD / other convention focal points, our efforts have been undertaken in tandem to that of local conservation organisations and follow national conservation plans.

The Cape Floristic Region (CFR), of which the Western Cape is a major part, is a Priority Area in South Africa's 2005 National Biodiversity Strategy and Action Plan (NBSAP). Our research on the eco-hydrology of fynbos plants has directly supported Strategic Objective 3 of NBSAP: "Integrated terrestrial and aquatic management across the country minimizes the impacts of threatening processes on biodiversity, enhances ecosystem services and improves social and economic security." More specifically, Outcome 3.7 indicates the need for "Research and monitoring programmes [to] support integrated management of terrestrial and aquatic ecosystems" and Activity 3.7.1 to "Carry out research on the impact of all current and future threatening processes on biodiversity...". Cape Nature is committed to place the management and maintenance of the CFR biodiversity on a solid scientific base, and therefore has adopted the NBSAP approach fully. A better understanding of the pattern and processes, including threatening processes in the CFR (as is the case from our work) will enhance the way in which this biodiversity hotspot is managed.

3 Project Partnerships

We established an MOU with our main partner, South African National Biodiversity Institute (SANBI), at the start of the project. The PI at SANBI was Dr Guy Midgley, Chief Director of the Climate Change & Bio-adaptation Division who conducts world-class research on the impact of climate change on plant communities and has played a full part in the development of our project. In addition, SANBI provided office accommodation as well as laboratory facilities at its Kirstenbosch research centre in Cape Town. SANBI technical staff were also trained so that they could develop their skills and support laboratory work and field monitoring. Equipment and the technical know-how utilised in the project was left for SANBI as permanent resource to bolster its research capacity.

Our second partner was Cape Nature, and particularly, the Scientific Services Division (SSD) (http://www.capenature.co.za/) headed by Dr Ernst Baard. Cape Nature have been an active collaborator in terms of providing research sites and making their staff/rangers available to do field monitoring. To strengthen the collaboration, training in the methods of acquiring and interpreting ecohydrological data was provided to their field rangers. We also have good collaboration links with South African National Parks - Table Mountain National Park (http://www.sanparks.org/parks/table_mountain/) headed by Mr. Chad Cheney.

Relations among the partners were excellent from the very start when we received a warm welcome from conservation managers who clearly saw the practical need for our research. SANBI provided enormous assistance to the project, dedicating a very able technician to assist us in the field and in the lab. Time spent in SA by the PIs and Post-doc from the UK could therefore be used to maximum efficiency. The lessons from this are 1. that a project must fulfil a perceived local need and 2. working closely with partners on the ground and making personal contacts is essential. The one area in which the project did not go according to plan (although we were able to rescue the situation in the end) was in the appointment of a local Post-doc. The person recruited by SANBI for this post looked ideal on paper, but did a poor job and left before the end of his contract. With agreement from the DI secretariat, we replaced him with a local PhD student who is now in his second year. He has just spent a month with us in the UK (funded by a personal grant to him from the Cambridge Conservation Forum) and is making good progress towards linking our results into regional climate models. All projects like this depend crucially upon the quality and performance of staff and all one can do about this is to recognize the risk this poses and to be alert to the need to take action quickly if progress is not satisfactory.

Excellent relationships have been built with the relevant scientific and conservation communities in the Western Cape. This is demonstrated by invitations to the lead PI (J. Silvertown) to give Keynote talks at the Fynbos Forum and at the launch conference of the Fynbos Node of the South African Environmental Observation Network (SAEON) in 2010. A number of useful links with local academic and research institutions including Universities of Cape Town, Stellenbosch and Western Cape as well as CSIR (Council of Scientific and Industrial Research) and South African Environmental Observation Network (SAEON; http://www.saeon.ac.za/) have also been cultivated. We have also enjoyed an excellent working relationship with Prof Peter Linder of University of Zurich who is the world expert on the family Restionaceae. In the UK, our links with Cranfield University, in particular Prof. Edward Youngs, have been fruitful.

Our good working relationship with nature conservation (e.g. Cape Nature) and research bodies (e.g. SANBI) continues and we are planning both a post-Darwin Initiative project and a new project.

4 Project Achievements

(1) We have now established a network of 10 sites across the region and gathered baseline ecohydrological data (Table 1). Throughout the sites, in the surveyed quadrats, we have encountered 192 unique species. The data on site details, soils, botany, topography, hydrology and site details has been placed in an access database and been made available to our partners and collaborators, namely SANBI, Cape Nature and SAEON. This is the most complete ecohydrological dataset for any fynbos area to date, and we believe that it will be valuable as a reference point and source of data for future analysis by others.

Table 1. Sites details and monitoring results on the ten monitored sites

Site name	Location	Altitude /m a.s.l.	Quadrats recorded	Species
Bastiaanskloof	S 33 º 32.434' E 19 º 09.130'	358	200	20
Cape Point 1	S 34 º17'41.1" E 18 º 26'18.7"	120	225	28
Cape Point 2	S 34 º 18.705' E 18 º 25.901'	112	201	27
Jonkershoek	S 33 º 59.600' E 18 º 57.174'	350	201	29
Kogelberg	S 34 º 16.745' E 19 º 00.508'	131	200	29
New Years Peak	S 33 º41'19.7" E 19º 06'02.9"	1080	235	22
Riverlands	S 33 º29'12.8" E 18 º 35'43.3"	120	305	65
Silvermine	S 34 º 06.555' E 18 26.901'	378	200	26
Steenbras	S 34 º 11'39.7" E 18 º 52'14.0"	350	172	23
Theewaterskloof	S 33 º 58.906', E 19 º 07.887'	347	200	31

(2) We have been able to quantify the dependence of fynbos community structuring upon hydrological processes. This result, shared under Araya et al. (2011) in Figure 2 extends our previous findings in UK meadows (Silvertown et al., 1999[1]), the original inspiration behind this project. We were also able to quantify the niche breadth of a number of species in relation to hydrological regime, which is a useful information for conservation personnel (Figure 3).

We were able to further our findings by making advanced species distribution models incorporating our detailed data and employing contemporary methods such as HyperNiche (McCune & Mefford, 2004[2]). A result of this is shown in Figure 4 below.

[1] Silvertown, J. et al. (1999) Hydrologically-defined niches reveal a basis for species-richness in plant communities. *Nature* 400, 61-63

[2] McCune, B. & Mefford, M.J. (2004) *HyperNiche. Non-parametric multiplicative habitat modeling.* Version 1.16. MjM Software, Gleneden Beach, OR, US.

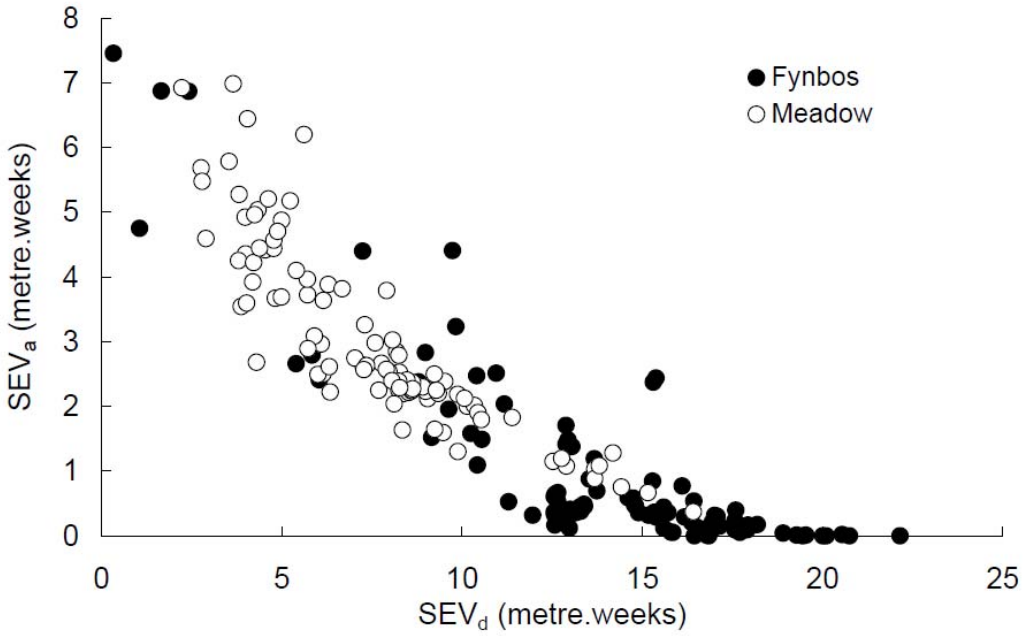

Figure 2. Plant species segregation/structuring along two indices of hydrology i.e. Sum Exceedence Value for soil drying stress (SEVd) and soil aeration stress (SEVa) for a sample of 96 fynbos (filled circles) and 99 meadow species (open circles). (From Araya et al., 2011)

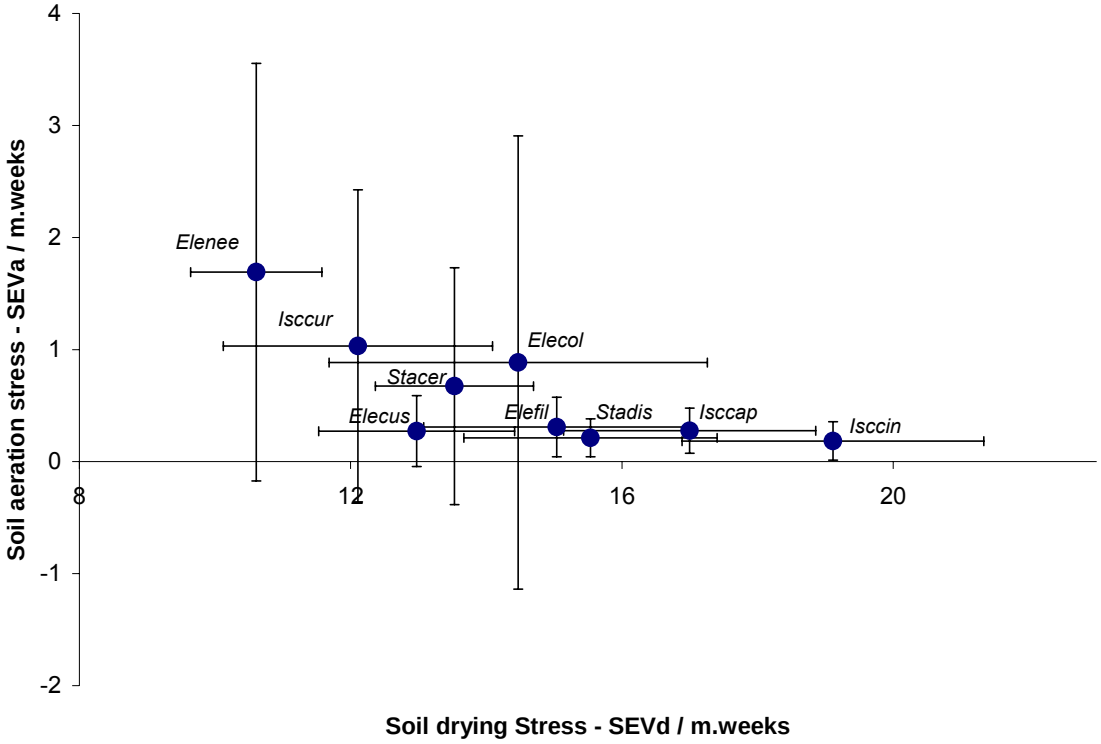

Figure 3. Niche breadths along hydrological indices of Sum Exceedence Value for a selection of Restionaceae species sampled during our project. The x-axis depicts increasing soil drying stress, while the y-axis shows increasing flooding (i.e. aeration). The values show the median and inter-quartile ranges. The Restionaceae species shown are only those that were frequent (i.e. >10% of quadrats per site) in at least 3 of the 10 sites that we studied.

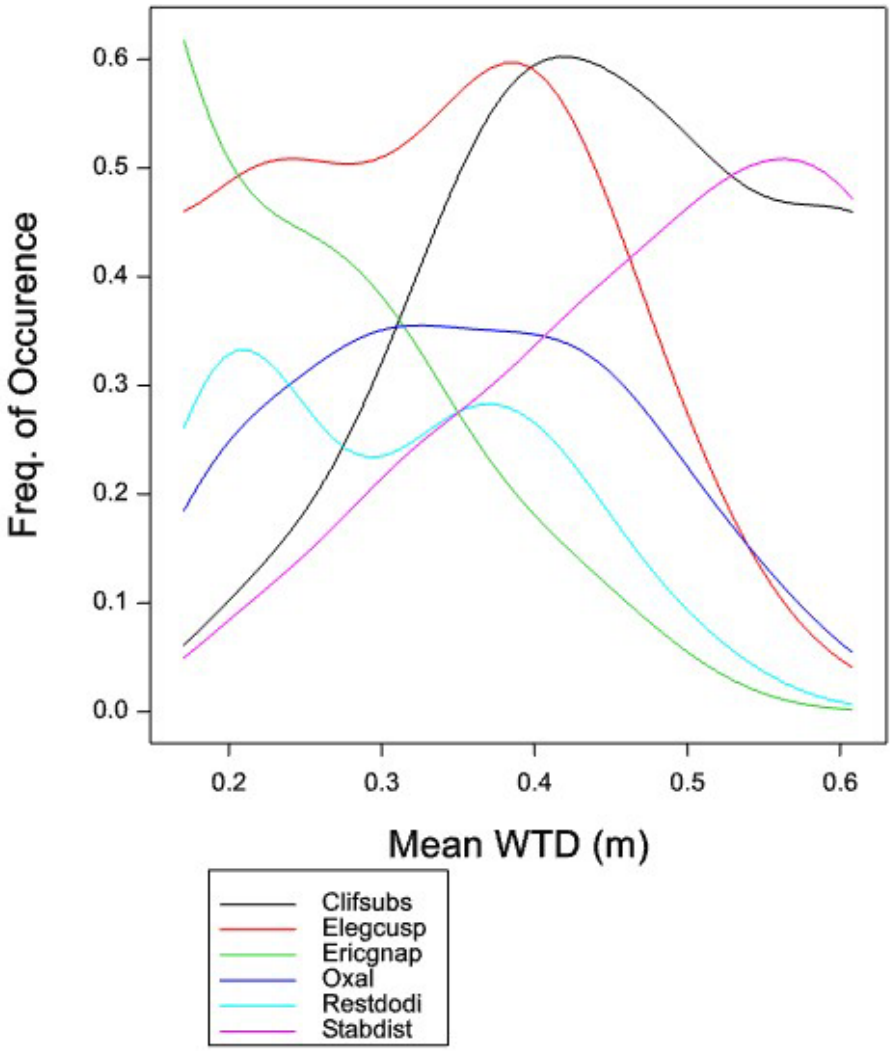

Figure 4. Distributions of 6 species (3 of them Restionaceae) along the gradient of mean water table depth at our Cape Point 1 site, fitted using Non-Parametric Multiple Regression method using Hyperniche® software. This modelling was performed by the project-funded PhD student James Ayuk after a training visit to our lab at the Open University.

(3) We were able to predict future water regime response in our sites and quadrats, so that we can relate it to vegetation communities. We were able to do this: first by building up a relationship between water regime and meteorological data based on present observations using ModelMaker® (FamilyGenetix Ltd., UK). We then downscaled regional future climate predictions (supplied by Climate Systems Analysis Group, University of Cape Town) to extract meteorological variables. These were then run in ModelMaker® to predict future water regime scenarios. Finally HyperNiche® was used to analyse how the distribution of the fynbos flora would respond to perturbations in the hydrological regime. An example is presented in Figure 5. The projected distribution in Figure 5 shows a 33% decrease in the number of quadrats (from 85 to 57) containing *E. cuspidata*. Calculations like these for all species and 10 sites can be used to predict how species abundances can be expected to change due to perturbations in water table depth. Further projections and analyses are being done by the PhD student working at SANBI.

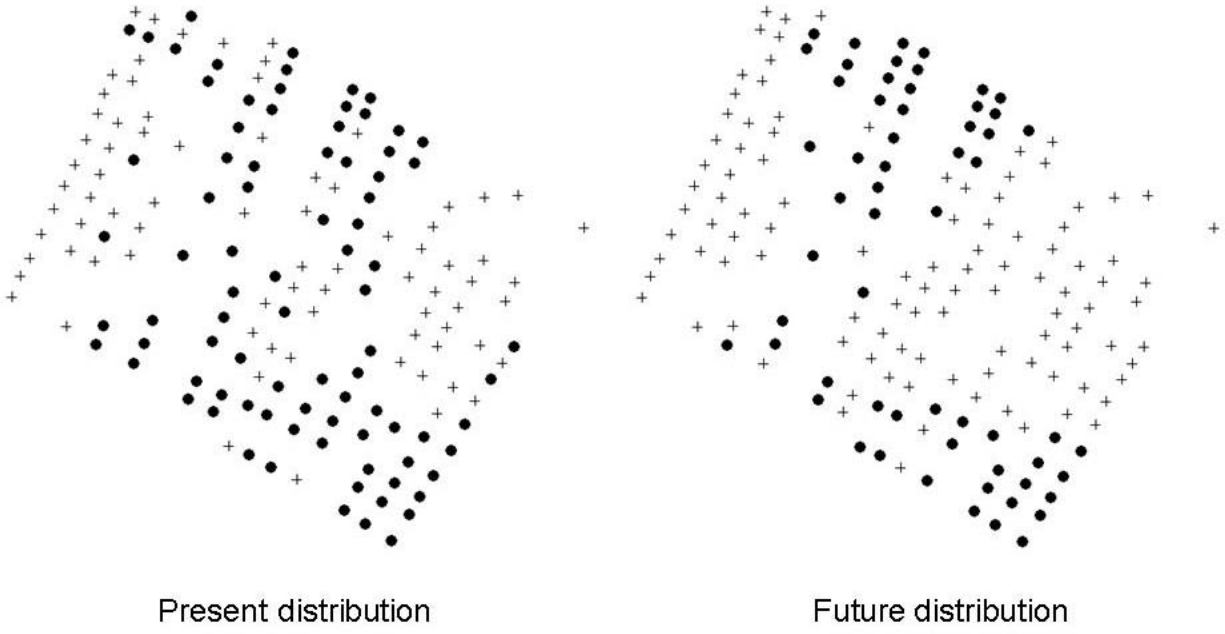

Figure 5. The present distribution of *Elegia cuspidata* (shown by dots) in our study plot (approximately 50m x 50m in size) at Cape Point 1, compared with a projection of its future distribution for a scenario in which a drier climate leads to a 15% increase in mean water table depth relative to current levels. The projection is based upon the hydrological niche for 'Elegcusp' shown in Figure 4.

(4) To ensure continuity of ecohydrological methods and assessment in the Western Cape and South Africa, we have trained SANBI technical staff, as well as local conservation personnel. The training was welcomed enthusiastically and enabled more efficient site monitoring by taking the work-load from our technical staff based at SANBI. Moreover, Cape Nature promised to integrate the task to their rangers for the next 3 years, ensuring the first steps in the legacy of the project.

Figure 5. A cohort of nature reserve rangers who attended a 3 day training in the theoretical and practical techniques of ecohydrological monitoring.

We are now actively working to disseminate our findings among conservation managers and stakeholders to guide decision-making. To this end we are disseminating conservation notes prepared for managers and popular magazines of members of conservation networks as well as outreach releases in local media (included in the report).

4.1 Impact: achievement of positive impact on biodiversity, sustainable use or equitable sharing of biodiversity benefits

The project was envisaged an impact on fynbos conservation in the Western Cape in three ways: (1) the collection and incorporation of ecohydrological data into Environmental Impact Assessments (EIAs); (2) capacity building of field Rangers and other staff in hydrological monitoring required for the assessments and (3) incorporation of eco-hydrology into models of the impact of climate change and or hydrological perturbation on the flora of the Cape Floristic Region.

Sections 2 and 4 of this report address the main outcomes of the project and its relevance to issues of biodiversity in the Cape Floristic Region. Overall although the specific impact on biodiversity is yet to come, the progresses made in the above three aspects demonstrate success.

4.2 Outcomes: achievement of the project purpose and outcomes

The project aimed to provide a quantitative, scientific basis for the incorporation of eco-hydrology in the management of fynbos habitats in the Cape Floristic Region potentially threatened by water abstraction. In this respect the following outcomes have been achieved:

(i) A database of eco-hydrological requirements of endemic species was collated, most of it for the first time in the region. The database includes data on the soil and hydrological measurements as well as fully survey of species presence of 10 sites.

(ii) Enhanced models of the distribution of species of Restionaceae were possible to produce using the collected data. Furthermore, vegetation distribution in response to predicted future scenarios due to change in climate and hydrology were incorporated.

(iii) Staff from SANBI (2 + 2 research students), Cape Nature (13), and SANParks (8) were trained in ecohydrological monitoring. Moreover, our project employed student, Mr. James Ayuk is expected to get a PhD based on this work. There were also 5 other casual field assistants trained on the job.

(iv) Improved decision-making tools were possible to produce, using data from the detailed monitorings of hydrology. We envisage these tools to be refined as data collection and analysis progresses in the future.

4.3 Outputs (and activities)

The project has achieved all the outcomes envisaged at the start. We had made adjustments e.g. to scale back our monitoring of Proteaceae, due to our limited quadrat and plot sizes (Annual Report 2 explains the reasoning).

The major problem faced by the team was the poor performance and departure of our climate modeller postdoc. He was employed by SANBI from November 2008 to November 2009. It took time and effort to find a replacement, which finally was a PhD student, to suit the remaining budget over the time duration required for the project. Mr. James Ayuk formally started in March 2010 and has been making good progress. Prior to his employment the tasks were covered by the rest of the team. We then requested a no-cost reporting extension of the project from DI secretariat to allow us to accommodate this lapse of employment.

4.4 Project standard measures and publications

Annexes 4 and 5 describe the details of project measures.

Journal publications:

Araya, Yoseph N.; Silvertown, Jonathan; Gowing, David J.; McConway, Kevin J.; Linder, H. Peter and Midgley, Guy (2011). A fundamental, eco-hydrological basis for niche segregation in plant communities. *New Phytologist*, 189(1), pp. 253–258.

This paper was published at the high impact *New Phytologist* journal and merited an invited commentary by Peñuelas et al. (2011) Solving the conundrum of plant species coexistence: water in space and time matters most. *New Phytologist* 189 (1): 5-8. The topic even merited an illustration on the journal cover page.

Araya, Yoseph; Silvertown, Jonathan; Gowing, David; McConway, Kevin; Linder, Peter and Midgley, Guy (2010). Variation in δ13C among species and sexes in the family Restionaceae along a fine-scale hydrological gradient. *Austral Ecology*, 35(7), pp. 818–824.

Other publications:

Araya, Yoseph and Walker, Nick (2009). Understanding how water resources shape our flora. *Veld and Flora*, 95(2), pp. 96–97.

Araya, Yoseph (2008) Practical ecohydrological monitoring techniques, Open University, Milton Keynes http://www.open.ac.uk/fynbos/pics/d105984.pdf (Training Manual)

Araya, Y. N.; Silvertown, J.; Linder, H. P; Gowing, D. J.; Midgley, G. F. and McConway, K. J. (2008). Evolution of hydrological niches in Restionaceae: a project update. In: Mucina, L.; Kalwij, J. M.; Smith, V. R.; Chytry, M.; White, P. S.; Cilliers, S. S.; Pillar, V. D.; Zobel, M. and Sun, I-Fang eds. *Frontiers of Vegetation Science - An evolutionary angle*. Somerset West: Keith Phillips Images, pp. 15–16.

Conferences presentations:

South African Environmental Observation Network Summit (2010). Environmental myopia: Avoiding short-sighted decisions with long-term studies 5-6 October, Cape Town, South Africa (invited)

Silvertown, Araya, Gowing, McConway, Linder and Midgley (2010) British Ecological Society Annual Meeting – 7-9 September, Leeds

Fynbos Forum (2010) Eco-hydrology of Restionaceae in the W. Cape and its implications for conservation
3-6 August, Citrusdal, South Africa (invited)

Silvertown, Araya, Gowing, McConway, Linder and Midgley (2009). *Hydrological niches in the Cape flora.* British Ecological Society Annual Meeting; Sept. 8-10; Hatfield, UK

Silvertown, Araya, Linder, Gowing, McConway and Midgley (2009) *Evolution of hydrological niches*. Ecological Society of America Annual Meeting, Aug 2-7, 2009; Albuquerque, NM

Araya, Y and D. Gowing (2008) *Ecohydrology of wet fynbos habitats in the Cape Floristic region*. Wetland and Aquatic Ecosystems: Their functions and values; 24 - 25 November; Oxford.

Araya, Silvertown, Linder, Gowing, Midgley and McConway (2008) *Evolution of hydrological niches in Restionaceae - a project update*. International Association of Vegetation Science Symposium; Sept. 7-12, Stellenbosch, South Africa

Araya, Silvertown, Gowing, McConway, Linder and Midgley (2008) *Does variation in $\delta^{13}C$ correlate with niche position among plants growing along a hydrological gradient?* Ecological Society of America Annual Meeting, Aug 3-8; Milwaukee, WI

Outreach Activities:

Briefing to a daily Afrikaans national broadsheet newspaper by Prof. Jonathan Silvertown (October 2009). *Die Burger;* www.dieburger.com)

Briefing by Dr. Yoseph Araya in *Bush fires are part of the natural cycle* (January, 2009). Open University Platform.
http://www8.open.ac.uk/platform/news-and-features/bushfires-are-part-the-natural-cycle

Von Witt, Caitlin (2006) Our First Plant Monitoring Day. *Veld and Flora*. 92: 190-191
(The contribution of Dr. Yoseph Araya in the initial start of the project is mentioned. The project has been on going since then).

4.5 Technical and Scientific achievements and co-operation

The main technical and scientific cooperation results were in the form of data collection, analysis and in the future implementation of decision making tools provided. Aspects of these have been raised in Sections 4.

4.6 Capacity building

Our partners' capacity building was achieved via trainings to staff both on the importance of ecohydrological considerations for fynbos conservation and on the techniques of ecohydrological monitoring.

Moreover, the equipment used and left on the site or given to SANBI will become useful for future use. We also expect more research initiatives on ecohydrology being promoted among South African Institutions (universities, conservation organizations and research bodies as well as other UK/international organisations.

The Open University, as the sole partner and leader has improved the capacity of the junior research employee (Dr. Yoseph Araya) who is involved in the project. Moreover the project over the last 3 years has enriched the research atmosphere of the department, with seminars and similar research collaborations being initiated in other countries (e.g. Spain).

4.7 Sustainability and Legacy

The chief legacy of the project will be the understanding of the role and mechanism of dependence of fynbos flora to hydrological conditions. This new ecological knowledge, and the skills and understanding acquired by our partners in the process of conducting the research is hoped to result in the protection of fynbos habitats from any haphazard water abstraction that could damage their biodiversity in the short to medium term. Moreover, an understanding of how hydrology influences fynbos biodiversity will complement SANBI's own climate change research, which studies such vegetation response.

To this end, we have received enthusiastic support and involvement from all partners involved (Cape Nature, SANBI and SANPARKS) as well as from the three main HEIs in the Western Cape: University of Cape Town, Stellenbosch University and more recently University of the Western Cape. Moreover other interested research bodies include Centre for Scientific and Industrial Research (CSIR).

In all this, the trainings we provided to our partners will ensure future sustainability, without the necessity of direction from the UK partners. However, the intention is and our partners mutually agree, to extend the work and continue our collaboration.

5 Lessons learned, dissemination and communication

The nature of our results and the relevance is so enduring that we intend to carry on dissemination work, beyond the completion of the project.

During the project, our dissemination has involved communicating with nature reserve managers; scientific personnel at conservation organizations (Cape Nature, South African National Parks) and academic/research institutions (CSIR, SANBI, University of Cape Town, Stellenbosch University and University of the Western Cape).

We have used popular conservation media like *Veld and Flora* to share an accessible version of the science and relevance of our project. We have kept an updated web page on our project at the Open University (http://www.open.ac.uk/fynbos) and intend to keep it live and updated beyond the completion of the project. We also share our research outcomes at the University's OpenLearn platform (e.g. http://www.open.ac.uk/openlearn/profiles/dr-yoseph-araya).

Another more recent dissemination has been, in collaboration with our project partner Cape Nature, to produce flyers about our research for the use of rangers, managers and the general public.

5.1 Darwin identity

We have a dedicated website for the project (http://www.open.ac.uk/fynbos), to prominently acknowledge our funding from Darwin Initiative. Publicity of the initiative has permeated all our South African as well as UK presentations, collaboration as well as media reports. The project had also enabled us to purchase a vehicle for field work. This vehicle displays the Darwin Initiative logo. The vehicle will keep this logo even when bequeathed to SANBI at the completion of the project.

6 Monitoring and evaluation

No major changes were made to the project design that required changes to the logframe.

Output 1 As detailed in Annex 1, we acquired data on the ecohydrology of 49 Restionaceae species an a total of 92 fynbos species in all.

Output 2 Niche models for the more common species have been developed, as planned, as illustrated in Figures 3 & 4, above.

Output 3 We trained 26 staff from Cape Nature and other partners in field eco-hydrology.

Output 4 Figure 3 (above) summarizes the ecological tolerances of some of the more frequent fynbos species. This will provide a new source of data for decision making at Cape Nature.

We followed the M&E system, but we cannot honestly report that we found it useful. On the other hand the comments on our reports provided by evaluators for the Darwin Initiative were constructive and useful.

We did internally evaluate progress on a regular basis and replaced one member of staff in S. Africa with a PhD student when the staff member failed to make progress. The Darwin Initiative office was very helpful in facilitating this change which has enabled us to meet all our objectives.

6.1 Actions taken in response to annual report reviews

We have responded to all arising queries as they appeared during the report reviews. The only one remaining was the query for provision of more details on a side project run by Dr. Yoseph Araya on 'Plant Monitoring Day'. This project was initiated before the Darwin Initiative project got funded. It was started with an education innovation grant from the British Ecological Society in 2006. Since then it has been running alongside our involvements though we don't directly follow it anymore.

A brief summary is given as follows.

In 2006, in collaboration with Custodians of Rare and Endangered Wildflowers (CREW) project of the South African National Biodiversity Institute (SANBI) we initiated Plant Monitoring Day.

Plant Monitoring Day is an annual regional educational exercise aimed at making students and teachers aware of the rich diversity of plants in their local surroundings, develop skills in field botany as well as scientific inquiry. Furthermore, the exercise is important not only as an educational experience but also as a source of gathering useful data for conservationists.

Plant Monitoring Day is conducted in the first week of September each year, which coincides with Arbor Week. CREW coordinates the activity through provision of experts and involves its extensive volunteer network.

The project started with 6 schools from the three provinces of the Cape (Western, Eastern and Northern) in 2006. As of 2008, Plant Monitoring Day has been launched nationally.

This work in collaboration with CREW and another European partner (University of Hamburg) has resulted in a citizen science publication by a member of this project.

Araya, Yoseph N.; Schmiedel, Ute and von Witt, Caitlin (2009). Linking 'citizen scientists' to professionals in ecological research, examples from Namibia and South Africa. *Conservation Evidence* 6: 11–17.

7 Finance and administration

7.1 Project expenditure

Item	Allocated	Actual	Variance
Rents, rates, heating , cleaning, overheads			
Office costs eg postage, telephone, stationary			
Travel and subsistence			
Printing			
Conferences, seminars etc.			
Capital items/equipment (please break down)			
24 Divers @ £XXX Dip wells, plot markers, Divermate Authorised contribution towards a 2nd hand vehicle Sub-total			
Other costs : Consultancy for Prof. Edward Youngs			
Salaries			
Researcher - Araya			
PI - Silvertown			
Co-PI - Gowing			
Co-PI - McConway			
SANBI staff -			
TOTAL DARWIN COSTS			

7.2 Additional funds or in-kind contributions secured

In response to the fires that occurred at two of our study sites (Steenbras and Jonkershoek) in late 2008 and early 2009, we obtained an urgency grant from NERC to study post-fire regeneration of fynbos species on those sites. This grant has enabled us to extend the scope of our research into the origin of the patterns that we have discovered in fynbos vegetation. We have completed the survey and molecular identification work of species that have emerged and are currently writing up the results. Hydrological monitoring of the sites continues.

7.3 Value of DI funding

All the equipment bought under this project has now become the property of SANBI. With DI authorization, we used some of our T&S budget to buy a second hand field vehicle, thereby saving money on vehicle hire and enabling us to donate the vehicle to SANBI at the end of the project.
Expert level training in ecohydrological techniques from UK experts was made possible through this funding. This institutional capacity building for both nature reserve and research staff in South Africa will pay dividends in the future management of fynbos.

Furthermore, the funding has also opened up collaboration links between and within both South African and UK institutions, which is hoped to enable future conservation/research work. A recent example of this is research visit by Mr. James Ayuk, who was funded by an external body (Cambridge Conservation Forum) to spend a month visit at Open University.

Annex 1 Report of progress and achievements against final project logframe for the life of the project

Project summary	Measurable Indicators	Progress and Achievements September 2007 - March 2011	Actions required/planned for next period
Goal: *To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but constrained in resources to achieve* *The conservation of biological diversity,* *The sustainable use of its components, and* *The fair and equitable sharing of the benefits arising out of the utilisation of genetic resources*			*(do not fill not applicable)*
Purpose: To provide a quantitative, scientific basis for the incorporation of eco-hydrology in the management of fynbos habitats in the Cape Floristic Region potentially threatened by water abstraction.	Inclusion of eco-hydrological data in impact assessments and conservation management plans for fynbos habitats.		
Output 1. A database of eco-hydrological requirements of endemic species	Number of species and sites for which eco-hydrological parameters have been entered in the database.	We have data on 49 frequent unique species of Restionaceae at 10 sites. This has been compiled in a database including soil and hydrological measurements.	
Activity 1			
Output 2. Enhanced models of the distribution of species in Restionaceae.	Comparison of the performance of models with and without eco-hydrological parameters.	We have developed models and tools to relate hydrological measurements with climate variables. We were also able to develop this relationship to predicted future climate scenarios. We have then used these outputs to develop enhanced species distribution models.	
Activity 2			
Output 3. Trained staff.	Number of trained staff.	We designed a training course lasting three days and incorporating both theoretical and practical aspects of ecohydrological monitoring. A written course material was prepared as well as lectures. We undertook 2 training cohorts (July 2008 and October 2008). 21 rangers from Cape Nature and	

		SANPARKS have successfully completed. In addition 2 SANBI staff and 3 research students were also trained. All are involved and helping in monitoring.
Activity 3		
Output 4. Improved decision-making tools.	Comparison of new decision-making tools with previous practice.	The outputs of 1 (database) and 2 (enhanced distribution models) were combined to get information on species niche breadth and vulnerability of sites to hydrological perturbations. The outputs of these assessments were then used to inform into management decision making.
Activity 4.		

Annex 2 Project's final logframe, including criteria and indicators

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Goal: **To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but poor in resources to achieve** • **the conservation of biological diversity,** • **the sustainable use of its components, and** • **the fair and equitable sharing of benefits arising out of the utilisation of genetic resources**			
Purpose To provide a quantitative, scientific basis for the incorporation of eco-hydrology in the management of fynbos habitats in the Cape Floristic Region potentially threatened by water abstraction.	Inclusion of eco-hydrological data in impact assessments and conservation management plans for fynbos habitats.	Impact assessments and management plans for fynbos habitats	Impact assessments and management use an evidence-based approach.
Outputs (i) A database of eco-hydrological requirements of endemic species (ii) Enhanced models of the distribution of species in the Proteaceae and Restionaceae. (iii) Trained staff. (iv) Improved decision-making tools.	(i) Number of species and sites for which eco-hydrological parameters have been entered in the database. (ii) Comparison of the performance of models with and without eco-hydrological parameters. (iii) Number of trained staff. (iv) Comparison of new decision-making tools with previous practice.	(i) Reports and publication of peer-reviewed papers. (ii) Test models against observed distributions of species with and without inclusion of eco-hydrological parameters. (iii) Independent verification by Cape Nature &/or allied bodies. (iv) Testing and use of decision-making tools.	Sufficient staff of the right grades obtain training, so as to permanently enhance the capacity of conservation managers in eco-hydrology,

Activities	Activity Milestones	Assumptions
(i) Acquisition of quantitative data on the eco-hydrological requirements of endemic species in fynbos habitats of the Western Cape.	(i) Number of species and sites for which eco-hydrological parameters have been measured	A set of decision-making tools can be devised that are sufficiently simple to use so that they can be readily adopted by conservation managers.
(ii) Incorporation of the data acquired into regional models of the distribution of species in the Proteaceae and Restionaceae.	(ii) New or modified models that include eco-hydrological parameters.	
(iii) Training of South African nature conservation staff in the principles and practice of eco-hydrology as applied to fynbos.	(iii) Identification of key personnel for training & decision-making; training of those personnel; utilization of training in conservation management & planning.	
(iv) Design of tools to enable eco-hydrology to be incorporated into decision-making about fynbos management and conservation.	(iv) Production of decision-making tools.	

Annex 3 Project contribution to Articles under the CBD

Project Contribution to Articles under the Convention on Biological Diversity

Article No./Title	Project %	Article Description
6. General Measures for Conservation & Sustainable Use		Develop national strategies that integrate conservation and sustainable use.
7. Identification and Monitoring	10%	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities that have adverse effects; maintain and organise relevant data.
8. In-situ Conservation		Establish systems of protected areas with guidelines for selection and management; regulate biological resources, promote protection of habitats; manage areas adjacent to protected areas; restore degraded ecosystems and recovery of threatened species; control risks associated with organisms modified by biotechnology; control spread of alien species; ensure compatibility between sustainable use of resources and their conservation; protect traditional lifestyles and knowledge on biological resources.
9. Ex-situ Conservation		Adopt ex-situ measures to conserve and research components of biological diversity, preferably in country of origin; facilitate recovery of threatened species; regulate and manage collection of biological resources.
10. Sustainable Use of Components of Biological Diversity		Integrate conservation and sustainable use in national decisions; protect sustainable customary uses; support local populations to implement remedial actions; encourage co-operation between governments and the private sector.
11. Incentive Measures		Establish economically and socially sound incentives to conserve and promote sustainable use of biological diversity.
12. Research and Training	75%	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).
13. Public Education and Awareness	5%	Promote understanding of the importance of measures to conserve biological diversity and propagate these measures through the media; cooperate with other states and organisations in developing awareness programmes.
14. Impact Assessment and Minimizing Adverse Impacts		Introduce EIAs of appropriate projects and allow public participation; take into account environmental consequences of policies; exchange information on impacts beyond State boundaries and work to reduce hazards; promote emergency responses to hazards; examine mechanisms for re-dress of international damage.
15. Access to Genetic Resources		Whilst governments control access to their genetic resources they should also facilitate access of environmentally sound uses on mutually agreed terms; scientific research based on a country's genetic resources should ensure sharing in a fair and equitable way of results and benefits.

Article No./Title	Project %	Article Description
16. Access to and Transfer of Technology		Countries shall ensure access to technologies relevant to conservation and sustainable use of biodiversity under fair and most favourable terms to the source countries (subject to patents and intellectual property rights) and ensure the private sector facilitates such assess and joint development of technologies.
17. Exchange of Information		Countries shall facilitate information exchange and repatriation including technical scientific and socio-economic research, information on training and surveying programmes and local knowledge
19. Bio-safety Protocol		Countries shall take legislative, administrative or policy measures to provide for the effective participation in biotechnological research activities and to ensure all practicable measures to promote and advance priority access on a fair and equitable basis, especially where they provide the genetic resources for such research.
Other Contribution	10%	Smaller contributions (eg of 5%) or less should be summed and included here.
Total %	100%	Check % = total 100

Annex 4 Standard Measures

Code	Description	Totals (plus additional detail as required)
Training Measures		
1a	Number of people to submit PhD thesis	1
6a	Number of people receiving other forms of short-term education/training (ie not categories 1-5 above)	26
6b	Number of training weeks not leading to formal qualification	4
7	Number of types of training materials produced for use by host country(s)	1 Practical Ecohydrological Training Manual
Research Measures		
8	Number of weeks spent by UK project staff on project work in host country(s)	34
11a	Number of papers published or accepted for publication in peer reviewed journals	2 (+3 in prep)
11b	Number of papers published or accepted for publication elsewhere	2 (+1 in prep)
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	1
13a	Number of species reference collections established and handed over to host country(s)	10 collections (1 per site)
Dissemination Measures		
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	2
14b	Number of conferences/seminars/ workshops attended at which findings from Darwin project work will be presented/ disseminated.	8
15b	Number of local press releases or publicity articles in host country(s)	1
15d	Number of local press releases or publicity articles in UK	1
Physical Measures		
20	Estimated value (£s) of physical assets handed over to host country(s)	£20,000
22	Number of permanent field plots established	10
23	Value of additional resources raised for project	£45,000
Other Measures used by the project and not currently including in DI standard measures		

Annex 5 Publications

Type *	Detail (title, author, year)	Publishers (name, city)	Available from	Cost £
Journal*	Araya, et al. (2011). A fundamental, eco-hydrological basis for niche segregation in plant communities.		*New Phytologist*, 189(1), pp. 253–258.	
Journal*	Araya et al. (2010). Variation in $\delta^{13}C$ among species and sexes in the family Restionaceae along a fine-scale hydrological gradient.		*Austral Ecology*, 35(7), pp. 818–824.	
Journal*	Araya & Walker (2009). Understanding how water resources shape our flora.		*Veld and Flora*, 95(2), pp. 96–97.	
Training Manual*	Araya (2008) Practical ecohydrological monitoring techniques	Open University, Milton Keynes	http://www.open.ac.uk/fynbos/pics/d105984.pdf	
Book section	Araya, et al. (2008). Evolution of hydrological niches in Restionaceae: a project update.	Keith Phillips Images, Somerset West	Mucina *et al.* (eds.) *Frontiers of Vegetation Science - An evolutionary angle*. pp. 15–16.	
Brochure*	Monitoring soil water regime for fynbos conservation	Cape Nature	In prep.	

Annex 6 Darwin Contacts

Ref No	16-003
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