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Science Review of the Royal Botanic Gardens, Kew

Independent Review Panel Report

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Contents

Introduction

1. We were asked by the Chief Scientific Adviser of the Department for Environment, Food and Rural Affairs (Defra) to undertake an independent, expert review of the science at the Royal Botanic Gardens, Kew ("Kew"), to assess the quality, balance, scope, and appropriateness of the programme. This review came five years after the previous review, and reflects Defra's practice of commissioning reviews of its science-based agencies and non-departmental public bodies at roughly this interval.

2. A list of the members of the panel is set out in Appendix 1, and the formal terms of reference given to us by Defra are set out in Appendix 2. Members were serving in an individual capacity, rather than representing any institutions by which they are employed. Each member of the panel made declarations of interest and also signed agreements to respect any information given to them in confidence.

The review

3. The review took place from Monday 28th November to Thursday 1st December 2011, based primarily at Kew. We visited the Wakehurst site on Tuesday 29th November 2011.

4. Kew provided us with various supporting material in advance including information on governance, structures and organisation, science highlights and outputs and the new corporate strategy – the Breathing Planet Programme (BPP). We additionally requested information on a number of metrics of science quality and impact including the number of research grants and science-related funding awarded to Kew over the review period, scientific esteem measures, key outputs by BPP theme, and more detailed information on the approval and decision making process for science strategy and research.

5. During our visit, we received a series of presentations from Kew scientists, describing work undertaken over the last five years by nine of the 21 cross-directorate science teams (selected by the Director of Kew), and setting out plans for the coming five years under each of the themes of the Breathing Planet Programme. These presentations were open to the staff of Kew, and many did attend and joined the discussion.[a] We also had private meetings with the Director and the senior executive team, some individual scientists, and with Trades Union representatives of Kew staff. We also toured the Millennium Seed Bank, and had a number of informal opportunities to meet Kew staff and to view the Jodrell Laboratory, the Herbarium, and the

[a] The presentations on Wednesday 30th November unfortunately took place on the day of industrial action by public sector unions, and the number of staff attending was therefore less than it might have been.

Fungarium. The full programme and a list of those whom we met is at Appendices 3 and 4.

6. We were very struck by the enthusiasm and engagement of the Kew staff, and we are grateful to them for the information they provided and for the way in which they contributed to our work. We are also grateful to the Director and his team for their support in providing information and in making practical arrangements for the review.

Review of recent scientific achievements 2006-2011

7. During our discussion of recent work, we noted many areas in which Kew is particularly strong or indeed has a unique capability, but also some areas in which Kew's work in not unique or pre-eminent. We also noted some areas where, in our view, Kew has opportunities to exploit its collections to even greater effect. Since the aim of our review is to help to guide future science, and as the future programme will be organised around the strategies set out in the BPP, we have incorporated some of our specific views on these issues into our comments on the BPP strategies.

8. We received presentations by nine out of 21 cross-directorate science teams, describing the scientific work achieved over the last five years. The selection of teams to present was made by the Director of Kew and so we cannot comment on the quality of science across all teams from the presentations. However, we spoke separately to selected team leaders (see Appendix 4) about some of the work which was not presented, and examined the publication record of all teams. In this section we highlight some of Kew's key achievements over this period, review their publication record and success in securing grants, and give our overall judgement about the quality of the science as far as we were able, based on the information provided by Kew.

Major achievements, 2006-2011

9. We saw many examples of achievements of international standing in presentations made to the panel by Kew staff including:

- Kew scientists identified and described more than 1,000 new species during the five years 2006-11;
- A paper on angiosperm phylogeny, published in Botanical Journal of the Linnean Society in 2009 has been cited more than 250 times - Kew staff were significant contributors.
- The World Checklist of Selected Plant Families and Monocots was published;
- An Atlas of the Vegetation of Madagascar and Field Guide to the Palms of Madagascar published, together with other field guides to flora of Madagascar;

- Work on sympatric speciation in palms on Lord Howe Island which has resulted in papers in the high-impact journals Nature and PNAS;
- DNA barcoding work on the floras of biodiversity hotspots which has produced papers in Nature, PNAS and PLoS Biology;
- The Flora of Tropical East Africa – due for completion in 2012 – will be the largest tropical flora ever completed;
- The eMonocot consortium with National History Museum and the University of Oxford has been launched to develop a web-based biodiversity information resource on monocots, with a grant to Kew of £1 million from the Natural Environment Research Council (NERC);
- The Kew Plant Glossary – An illustrated dictionary of plant terms was published, and was a finalist in Garden Media Guild Awards, Book of the Year 2010.

Science quality and impact

10. The panel considered various standard indicators of science quality and impact including the number and value of competitive research grants, number and trends in publications and in high impact journal publications. It was difficult to judge the overall quality of Kew science outputs by comparison with other institutions, since Kew's scientific work is very different from that of university departments. The collections present a unique research resource but also carry the responsibility for staff to maintain collections. It is possible to compare the output of Kew with that of other botanic gardens, however not all gardens engage in research as well as curation, and different reporting systems are used. As well as scientific papers, Kew produces monographs and *Flora* which are the comprehensive descriptions of a taxon or of the flora of a geographic region. These are important scientific outputs that ISI citation metrics[b] under-value or even miss entirely. These publications include definitive reference works that will provide the foundation for future work in taxonomy, systematics and conservation for decades to come. They are clearly of great practical value, and Kew is uniquely placed to produce them.

Publications

11. We were provided with details of peer reviewed papers generated by Kew staff over the last five years, with the totals broken down by cross-directorate science team and also separately identifying the number published in 'higher impact' journals (those in journals with a citation rating greater than 2).

[b] Institute for Scientific Information (ISI) metrics for journals indexed in Thomson Reuters *Journal Citation Reports.*

Figure 1. Total number of Kew staff publications by year (includes papers, books, book chapters, PhDs).

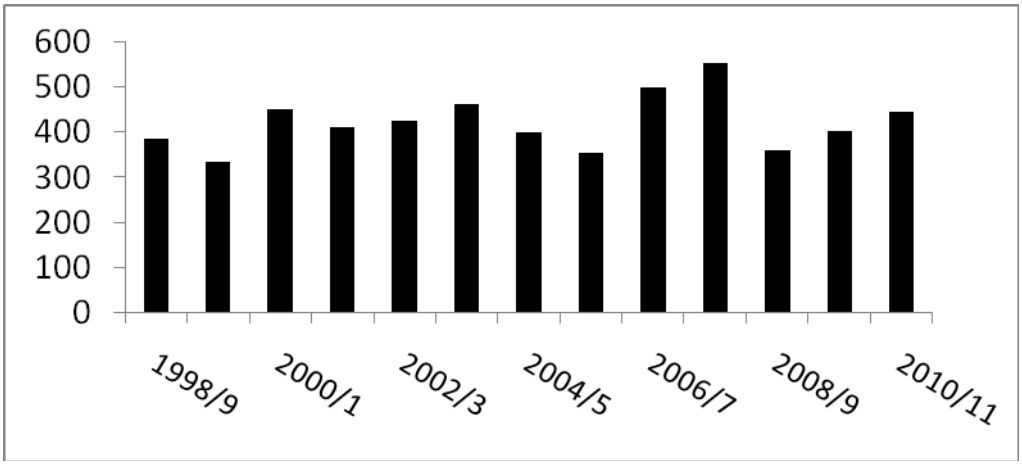
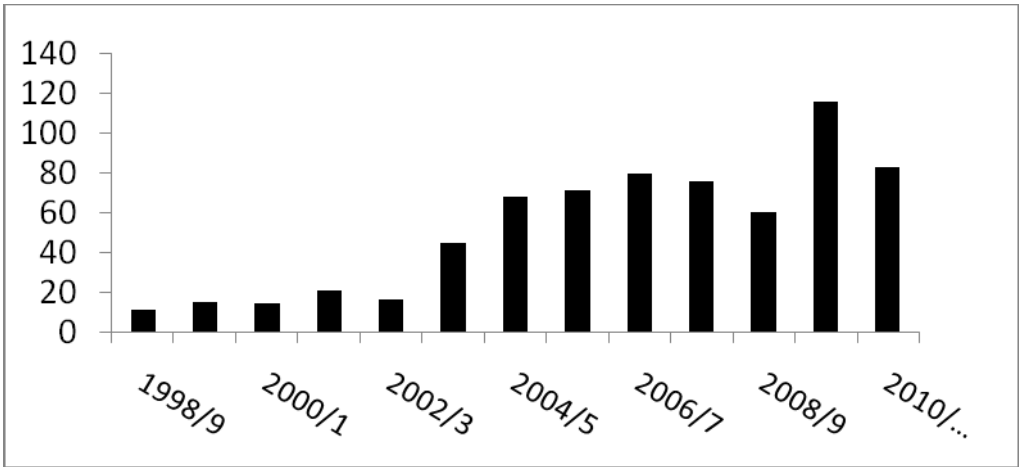


Figure 2. Total number of Kew staff publications, by year in journals with an impact factor greater than 2.



12. We note that the report of the Independent Review of the Royal Botanic Gardens chaired by Sir Neil Chalmers in 2010[c] ("Chalmers Report") included statistics for 2008 which showed a fall in the number of Kew's publications from previous years, and the report drew an unfavourable comparison with the publication rates of some other botanical gardens. The graphs show that 2008/9 turned out to be a low year, and that the number of papers was higher in the following two years. However the number of staff publications, of all types, has not increased over the last thirteen years (Figure 1). On the basis that Kew has 85.2 researchers who are expected to publish papers, as suggested by Kew, the total number of publications is comparable with similar research centres and universities and seems reasonable (4 to 5 per researcher per year) but an average of around 1 high impact publication per researcher per year seems rather low.

[c] Independent Review of the Royal Botanic Gardens, Kew – Consultants' Report, February 2010 (see: www.archive.defra.gov.uk/corporate/about/with/kew/kew-review100210.pdf).

Success in securing research grants

13. Kew has had some notable successes at securing competitive grants, particularly in collaboration with universities (e.g. Oxford, Queen Mary and Imperial). Based on information provided by Kew that there are 41 Principal Investigator (PI) equivalents (i.e. research staff who have grant proposal writing as a formal part of their job) at Kew, the average grant income from NERC since 2000 is £44,822 per PI for Kew, compared with £25,225 for RBG Edinburgh, £77,860 for the Natural History Museum and £200,948 for the Zoological Society of London (Table 1). We consider that - in comparison with other broadly comparable institutions - there is scope for inceasing income from research grants.

Table 1. NERC Grants, fellowships and training grants held between 2000 and present (from Grants on the Web as at 04/02/2012).

Institution	Total NERC Grant income since 2000[(a)] (£ millions)	Number of grants held	Number of PIs in organisation[(b)]
RBG Kew	1.84	7	41
RBG Edinburgh	0.76	4	30[(c)]
Natural History Museum	5.91	50	76[(d)]
Zoological Society of London	4.22	24	21[(e)]

Notes:
(a) Note that some institutions may not have been eligible to apply for research council grants during all of this period;
(b) We have tried to ensure that the PI figures are directly comparable across institutions. The figure of 41 PIs for Kew was only provided to us after the review had taken place;
(c) Figure taken from Chalmers Report 2010;
(d) Information provided by Natural History Museum, and represents the number of research staff eligible to apply as PIs who have formal performance criteria for grant income in their research plans;
(e) Category A staff from RAE2008.

14. In terms of the quantity and impact there was no evidence of a consistent upward trend in high impact publications or in competitive grant income over the review period. Compared to botanic gardens concentrating just on taxonomy and systematics of collections, Kew is performing better; however compared to university research departments, Kew perhaps unsurprisingly scores lower on peer reviewed publications and grant income. As already noted in paragraph 10, its achievements cannot all be measured by standard academic metrics, but compared to organisations like the Natural History Museum and RBG Melbourne, indications are that Kew could improve in terms of numbers of high impact publications and research income.

Science evaluation

15. Both the previous independent science review of Kew in 2006 and the Chalmers Report in 2010 identified a need for Kew to evaluate its scientific work and science teams. We have not seen evidence that this recommendation has been implemented. Kew needs to do more to evaluate the success and quality of its science activities. Our impression is that the output, and the quality, being achieved by Kew compares well with that of other botanical gardens in a similar situation. However, Kew should devote more attention to assembling information about its scientific output, to provide a better basis for assessing its contribution. First, Kew needs to clearly articulate its own key factors of science success and then these should be used to monitor performance on a regular basis. Metrics that are appropriate for Kew would then provide a basis for monitoring performance over time and for making comparisons with similar institutions.

16. **We recommend that the Science and Conservation Committee should develop indicators of science quality, success, and impact. These will need to be relevant to Kew (eg by including curation criteria) but also reflect standard academic metrics related to grant income and publications as described above. [Recommendation 1]**

17. **Kew should then regularly report to Kew Trustees and Defra on this basis and benchmark its performance against equivalent organisations. This needs to be done at a science team level as well as for the whole science function. [Recommendation 2]**

18. **We note that Kew has not implemented previous recommendations on science management to ensure that staff know what the measures of success are. We recommend that staff appraisals are linked to the science plan and the indicators of science quality, success and impact. [Recommendation 3]**

Conclusions on recent achievements

19. We were in no doubt that Kew's collections remain globally important. These include not only the plant and mycology collections in the Herbarium and Fungarium, but also the Millennium Seed Bank, the RBG Kew DNA Bank, electronic DNA bar code collections and the other on-line databases that Kew maintains or contributes to, including the International Plant Names Index, World Checklist of Selected Plant Families, The Plant List, and Plant DNA C-Value database. These globally important collections allow Kew to lead and undertake world-class scientific discovery, description and analysis.

20. Much of the scientific work is of high quality, and indeed is of global significance. In particular, the collections-based science including taxonomy, systematics and curation work, natural history of macro-

fungi and the work on floras of areas such as the British Overseas Territories and in parts of Africa where no others are working is often both globally important and unique. Perhaps one key aspect of the significance of Kew is summed up in a comment made by a leading African botanist:

> "In reality, Kew is the last hope for plant taxonomy in Africa - i.e. for identifying, assessing and guiding scientifically sound approaches to saving the continent's flora."

21. It was also clear to us, however, that Kew does not have strong expertise, skills or experience in some areas that are highly relevant to its mission, including, quantitative data analysis, conservation planning and in-situ conservation. This lack of expertise is limiting the value of Kew's work. It is also the case that in some areas, where Kew's work is not based on its traditional strengths, Kew's comparative advantage is currently limited. This could be improved if Kew were to develop stronger alliances with Non-Governmental Organisations (NGOs), Research Institutes and University departments that specialise in the land use sciences and conservation ecology.

Collections and collections-based research

22. As we have said, Kew's plant and mycological collections are globally important and the collections based science is world class. Curation of the core collection and associated databases and the research that supports this is essential to maintaining the integrity, quality and value of the collections as a global scientific resource.

23. Currently individual staff perform both curation and research activities associated with the collections. The Chalmers Report recommended that Kew considers a move towards separating curation and research activities in order to raise standards across both types of activity and to enable professional development to be targeted accordingly.

24. We are aware that some organisations have followed this approach, while Kew has decided not do so. It was clear from a number of the presentations by the cross-directorate teams that in Kew's context curation activity and collection-based science are closely linked and have produced fruitful results, and that there are advantages in maintaining the current position. In the light of this evidence, **we endorse Kew's decision that curation and science roles should remain integrated**. **[Recommendation 4]**

25. It is nevertheless important that due attention is paid to developing specific skills in and professional standards of curation as well as in research, whether done by staff working mainly in curation or by scientists undertaking curation as only a small part of their roles. **We recommend that Kew should develop metrics to assess and monitor performance on curation activity. [Recommendation 5].** It

should be possible to benchmark these measures against those used in other collection-based institutions and employ them to monitor performance over time.

26. We do have concerns about the level of effort being devoted to curation activity. Since Kew's international standing depends on its collections, it is vital that curation is carried out to a good standard. We are aware, for example, of herbaria elsewhere where performance has slipped below a critical point and substantial backlogs of uncatalogued specimens have built up, which has seriously reduced the value of the collection as a reference and research tool. We were told that some gaps had opened at Kew, as staff primarily focused on curatorial activity had left, retired or moved, and had not been replaced given the current restrictions on public sector recruitment. We did not receive a response to our queries about how real term declines in core funding for the collections were being assessed and managed to maintain capability.

27. It is likely that that the core funding available for Kew from Government will remain tightly constrained for some years to come. If staff reductions are made opportunistically as people move, there must be a risk that cuts in the effort devoted to curation will reach a point which will compromise Kew's ability to deliver collections-based plant and fungal science – its unique global capability. In some areas, such as mycology, this threshold may already have been passed.

28. It is therefore important that Kew should follow a more strategic approach to filling posts, so that unplanned gaps do not open up. In its business planning Kew should ensure that the effort devoted to curation is at least sufficient to ensure that the collections are maintained above a critical point. It will first be necessary to be clear what that critical minimum level of effort would be, not only for the benefit of Kew's planning but also so that Defra can be clear about its responsibilities to maintain this resource.

29. Kew should also address succession planning, so that retirements do not create unexpected gaps and a loss of knowledge and experience.

30. In summary, **we recommend that Kew should adopt a more strategic approach to staffing to ensure that it can continue to fulfil its role to maintain its globally important collections. Kew should be clear about the minimum levels of curation effort necessary to maintain them, and should ensure that effort never falls below those levels. [Recommendation 6]**

Mycology collections and research

31. The mycological collection at Kew has long been of global significance, and the recently published Basidiomycete Checklist for the UK represents a major milestone in understanding the national mycota.

With the recent addition of 400,000 specimens formerly housed at CABI[d], the Kew collection is now world-leading in size, breadth, and importance. It offers an outstanding scientific opportunity, on which Kew is currently failing to capitalise.

32. Previous reviews have noted the inadequate support for mycological staff, even before Kew accepted the CABI collection. Since the 2006 review, two senior staff members have retired. Two CABI members are due to transfer to Kew in the next year (though we understand that one may retire). Some young mycologists have been added to the staff by forging creative partnerships with Natural England and with Imperial College. While the current number of mycologists is growing, strengthening the mycology team should be a priority. In particular, a senior mycologist is needed to serve as head of group, both to provide leadership and to enable younger team members to focus on developing their research programmes, and we are delighted to hear that Kew is currently recruiting one.

33. Research could usefully focus on DNA bar-coding of fungi, phylogenetics and its application to conservation (both of which are currently being explored), and on fungal pathogens (which would increase the value of the research to the agricultural and forestry sectors).

34. **We recommend that Kew should give higher priority to mycology, develop a plan for the future of the fungarium collection, and as a minimum act soon to fill any vacant posts within the team and explore the possibilities for creating new posts. In the longer term, we would expect to see significant effort in this area. [Recommendation 7]**

Electronic collections databases

35. Kew has the largest and most diverse collection of plant- and fungal-related electronic data in the World. Over the past six years, Kew has made considerable progress in enhancement of its databases. Digital collections include the International Plant Names Index (IPNI), the Herbarium catalogue, the DNA Bank Database, the global plant checklist, the literature database on plant micromorphology, data on economic uses of plants and fungi, and the database of botanical literature and art.

36. The unique capabilities of Kew would be in jeopardy if these databases were allowed to stagnate, either in terms of their current sizes and content or in terms of up-dates to the supporting information technologies, including computer software and hardware. Currently, Kew has no staff member dedicated to research in biodiversity

[d] CABI is a not-for-profit international organisation providing information and applying scientific expertise to problems in agriculture and the environment (see: www.cabi.org/).

informatics. Although it has a Science Applications Team of six permanent staff, the majority are computer scientists and none is a biodiversity-focused computer programmer or biodiversity-focused informatics specialist engaged in biodiversity informatics research. Other natural history collections, such as the Missouri Botanical Garden and Herbarium, the Berlin Botanical Garden and Herbarium, the Bavarian natural history collections, and the New York Botanical Garden and Herbarium, all have biodiversity informatics groups to develop forward-looking plans of how to update, link, and improve the databases institution-wide. Kew needs to add one or two expert biodiversity informatics researchers and develop collaborations with other leading institutions involved in biodiversity informatics to maintain and develop the value of its biodiversity data.

37. **We recommend that Kew should develop its biodiversity informatics capability to support collections databases, and should prepare a corporate strategy for biodiversity informatics within the organisation. Kew should look to develop this in collaboration with other institutions with biodiversity collections. [Recommendation 8]**

38. Collections-based research increasingly involves large scale synthesis and statistical analysis of datasets, and in our view Kew is not fully exploiting the opportunities of its large datasets. For example, there seemed to be a lack of statistical expertise for undertaking inference studies on the data resources at Kew. Kew needs statistical, other quantitative and numerical analysis skills to develop new tools and techniques for interpreting the collections data.

39. **We therefore recommend that Kew should develop its capacity for the large scale synthesis and analysis of its data sets, including relevant statistical and computational expertise. [Recommendation 9]**

The Breathing Planet Programme

40. The Breathing Planet Programme (BPP) has been developed over the last three years to provide a context for all the work of Kew (i.e. not just the science). It comprises seven corporate strategic themes, which between them span the whole range of Kew's work, and it is being used to underpin Kew's corporate plan. The BPP Strategy was endorsed by the Trustees in 2007, launched in 2010, and a set of milestones have been developed for the period 2012-2017. A list of the themes is in Appendix 5. We received presentations on each. In the following paragraphs we give our views on the strength of Kew's potential scientific contribution to each theme.

General comments

41. The BPP could be taken as an agenda for the wider botanic garden and science community, but we understand that it is intended principally to give direction to Kew's own science – it will determine at a high level the activities Kew will need to undertake to deliver its mission. It is an ambitious programme and already had the positive effect of getting Kew to look at its current research areas more strategically. But it is clear to us that there are some areas in which Kew currently does not have sufficient capability to deliver the BPP strategy – we explain this in the sections below on each BPP theme.

42. We are unclear about the process for prioritising science activities within the BPP framework. The relationship between the seven BPP strategies and the cross-directorate matrix management structure is complex and evolving. In addition because budgets are assigned through the Science Directorates to section teams, it is not clear how funding is matched to outcomes or priorities at a BPP or cross-directorate team level. Furthermore, the large variation in resources allocated to each of the seven BPPs, makes it difficult to develop consistent and comparable outcomes and performance objectives. We will make a number of more specific comments about the organisation and management of science later.

BPP 1: Diversity Challenge.

43. BPP1 represents the core activity for Kew covering the collections, biodiversity science and providing global access to essential information on plant and fungal species. In this sense BPP1 underpins the whole mission of Kew including efforts on the other BPP themes. We were not shown any figures for science spend within each BPP theme, but almost 30% of Kew's total expenditure supports BPP1 – second only to BPP7 (at 41%) which includes the maintenance of the gardens and buildings.

44. This theme encompasses Kew's work on curating the collections, and the scientific work on taxonomy and systematics. These are Kew's traditional strengths, and Kew is very well placed to continue to make a significant and globally important contribution under this theme. We have already made recommendations about curation, mycology and areas where Kew could enhance its capabilities (paragraphs 22 to 34), and beyond that we do not need to say more.

BPP 2: Search and Rescue

45. BPP2 is focussed on identifying and helping to conserve plant species and habitats that are globally most at risk. This includes undertaking conservation assessments through collections and targeted field work,

Red Listing of threatened species[e] and using GIS approaches to mapping distributions.

46. The programme is relatively small but makes useful contributions to a wide range of conservation and mapping initiatives. Some specific contributions include Red List assessments, leadership of International Union for Conservation of Nature (IUCN) specialist groups, collection of data and coordination of Target 2 of the Global Strategy for Plant Conservation and the Sampled Red List Index (SRLI),[f] and local and global habitat assessments. The plan to continue targeted and global assessments will be valuable.

47. Kew staff have outstanding skills in botanical survey, the creation of species lists, checklists and flora and there is a critical mass of staff to maintain this effectively in a very wide range of regions around the world. The very extensive local and global knowledge of the organisation's staff makes Kew a potential international leader in the provision of plant conservation assessments (but see comments below on Red List assessments). Many local and international groups conduct flora surveys, although few if any have the same breadth of environmental experience and taxonomic support that is found at Kew.

48. Kew staff have integrated Red List assessments for plants into their routine business effectively, although they need to improve coordination of Red List activities across Kew and to increase collaboration with relevant IUCN Species Survival Commission (SSC) Specialist Groups including those external to Kew. Additionally, while the number of assessments is extensive (1500 assessments in the last five years), they are mostly based on static spatial interpretations of plant record data, together with some assessments of changes in habitat extent. Many have not yet been incorporated into the IUCN Red List, for various reasons. Many organisations conduct Red List assessments, using broader data support than those that are routinely done by Kew and in this latter area Kew should consider what technical and/or data contributions they can make to add value to the Red Listing process.

[e] "Red Listing" is a process for evaluating the conservation status of plant and animal species at global and regional scales. The International Union for Conservation of Nature (IUCN) Red List System is recognised as the definitive "Red Listing" process for highlighting those species threatened with extinction and promoting their conservation. More precise and quantitative Red List Categories and Criteria were adopted by IUCN in 1994, based on biological factors related to extinction risk including rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation. The IUCN has a standardised process for reviewing and accepting Red List assessments as official IUCN Red Lists.

[f] SRLI is the Sampled Red List Index for plants – because it is not possible to assess the conservation status of all plant species and subspecies at a global scale, a sampling approach has been adopted. For the five major plant groups, a representative sample of species has been selected and each assessed against the IUCN Red List Index categories and criteria to produce a Sampled Red List for plants.

49. Skills relevant to the analysis of collection, spatial and survey data are not apparent within Kew. There is a lot of work on mapping and assessments but little coverage of sampling methodologies and spatial analysis of the data. The geographical information systems (GIS) unit is currently more of a service unit than a science unit which is limiting Kew's ability to exploit its data resources fully.

50. In order to enhance Red Listing contributions further Kew needs to acquire additional expertise in the areas of mapping (spatial analysis) and statistical analysis and modelling of spatial datasets. These analyses could be supplemented by the development of skills and scientific agendas to support inferences drawn from collections data, population data collected from field samples, improved species distribution modelling and more extensive use of remotely sensed data to assess trajectories over time. Kew could become an international leader in plant Red List assessment if it invests in numerical, quantitative and modelling skills relevant to these tasks.

51. **We recommend that Kew should develop its capacity for the large scale synthesis and statistical analysis of its datasets and conservation assessments and should invest in numerical, quantitative and modelling skills relevant to these tasks. [Recommendation 10] (see also Recommendation 9)**

52. There is significant opportunity for external income from surveys for individual species and ecological communities and to partner with other countries on joint research projects. The Kew 'brand' has a niche for credible, reliable, verified flora surveys. If carefully nurtured and properly supported, this could grow into significant external consulting opportunities.

BPP 3: Help for Habitats

53. BPP3 covers two aspects of Kew's work. The first focuses on helping global conservation programmes on the ground which to date has been focused on high priority areas for plant diversity in Cameroon and Madagascar with some work in Sumatra, Brazil, Peru and Bolivia. The second aspect to BPP3 is strategic policy advice at a UK and international level, with a particular focus on work related to the Convention on International Trade in Endangered Species (CITES) and the Convention on Biological Diversity (CBD).

54. Given Kew's current focus on plant conservation, the fit to mission is strong and it was good to see research at Kew contributing to on-the-ground conservation action. BPP3 focuses on 'integrated conservation on the ground', but Kew needs to clearly articulate its role in this and identify the benefits of its involvement. Kew's role has generally been in an advisory capacity, which is appropriate, given its strengths.

55. Whereas Kew has demonstrable capacity in ex situ conservation, it has less capacity, skills and experience at in situ conservation. In situ conservation is primarily about people, through the management of reserves or working with local communities and other stakeholders to change current land use practices. Kew has very limited capacity in relevant areas of social science, human livelihoods and natural resource management. 'Conservation on the ground' will therefore typically have to be undertaken in partnership with other organisations, such as conservation NGOs, who possess the relevant capacity and expertise. This needs to be made explicit in Kew's strategic plans and it needs to be clear on its remit and capacity in this area.

56. Kew's activities in support of in situ conservation action might have greater impact if focused in a small number of high profile case studies, which could provide a strong basis for education and public outreach. For the strategy to be coherent BPP3 should ideally link with other elements of the BPP - for example the results of BPP2 should enable conservation priorities to be identified, which logically would be addressed in BPP3, and with the sustainable use agenda. Kew might usefully focus its conservation activities in countries where it has a clear mandate to do so, such as the UK Overseas Territories.

57. **We recommend that Kew develops specific achievable targets for in–situ conservation work in BPP3, including partnerships to add value and capacity to the work. [Recommendation 11]**

58. The second element of BPP3 focuses on strategic policy advice, in which Kew has a strong track record, particularly with respect to two international conventions, CITES and the CBD, and the area of "Access and Benefit Sharing". There is scope for Kew to offer greater leadership in terms of setting the international agenda for plant conservation, which the panel would encourage. There is scope for the CITES policy work to be linked more closely with the sustainable local use work in BPP4. In addition the scope of policy-related activities could usefully be broadened, for example to increase relevance to the forestry and agricultural sectors and emerging policy areas such as biomass for renewable energy and biofuels.

59. **We recommend that, in discussion with users, Kew should broaden the scope of its policy work and strengthen its role in areas such as Access and Benefit Sharing where it has expertise. [Recommendation 12]**

BPP 4: Local Plants for Local People

60. BPP4 is concerned with exploring the potential of plant and fungal diversity to contribute to human well-being and working with partners to apply research on the uses of plants and fungi.

61. BPP4 takes Kew core science into applied topics of food security, nutrition, use of natural products and authentification of plant material for medicinal use, summarised as "Sustainable Local Use". The challenge for BPP4 is to define Kew's particular research niche, within these broad research topics, where it has competitive advantage and can establish scientific excellence. If this is done successfully, we anticipate that it will open up new opportunities for Kew that align with cross-agency research programmes such as Living With Environmental Change (LWEC)[g] and the Global Food Security (GFS) programme[h].

62. We note that BPP4 as it currently stands appears to depend on drawing together independent threads across Kew to achieve collective impact against one theme of contemporary relevance (sustainable use). The challenge will be to find ways to coordinate and manage these activities to ensure a coherent programme. At present work in this area is too diffuse across the organisation. This is acceptable for reporting purposes, but it lacks coherence from a practical point of view. Kew needs to think about how to bring this important area together across the organisation.

63. We were not clear whether the focus of BPP4 was directed more to the commercialisation and authentication of plant resources, or to "local crops for local people". Kew needs to separate these two aspects of its work and be clear about its research strategy in this area.

64. We are concerned that the wider context for research in BPP4, that is outside Kew's traditional areas of expertise, is not yet well enough developed to allow BPP4 to fulfil its potential. This is particularly apparent in the areas of agriculture and nutrition, but also to a lesser extent climate change and livelihoods. For example, is there a clear vision for how Kew science can bring new knowledge to how plants are used to enhance nutrition, from their role in small home gardens to discovering genetic traits in crop wild relatives with potential for bio-fortification of major staple crops?

65. External partnerships will be key to the success of BPP4. To help realise the potential of BPP4 **we recommend that Kew works with an external focus group of academics, practitioners, NGOs and agribusiness charged with identifying areas of Kew's research that could be developed into strategic agriculture-, food- and nutrition-facing programmes at Kew within BPP4. [Recommendation 13]**

[g] A partnership of 22 public sector organisations that fund, carry out and use environmental research and observations (see: www.lwec.org.uk/).

[h] A multi-agency programme bringing together the interests of the Research Councils, Executive Agencies and Government Departments (see: www.foodsecurity.ac.uk/).

BPP 5: Save Seed and Prosper (including the Millennium Seed Bank)

66. BPP5 covers seed banking through the Millennium Seed Bank (MSB) Partnership and includes seed banking as a tool for long-term conservation of wild species, use of seed for innovation and adaptation in agriculture, horticulture, forestry and habitat restoration, and novel research on seed biology.

67. The Panel were very impressed by the facility, its strong leadership and the quality of the science produced by the research team, as evidenced by their publications. The business plan, while ambitious, has clear milestones and seems to be well integrated with other areas of Kew's work and BPP themes.

68. Kew is undoubtedly a world leader in the field of seed science (in the UK the University of Reading has a smaller research team in this area; in the US the USDA Plant Germplasm Preservation Research Unit in Colorado primarily focuses on crop plants and was established before the Millennium Seedbank initiative, however Kew has provided the catalyst for seedbank science on native plants in the US). However while the seed biology work is world class, especially where relevant to seed storage and germination, the extent to which a seed bank is needed to underpin a world class programme in seed biology was not clear to us. If, as seems likely, future seed biology scientific work will focus more on intra-specific diversity, then it will be necessary to implement the ambitious MSB strategy to sample a range of populations of each species.

69. While we welcomed the synergy with other BPP themes, there was a contradiction between the narrow genotypic variation of the seedbank collection and the broad genotypic variation that would be needed for the seedbank to have a role supplying people with seed or plant products for habitat restoration and the sustainable use of plant genetic resources by local communities. Kew is working with Cornell on population level issues relevant to the collection. Kew needs to address this issue in developing its sustainable use agenda as it is not clear to what extent the current seed collection can meet restoration and sustainable use goals.

70. Kew needs to articulate whether BPP5 has a genebank focus or a sustainable use agenda. At the moment the research is focussed on seed biology and germination – the conservation role needs to be articulated and Kew needs external guidance on where to prioritise given current resources and the limitations of the current collection. We understand that the MSB are applying broad genetic sampling protocols for the seed collections, but we were not clear on how this would present opportunities for research on intra-specific aspects of seed biology.

71. **We recommend that Kew clarifies and articulates the role of the Seedbank, by considering its potential contribution to genebanking versus contributing to conservation, restoration and**

sustainable use; and the links between the seed biology research programme and the genebank operations. [Recommendation 14]

BPP 6: Repairing the Damage

72. BPP6 is concerned with restoration ecology and a new cross-directorate Restoration Ecology team has recently been established.

73. The programme is currently organised around three main areas – development of a large collaborative restoration project following surface mining operations on a tropical forest site in Brazil; establishment of an "ecological restoration alliance" of botanic gardens to perform ecological restoration on a global scale (100 places on six continents) and a grassland restoration experiment at Kew Gardens.

74. At present only around 1% of Kew's budget goes towards BPP6, although there are plans to increase the level of investment in restoration ecology.

75. While there has been limited activity in some countries as part of the regional teams' work, restoration ecology is a new area of focus for Kew. A head of restoration ecology has recently been appointed who brings enthusiasm, experience, new skill sets and ideas. His presentation set out a very ambitious action plan which includes several very large, complex initiatives. Given that Kew does not have the breadth of skills needed to plan or carry out such initiatives, and that the cost of undertaking work of this scale is incredibly high, aspirations for this area may need to be tempered. Kew's work on the restoration genetics and founding populations of Lady's Slipper Orchids illustrates the scale of operation in this area that has been very effective up to now.

76. Kew is not an international leader in this area and there are other organisations that are clear leaders. At present Kew are taking a taxonomic assembly-disassembly approach to this work area without taking account of functional ecology. It is essential to understand functional ecological processes (taxonomic functional approach to restoration) and this would need an interdisciplinary team and substantial funding - Kew do not currently have the requisite expertise.

77. Expansion in this area would need major investment from Kew and would only be achievable with substantial additional resources - we understand that this is a current priority for fundraising. We are concerned that the scale of investment required could compete with the need to sustain core activities. **We recommend that Kew should consider carefully the level of resource needed for the restoration work planned under BPP6 to become a viable programme, or whether this programme should be delivered through partnerships with other organisations already established in this area. [Recommendation 15]**

BPP 7: Wonders and Marvels

78. BPP7 is about communicating the importance of plant and fungal diversity, the significance of biodiversity loss and sustainable use of the world's resources through two first class botanic gardens supported by educational and outreach programmes and an accessible website.

79. Outreach and engagement efforts at Kew are focused on the science of plants, even when this message has to be packaged as entertainment or presented as 'marvels' and 'wonder'. Media mentions of Kew feature science stories much more prominently now than before, with 48% of stories now falling into this category compared with only 15% in 2007. About a dozen books are published annually, plus four periodicals that are aimed at different sectors of the public. Kew Magazine is sent to 75,000 members and features specially-written science stories that can be re-purposed for other audiences. Kew Scientist is aimed at the scientific community and will in future be published only in an electronic edition that can be more widely circulated.

80. There is also a high-quality website that can now be accessed from a smartphone app by visitors to Kew. The app gives access to location-specific information via a QR Code reader that can be used on plant labels in the garden and via an augmented reality feature. These are exciting developments with huge potential for engaging Kew's visitors with science. They could also be used to make Kew's relationship with its visitors more 'sticky', so that it does not end at the exit.

81. A notable success during the reporting period was 'The Great Plant Hunt', which received £2m in funding from Wellcome and which reached children in 22,000 schools. An even more ambitious programme that aims to reach half the population of the UK is planned for the next five years. We commend Kew on the integration that it is clearly achieving between science, the collections and public engagement. The opportunities for this in the future are perhaps greater at Kew than anywhere else in the world because of the size of the living and other collections, the standard of the collections-based science and the number of visitors to the gardens. If this conjunction is fully exploited using the technological tools now becoming available, Kew can offer an immersive experience that will make it the leading science-based visitor attraction in the world, even against strong competition from well-funded museums and zoos.

82. Generally, we noted that Kew showed a good appreciation of the need to bring out Kew's science role to visitors and that people often hear about Kew through science stories. There is enormous potential for Kew to develop its public awareness and outreach activities.

Conclusions on the Breathing Planet Programme

83. The Breathing Planet Programme sets out a comprehensive set of themes illustrating where a botanic garden and research institution

such as Kew can contribute to a better understanding of plant and fungal biodiversity, and to national and global efforts to conserve that biodiversity and to promote its sustainable use. We commend Kew for developing this vision, and for using it to think afresh about the contribution that its science programme has made and can make in the future towards achieving it.

84. However, it is clear to us that the BPP alone does not represent a sufficient science strategy to guide the development of the science programme. We have not seen clear evidence that Kew has sufficiently addressed the question of where it is uniquely placed to take forward particular parts of the BPP – and there are many areas in which, as we have said, Kew has a unique capability and world class science - and other areas where Kew does not currently have the comparative advantage to make a unique or leading contribution.

85. It is admirable to have the ambition to move into new areas, and to seek to develop new capabilities to exploit more fully Kew's resources. But Kew needs to reflect that, at a time when public sector support is likely to be constrained, and may well fall further for many years to come, it should protect its core assets and strengths which depend on the curation of its collections – this being one of its statutory duties. A better course might well be for Kew to seek to work in partnership with others to an even greater extent than it has done already, to combine with the capability of other scientific institutions and conservation NGOs.

86. We also understand that Kew is seeking to raise substantial extra money from external partners and philanthropic sources to develop areas such as restoration ecology, and we welcome this. If genuinely additional funds can be raised to create new capabilities that can only be welcome. But Kew must guard against the risk that the allocation of its core funding is distorted by the need to chase external money.

87. We also note that BPP does not yet appear to be driving planning and resource allocation across the science programme and for monitoring performance – it is not yet an operational science strategy. There is some inconsistency in the way milestones, for example, are defined across the different BPP strategies - the Millennium Seedbank (BBP5) has a clear business plan with quantified targets, but BPP4 (Local Plants for Local People) has no clear milestones. Milestones need to be revised and made more measurable. We hope that the current development of the five year business plan will provide the opportunity to start the process of developing clearer targets.

88. The BPP is functioning well as a vision for Kew, and for building constructive links both internally and externally. **We recommend however that more thought is directed to the balance and relationships among the seven BPP themes, and that a science**

strategy be developed that complements the BPP. [Recommendation 16]

Fundraising, support and exploitation of Kew science

Research office

89. Kew will be increasingly dependent on external funding to support its science. Kew has resolved eligibility issues and has now regained 'Analogue Status' from the Research Councils, which means it can compete for their funding on the same basis as UK Higher Education Institutions, and there seem to be opportunities to secure grants to support food security work and other initiatives relevant to Kew. There are therefore grounds for optimism that Kew should be able to achieve more external funding. The Chalmers Report recommended that Kew should establish a Research Support Office, to be proactive in seeking out funding opportunities, to raise Kew's profile with funding bodies, and to coordinate and support research teams in making applications. While Kew has established some corporate science capacity, we do not believe that it has yet sufficiently implemented this recommendation.

90. Kew should aim to increase income from Research Council and other research funders' grants taking account of new initiatives that are relevant to Kew. **We recommend that Kew should fully implement the Chalmers Report recommendation to establish a Research Support Office to identify science funding opportunities, coordinate research grant applications and raise Kew's science profile with funding bodies. [Recommendation 17]**

Kew Innovation Unit

91. The Kew Innovation Unit (KIU) is Kew's plant-based consultancy and provides services including plant product identification, authentication, vegetation surveys, habitat restoration, seed management and the development of plant based products amongst others. The KIU enables Kew to exploit the intellectual property and commercial opportunities represented by the vast resource of the collections and scientific expertise of Kew. It has the potential to raise considerable sums to supplement the core funding received from Defra, to secure the future of the Gardens. It is however properly subject to constraints on the extent to which resources gathered from overseas can be exploited, given the agreements made with the countries of origin in earlier times, and more recently the protocol on Access and Benefits Sharing agreed in the context of the Convention on Biological Diversity. We were told that demand from potential external partners to work with KIU is growing, and indeed that the unit is having to be to selective about what it can take on.

92. We very much welcome the initiative to generate funds by the KIU and recognise that this is an important funding diversification activity for Kew. However we do have two concerns which we suggest the Trustees and management continue to keep in mind as they develop the KIU. The first is to ensure that the pursuit of commercial opportunities does not distort science priorities as laid out in a Kew science strategy (see below). Second, the reputation ('brand') of Kew is valuable and of great importance to the business, and KIU must be very careful to ensure that the integrity of the institution is not damaged by, for example, inappropriate endorsement of commercial products. Criteria for defining sustainability in commercial claims need to be robust.

93. **We recommend that Kew ensures that the activities of the Kew Innovation Unit complement existing areas of work and are synergistic with Kew's strategy for science. The Trustees need to ensure that the risks are formally assessed and monitored. [Recommendation 18]**

The organisation and management of science

94. The senior management structure of Kew has recently been reorganised, following the recommendations of the Chalmers Report, so as to create six Directorates, and we welcome this simplification. The scientific staff fall within three of these, headed by the Keeper of the Jodrell Laboratory, the Keeper of the Herbarium, Library, Art and Archives and the Director of Conservation, Living Collections and Estates. Within the Directorates, the staff are organised into Sections (e.g. Molecular Systematics, Regional Teams, Mycology), and into teams within these. Resources are allocated through this structure, and staff are formally managed – for example in terms of agreeing their annual performance objectives - through it also.

95. The science programme has, however, been delivered by 21 cross-directorate science teams, focusing on a geographic region (for example, Wet Tropics: Africa), or on a taxonomic group (for example, Legumes). These teams were the basis for the presentations we received in reviewing past achievements. Each cross-directorate team typically comprises a number of people who are members of the within-directorate section science team dealing with that subject, together with other staff contributing part of their time. So, for example, the cross-directorate team dealing with Legumes comprised scientists working full time on this taxa based in the Herbarium, together with a contribution from others based in section teams in the Jodrell Laboratory who contribute their specialism (e.g. on molecular biology, or wood anatomy) to the extent required. In summary, there is a matrix management system and overlaid on this is are the seven strategies of the Breathing Planet Programme, adding a further dimension.

96. The use of cross-directorate teams and a matrix approach seems to have worked well. It has enabled cross-directorate teams to draw on

the specialisms they require to the extent they require them, and the individual specialists to contribute to the work of various thematic teams. It has established strong corporate ethos across the organisation avoiding silo structures, and it seemed clear to us during the open discussions that there was genuine team working.

97. We note however that research provision does appear to be unbalanced. For example, there are about 50 staff working on monocots, and 15 on legumes, but only four or five across all fungi (see paragraph 32). This does raise issues about critical mass in some areas, but also raises questions about how strategic research priorities are identified. Teams need to have a critical mass of people – some teams seem too small and there needs to be some rationalisation. On the other hand, the large scale synthesis team seems to have a very wide span involving almost all the Kew science staff.

98. Moreover, there does not appear to be an explicit mechanism for ending non-productive teams or work, and while some teams are excellent, others are less productive. The apparently 'ad hoc' creation of project teams has worked but with reduced resources this will increase pressures on teams/team members and there needs to be a clearer strategy for prioritising work and staff time at the project level.

99. **We recommend that Kew reviews the current cross-directorate science teams, in particular to close or re-structure less effective teams and ensure all teams have a clear role, critical mass and resources to deliver specific outcomes derived from the science strategy. [Recommendation 19]**

100. The allocation of specialist resources to individual cross-directorate teams appears to be based on long standing practice and informal cooperation. As we have noted, resources are allocated via the Directorates and section teams. The leader of a cross-directorate science team relies on the good will of the manager of specialist resources in the Directorate section teams to provide the level of input which is needed. This was not raised with us as a problem, which is a tribute to the strong collaborative approach we observed at Kew. But if the organisation wishes to deliver a strategic vision which may require shifts in resources, and as pressures on staffing become tighter as they may well, it will be necessary to find ways of making resource allocation decisions in more strategic ways. We recognise that it is difficult to do this in matrix management, and that the Kew infrastructure of management support is not strong.

101. There is a need for a more strategic approach to determining priorities. It appeared to us that much of the specific future work programme for individual cross-directorate teams is determined by the teams themselves. While we recognise that research scientists themselves are very well placed to spot gaps and opportunities, there does also need to be central direction to ensure that the organisation develops a

coherent programme which fulfils its mission. At present the process of identifying and addressing knowledge gaps appears to be ad hoc rather than strategic.

102. We have already commented that while the BPP provides an overall conceptual framework and vision, it falls short of being a science strategy, and it does not provide a sufficient framework for planning resource allocation, for example.

103. **We recommend that Kew develops a science strategy, including a list of priority research questions and the level of people and resource required to effectively address them, along with a process for developing and resourcing cross-directorate projects and for prioritising these projects against each other. [Recommendation 20]** The current development of a five year business plan represents an opportunity to begin this work.

104. As part of the restructuring undertaken in 2010, the Board of Trustees has created a new Board committee - the Science and Conservation Committee - to provide non-executive advice and assurance on science strategy to the Board. The Committee is chaired by a Trustee and comprises at least one other Trustee (in practice currently the two other Trustees with a science background), the Director and the three Science Directors (Jodrell, Herbarium (currently vacant) and Conservation, Living Collections and Estates). We understand that science strategy has not been discussed in detail at any of the Science and Conservation Committee meetings to date. We question the extent to which the Trustees can provide an independent level of scrutiny if they are effectively part of the executive decision making in this way. The Trustee-led committee should oversee the regular reporting and assessment of science and reporting to Defra and/or independent review. Also, this committee should meet regularly with the science directorates to advise on major initiatives, resource allocation priorities and senior appointments in science. **We recommend that Kew review and clarify where in the institutional structures the responsibility lies for science management, leadership and assessment and the role of the Trustee-led Science and Conservation Committee. [Recommendation 21]**

Meeting with trades union representatives

105. We met representatives from Kew Trades Union Side, and we are grateful for the time they took to give their views. They expressed concerns about the pay scales for Kew staff, which they suggest compared unfavourably with other institutions and presented a particular problem given the cost of living near the Kew and Wakehurst sites of the RBG, and the lack of progression and recognition available to scientists as they develop through their careers given the limited promotion opportunities. We accepted that the absence of a pay

progression process can impact on career development for scientists and we expect that this will be reviewed by management.

Summary and list of recommendations

106. We were very impressed by much of what we saw at Kew. It remains one of the leading botanic gardens of the world, and is making a very significant contribution to our understanding of the world's flora and to the conservation of plant and fungal biodiversity. It has a capable and very committed team of scientists, and a genuine ethos of team working across the organisation which is a great strength. Science is at the heart of all it does – it would be wrong to see the heritage and visitor attraction parts of Kew's work as being distinct from or irrelevant to the scientific work. And Kew can demonstrate many significant achievements over the last five years, continuing a long tradition of global leadership and influence in plant discovery, description and pure and applied research.

107. Kew is well placed to continue to make a significant contribution over the next five years, but it does face challenges – not least in the harsh economic climate all institutions are likely to face over coming years. If Kew is to achieve its potential, it is important that it should develop a clear science strategy. Kew will need to be very clear where its core strengths lie, and will need to ensure that these areas are not compromised. It will also need to work in partnership with other organisations, particularly as it seeks to develop its contribution in areas where it currently does not have a strong capability. This will be a challenge which will need clear leadership, and better mechanisms for deciding priorities, allocating resources, and monitoring progress than we believe Kew currently has in place. Science must continue to be at the heart of Kew, and strong scientific leadership – as well as strong management capabilities – will be essential.

108. We have made a number of specific recommendations, and for convenience we set them out here in a single list:

1. We recommend that the Science and Conservation Committee should develop indicators of science quality, success, and impact. These will need to be relevant to Kew (eg by including curation criteria) but also reflect standard academic metrics related to grant income and publications as described above.

2. Kew should then regularly report to Kew Trustees and Defra on this basis and benchmark its performance against equivalent organisations. This needs to be done at a science team level as well as for the whole science function.

3. We note that Kew has not implemented previous recommendations on science management to ensure that staff know what the measures of success are. We recommend that staff

appraisals are linked to the science plan and the indicators of science quality, success and impact.

4. We endorse Kew's decision that curation and science roles should remain integrated.

5. We recommend that Kew should develop metrics to assess and monitor performance on curation activity.

6. We recommend that Kew should adopt a more strategic approach to staffing to ensure that it can continue to fulfil its role to maintain its globally important collections. Kew should be clear about the minimum levels of curation effort necessary to maintain them, and should ensure that effort never falls below those levels.

7. We recommend that Kew should give higher priority to mycology, develop a plan for the future of the fungarium collection, and as a minimum act soon to fill any vacant posts within the team and explore the possibilities for creating new posts. In the longer term, we would expect to see significant effort in this area.

8. We recommend that Kew should develop its biodiversity informatics capability to support collections databases, and should prepare a corporate strategy for biodiversity informatics within the organisation. Kew should look to develop this in collaboration with other institutions with biodiversity collections.

9. We therefore recommend that Kew should develop its capacity for the large scale synthesis and analysis of its data sets, including relevant statistical and computational expertise.

10. We recommend that Kew should develop its capacity for the large scale synthesis and statistical analysis of its datasets and conservation assessments and should invest in numerical, quantitative and modelling skills relevant to these tasks.

11. We recommend that Kew develops specific achievable targets for in–situ conservation work in BPP3, including partnerships to add value and capacity to the work.

12. We recommend that, in discussion with users, Kew should broaden the scope of its policy work and strengthen its role in areas such as Access and Benefit Sharing where it has expertise.

13. We recommend that Kew works with an external focus group of academics, practitioners, NGOs and agribusiness charged with identifying areas of Kew's research that could be developed into strategic agriculture-, food- and nutrition-facing programmes at Kew within BPP4.

14. We recommend that Kew clarifies and articulates the role of the Seedbank, by considering its potential contribution to genebanking versus contributing to conservation, restoration and sustainable use; and the links between the seed biology research programme and the genebank operations.

15. We recommend that Kew should consider carefully the level of resource needed for the restoration work planned under BPP6 to become a viable programme, or whether this programme should be delivered through partnerships with other organisations already established in this area.

16. We recommend that more thought is directed to the balance and relationships among the seven BPP themes, and that a science strategy be developed that complements the BPP.

17. We recommend that Kew should fully implement the Chalmers' report recommendation to establish a Research Support Office to identify science funding opportunities, coordinate research grant applications and raise Kew's science profile with funding bodies.

18. We recommend that Kew ensures that the activities of the Kew Innovation Unit complement existing areas of work and are synergistic with Kew's strategy for science. The Trustees need to ensure that the risks are formally assessed and monitored.

19. We recommend that Kew reviews the current cross-directorate science teams, in particular to close or re-structure less effective teams and ensure all teams have a clear role, critical mass and resources to deliver specific outcomes derived from the science strategy.

20. We recommend that Kew develops a science strategy, including a list of priority research questions and the level of people and resource required to effectively address them, along with a process for developing and resourcing cross-directorate projects and for prioritising these projects against each other.

21. We recommend that Kew review and clarify where in the institutional structures the responsibility lies for science management, leadership and assessment and the role of the Trustee-led Science and Conservation Committee.

109. We have found it a privilege and a pleasure to work with Kew on this review, and we wish the Royal Botanic Garden every success as it continues on its mission to understand, conserve and allow the sustainable exploitation of plant and fungal biodiversity.

Appendix 1. Independent Review Panel 2011

Panel Chair
Professor Georgina Mace, CBE, FRS
Director Centre for Population Biology, Imperial College, London, UK

Panel Members
Professor Mark Burgman, FAA
Adrienne Clarke Chair of Botany, University of Melbourne, Australia and Managing Director, Australian Centre of Excellence for Risk Analysis

Professor Dianne Edwards, CBE, FRS
Distinguished Research Professor, School of Earth and Ocean Sciences, University of Cardiff, UK

Professor Jon Hutton
Director UNEP World Conservation Monitoring Centre, Cambridge, UK

Dr Gregory M. Mueller
Vice President Science and Academic Programs, Chicago Botanic Garden, USA

Professor Adrian Newton
Professor in Conservation Science, University of Bournemouth, UK

Professor Susanne Renner
Professor of Systematic Botany and Mycology, Ludwig-Maximilians Universitat München, Germany

Dr Michael Roberts, CBE
Formerly Chief Executive, Defra Central Science Laboratory (now Fera), UK

Professor Jonathon Silvertown
Professor of Ecology, Department of Environmental Sciences, The Open University, UK

Professor Tim Wheeler
Professor of Crop Science, University of Reading, UK & Deputy Chief Scientific Adviser at the Department for International Development (DfID)

Ex-Officio Kew Board of Trustees Representative
Professor Michael Crawley, FRS

Declarations of interests
Professor Mace is a Trustee of the Natural History Museum, London and a professor in the Dept. Of Life Sciences at Imperial College, London where two colleagues are joint appointments between Imperial College and Kew. A number of the panel members have worked on collaborative scientific projects with Kew.

Appendix 2. Terms of Reference for Review Panel

The objective of the science audit is to provide the Chief Scientific Adviser of the Department for Environment, Food and Rural Affairs with an independent, expert assessment of the quality, balance, scope, and appropriateness of the scientific programmes being carried out by the Royal Botanic Gardens (RBG), Kew and those proposed under the Breathing Planet Programme for the next five years.

In particular, the audit should:

1. Evaluate the progress made and actions taken in response to the recommendations made in the previous Science Audit 2006, and in the Independent Review of RBG, Kew (Chalmers report);

2. Review the suitability of the current and proposed science programme to Kew's statutory objectives and Breathing Planet programme, and to the Government's objectives, taking account of the level of funding likely to be available, and to review the mechanisms for developing and formulating the programme;

3. Review the extent to which RBG Kew provides a unique national and international capability for plant science, and its effectiveness in fulfilling that role;

4. Consider the quality and suitability of the resources (including staff, equipment and facilities) available to RBG Kew, and assess Kew's ability to manage those resources and to retain, develop and use the skills of its scientists, and manage succession of key scientists;

5. Review the mechanisms used to transfer the results of its publically funded scientific activities to policy makers, both in the United Kingdom and more widely, in timely, effective and appropriate ways;

6. Review its scientific links with other organisations in the UK and overseas, including Defra's other agencies, government organisations, non-governmental and inter-governmental organisations, universities, and industry, including the ability of Kew to cooperate with other research teams and to share resources and scientific expertise;

7. Review the capability of Kew to achieve its mission through integrating its science programme with visitor experiences on site, online and through publications;

8. Ensure the review covers both the scientific achievements of the past five years and future plans.

Appendix 3. Programme for Kew Panel Visit

Monday 28 November – Wednesday 30 November 2011

DAY 1 - Monday 28 November, 2011
Kew Gardens, Kew, Richmond, Surrey TW9 3AB

Morning Tours of the Gardens, optional on request.

Afternoon

From 15.00 Panel members and Defra Secretariat - optional tour available

15.30 Optional tour of Herbarium and Jodrell Laboratory led by Professor Hopper

17.00 Panel members assemble, Jodrell Laboratory

Welcome and Introductions

17.30 Professor Mick Crawley, Professor Nicola Spence and Dr Geoff Hawtin join the meeting

18.00 Panel Session with Science Review Panel, Defra Secretariat and Professor Mick Crawley

Evening

19.00 Kew International Medal presentation and public lecture, Jodrell Lecture Theatre

Welcome and Introduction by Professor Stephen Hopper

Lecture presented by Professor Brian Huntley, The Kirstenbosch Story – Building a 'Kew of the Southern Hemisphere'

20.15 Panel working dinner with Defra representative/s, Science and Conservation Committee Trustees and Executive Board

DAY 2 - Tuesday 29 November, 2011
Wakehurst Place, Ardingly, Haywards Heath, West Sussex RH17 6TN

Morning

07.30 Panel and Defra Secretariat depart from Kew for Wakehurst Place

09.30 Welcome and address by Professor Stephen Hopper
An overview of Kew's science during 2006 – 2011. Followed by a series of short presentations by cross-departmental teams

presenting research highlights, each with a question and answer session:

09.50 UK Overseas Territories - *Dr Colin Clubbe, Sara Barrios*

10.20 Legumes - *Dr. Gwil Lewis, Dr Barbara Mackinder, Prof. Phil Stevenson*

11.10 Monocots I - *Dr Paula Rudall, Dr Paul Wilkin*

11.40 Mycology - *Dr Martyn Ainsworth*

12.15 Madagascar - *Dr Stuart Cable*

12.45 Conventions and Policies - *Mr Noel McGough, Natasha Ali*

Afternoon

13.50 Tour of Millennium Seed Bank for Panel, Science Trustees and Brian Huntley led by *Dr Paul Smith (accompanied by Professor Hopper and Dr Tim Entwisle)*

Continuation of cross-departmental team presentations

14.30 Wet Tropics, Africa - *Dr Martin Cheek*

15.15 Large Scale Syntheses - *Prof. Monique Simmonds, Dr Eimear Nic Lughadha, Dr Felix Forest*

15.45 Discussion – open to all

16.15 Overview of Corporate Strategies, the Breathing Planet Programme - Professor Stephen Hopper, Director (CEO & Chief Scientist)

17.00 - 18.00 Closed Panel Session

Evening

18.15 Working dinner with Panel members, Professor Mick Crawley, Professor Bob Watson and Defra Secretariat staff

19.45 Coach returns to Kew (arrive at Kew approximately 21.30)

DAY 3 - Wednesday 30 November, 2011
Kew Gardens, Kew, Richmond, Surrey TW9 3AB

Morning

08.30 Introduction to the Corporate Strategies (the Breathing Planet Programme): Professor Stephen Hopper, Director (CEO & Chief Scientist), Jodrell Lecture Theatre

08.45 BPP Strategy 1 (30 min) - *Professor Mark Chase*

09.15 Panel members divide between the two venues for the concurrent sessions.

09.25 Two concurrent seminars:

A) Jodrell Lecture Theatre chaired by Dr Geoffrey Hawtin
BPP Strategy 4 (30 min) *Prof. Monique Simmonds*
BPP Strategy 5 (30 min) *Dr Paul Smith*
BPP Strategy 6 (30 min) *Dr Bruce Pavlik*

B) Cambridge Cottage chaired by Professor Hopper
BPP Strategy 2 (30 min) *Dr Alan Paton*
BPP Strategy 3 (30 min) *Dr Tim Entwisle*
BPP Strategy 7 (30 min) *Prof. Angela McFarlane*

11.10 Group B Return to the Jodrell

11.15 Opportunity to meet with students and Kew scientific staff

11.45 Closed session between the Panel and Defra secretariat, Bennett room

Afternoon

13.45 Closed Panel meeting, with Defra Secretariat and Professor Mick Crawley in the Seminar Room

1 to 1 meetings with Kew staff

14.30 Panel Meeting with the Executive Board, Science and Conservation Trustees and Defra Secretariat in the Seminar Room

15.15 Panel meeting to draft report in the Bennett Room

17.00 Day concludes, or later as determined by the Chair

DAY 4 - Thursday 1 December, 2011

09.00 Professor Georgina Mace (and any available Panel members) to meet with Trades Unions in the Bennett Room (40 mins)

12.00 Professor Mace to meet Professor Hopper for final discussion

Appendix 4. Organisations and Individuals Consulted

The following individuals took part in one-to-one interviews with the review panel:

Royal Botanic Gardens Kew

Professor Stephen Hopper, Director and CEO
Dr Gwil Lewis (Head of Legume Section, Systematics, Herbarium)
Professor Monique Simmonds (Director of the Kew Innovation Unit, Deputy Keeper & Head of Sustainable Uses of Plants Group)
Dr David Simpson (Assistant Keeper Systematics, Herbarium)
RBG Kew Joint Trade Unions Side

Additionally the following individuals and teams provided information and views for the review panel:

Department for Environment, Food and Rural Affairs

Including:

Defra Biodiversity Programme policy and science teams
James Lowen, Arms Length Bodies Programme
Dr Miles Parker, Deputy CSA
Dr Sue Popple, Science co-ordinator for Farming and Food
Professor Sir Robert Watson, CMG, FRS, Chief Scientific Adviser

Royal Botanic Gardens Kew

Including:

Professor Mark Chase
Mrs Susan Glover
Dr Geoffrey Hawtin, Kew Board of Trustees
Professor Nicola Spence, Kew Board of Trustees
Kew Executive Board
Professor Simon Owens
Professor Monique Simmonds
Several members of staff in small group discussions

Others

Professor Brian Huntley, formerly Head of the South African National Biodiversity Institute (SANBI)

Appendix 5. The Seven Breathing Planet Programme Strategies

BPP 1 Diversity Challenge. Driving discovery and global access to essential information on plant and fungal diversity. We are speeding up the discovery of new species of plants and fungi under threat. New web-based identification tools and DNA technology are revolutionising this process. Working with botanists around the world, we are sharing our knowledge and data through our website.

BPP 2 Search and Rescue. Mapping and prioritising. Everywhere in the world there are habitats that need protection and plants that need saving, but some are at greater risk than others. We are pinpointing those places that need attention most urgently using cutting edge mapping techniques.

BPP 3 Help for Habitats. Conserving what remains - helping global conservation programmes on the ground. We are helping to conserve what remains of the world's intact habitats, sharing our knowledge and expertise with those working locally on conservation projects.

BPP 4 Local Plants for Local People. Sustainable local use. Kew's pioneering research into the biology, chemistry and cultivation of wild plants is helping to identify and grow species that can provide new sources of food, medicine, and a range of other benefits. This expertise is helping people in some of the world's poorest regions and those most vulnerable to climate change, to choose suitable wild plants for cultivation.

BPP 5 Save Seed and Prosper. Seedbanking through the Millennium Seed Bank Partnership. The Millennium Seed Bank Partnership, a collaboration between Kew and 120 partners in 54 countries, has two key roles – safeguarding plant diversity by storing seed from wild species and making seed available for sustainable use in agriculture, horticulture, forestry and habitat restoration. By 2020 we will have banked seed from 25 per cent of the world's plants.

BPP 6 Repairing the Damage. Restoration ecology - building a global network to restore damaged habitats. Conserving what remains of plant diversity and intact habitats is vital, but we can do more. By restoring lost and damaged habitats, we can protect diversity, improve marginal land and increase the Earth's capacity to lock up carbon in plant biomass.

BPP 7 Wonders and Marvels. Using botanic gardens to inform and inspire. Ultimately, one of the most effective ways to protect biodiversity is to raise people's awareness of the debt we owe plants and fungi, the problems they face and how our future depends on their continued survival. With its two gardens and outreach programme, Kew is uniquely placed to inspire an appreciation of the environment and engage the public in our mission.