Ascension Island Ecosystem Action Plan

MONTANE MIST REGION

SUMMARY

IUCN habitat classifications: 1.9 Subtropical/tropical moist montane forest; 3.6 Sub-tropical/tropical moist shrubland; 6. Rocky areas; 16. Introduced vegetation

Description: Ascension Island's cloud forest zone, or mist region [1], is confined to the summit slopes of Green Mountain, where frequent immersion in cloud banks creates continuously damp conditions. Although the ecosystem shares many of the features of a true cloud forest, the original vegetation of this zone was treeless and dominated by ferns and bryophytes, including several endemic species. These native habitats have now been largely replaced by a novel ecosystem of introduced trees, shrubs and grasses and survive in only a few isolated locations on the most exposed slopes and outcrops. Nevertheless, the mist region remains the centre of botanical diversity within the Territory, supporting populations of 15 out of the 18 known endemic plant species. The native fauna is comprised entirely of invertebrates and remains little known, although at least one endemic moth species has been described and others may await discovery.

Threats: Invasive alien species constitute the most immediate threat to the ecological integrity of the mist zone, with climate change posing a potentially significant, but unpredictable, long-term threat.

Citation: Ascension Island Government (2015) Montane cloud forest ecosystem action plan. In: *The Ascension Island Biodiversity Action Plan*. Ascension Island Government Conservation Department, Georgetown, Ascension Island

2. Distribution

Total extent:	**ca. 0.9 km^2**

The montane mist region is Ascension Island's most restricted bioclimatic zone, covering an area of less than 1 km^2 that includes the summit ridge and uppermost slopes of Green Mountain. In the absence of fine scale habitat mapping and climatic data, an elevation range of 660 – 870 m has typically been used to describe the mist-affected area [1,2] (Fig. 1), although the influence of the prevailing south-easterly trade winds undoubtedly results in some altitudinal variation between windward and leeward slopes.

Figure 1. Approximate distribution of Ascension Island's montane cloud forest ecosystem, defined as the area > 660 m.

3. Ecosystem characteristics

Physical

Virtually every aspect of the mist zone ecosystem, including soils, hydrology and all of the constituent biodiversity, is affected by regular immersion in the orographic cloud banks that frequently envelope the summit slopes of Green Mountain. These mists are formed as moisture-laden air carried on the south-easterly trade winds is forced to rise sharply over the mountainous eastern portion of the Island, cooling as it does. The amount of rainfall received is generally limited by the trade wind inversion which sits at a height of approximately 1000-1500 m and acts as a cap that inhibits vertical cloud formation [3,4]. However, as in other cloud forest ecosystems, much of the plant-available water in this zone arrives in the form of occult precipitation, or 'fog drip', caused by moisture droplets in mist adhering to foliage and other surfaces. There are no permanent, freshwater springs or rivers, but there are a number of locations where water percolates through banks of coarse cinder to form drips and areas of permanently wet rocks. Average monthly minimum and maximum temperatures at 660 m range from 14.5–17.4^{o}C and 20.8–25.5^{o}C, respectively, and average annual rainfall is approximately 700 mm [1] (Meteorological Office, unpublished data) placing Green Mountain at the drier, warmer and low-seasonality end of the cloud forest spectrum [5].

Biological

The ecology of the mist zone has been substantially altered by mass introductions of exotic species and many details of the original plant and animal communities are consequently lacking. Based on historical collections and observations of the few remaining fragments of native vegetation, we can surmise that the original biota of this area was relatively species poor, with a fauna comprised entirely of invertebrates and a flora dominated by ferns, bryophytes and lichens, along with club mosses (*Lycopodium* spp.) and a few grasses [1,3,6,7]. Nineteenth century accounts invariably describe the summit of Green Mountain as being overgrown with a carpet of ferns, probably comprised of species such as *Histiopteris incisa*, *Christella dentata* and *Ptisana purpurascens* which still form a vigorous community on a few exposed, south-facing slopes [1,7]. The extinct *Dryopteris ascensionis* is also thought to have formed part of this community [7]. Lycopods, bryophytes and smaller, lithophytic ferns and grasses probably became important on steeper banks and more exposed outcrops where they still occur today in a few places (see [7] for a more detailed discussion of community types). Although limited in terms of richness, the mist zone flora included a number of endemic species, including at least five ferns, one grass and 10 bryophytes, along with an unknown number of lichens. The grass *Sporobolus caespitosus* and the ferns *Anogramma ascensionis*, *Asplenium ascensionis*, *Stenogrammitis ascensionensis* and *Ptisana purpurascens* still occur either exclusively or partially in this area, as do 10 endemic mosses, one liverwort and the recently described frilly hornwort (*Anthoceros cristatus*). Unfortunately, no early accounts of the fauna of Green Mountain exist and the subsequent invasion of this area by introduced species largely vitiates any attempt to reconstruct the original animal community there. Scavengers and herbivores probably included collembolans, psocopterans and mites, along with teneid moths such as *Erechthias minutus* and the endemic *Erechthias grayii* which still occurs in some undisturbed areas [3,8]. Land crabs also occur throughout much of the mist zone, although appear to be largely absent from the highest elevations. Predators doubtless included mites and a few spiders, such as the linyphiids *Lepthyphantes* sp. and *Bathyphantes* sp [3].

4. Conservation status

Ascension Island's montane ecosystem has been irrevocably altered as a result of species introduced by man and virtually nothing still exists that could be described as truly "native habitat". The most significant event in this transformation was brought about at the instigation of the eminent botanist Joseph Hooker, who, following a visit to the Island in 1843, advocated an ambitious programme of planting aimed at creating pasture, reducing erosion and greatly increasing mist interception, soil development and water storage capacity. This plan was subsequently implemented by the Royal Botanic Gardens at Kew and entailed the introduction of over 220 exotic species from diverse parts of the world. Today, the higher reaches of Green Mountain are largely covered in dense invasive vegetation and man-made cloud forest. A small forest of bamboo (*Bambusa* sp.) and groves of exotic evergreen trees now occupy the summit ridge and some of the more sheltered slopes, while swathes of shell ginger (*Alpinia zerumbet*) and expanses of non-native grassland and shrubland cover many of the more exposed faces. Only on a few of the most mist-exposed ridges and banks do the last vestiges of the original, fern-dominated communities remain, and these are increasingly weed-infested. In some cases, native species have been able to infiltrate the novel ecosystem that has developed around them and now occur as epiphytes in cloud forest trees (e.g. *Stenogrammitis ascensionensis*) or in the shaded understory beneath them (e.g. *Ptisana purpurascens*). However, most are believed to have suffered precipitous declines. Of the six endemic vascular plants that once occupied the mist region, one is extinct (the fern *Dryopteris ascensionis*) and four are regarded as 'critically endangered' [9]. Lower plants have been poorly-studied on Ascension, but it is probable that several of the endemic bryophytes are now also very endangered. Along with imports of exotic vegetation and topsoil, large numbers of exotic invertebrates were inevitably introduced and these now dominate the montane fauna. At least nine introduced vertebrates, including rabbits, rats and feral sheep, are also present. The status of the native fauna is essentially unknown. Generalist species such as land crabs may have been relatively unaffected by recent changes, or may even have benefited from the greater abundance of food. However, species with more specialised habitat requirements are likely to have declined in concert with the native flora.

5. Current threats*

8.1 Invasive non-native/alien species	Impact:	HIGH

The large number of invasive plant species now present in the mist zone represents the greatest threat to the conservation interest and recreational value of this area. Unfortunately, the list of introductions includes some of the most notorious pest species in the tropics, comprising many extremely vigorous and competitive threats. *Alpinia zerumbet*, *Buddleja madagascarensis* and several other thicket-forming, invasive shrubs are a particularly pervasive problem. These species have already smothered large tracts of apparently prime native habitat and greatly diminish the amenity value of Green Mountain National Park, choking footpaths and obscuring otherwise panoramic views of the Island. There is no evidence to suggest that their advance has slowed; if anything, the spread of certain ascendant, shrubby species such as *Vitex trifolia* and *Clerodendrum chinense* appears to be accelerating. The increasing scarcity of open, sparsely-vegetated habitat is of particular concern for the conservation of the early-successional endemic flora. *Sporobolus caespitosus*, *Stenogrammitis ascensionensis*, *Anogramma ascensionis* and *Asplenium ascensionis*, are all at least partially dependent on a dwindling number of exposed, rocky banks. Some of these species now survive in only a handful of locations where they are vulnerable to encroachment by shrubs, maidenhair ferns (*Adiantum* spp.) and many small weedy species, including Koster's curse (*Clidemia hirta*), goat weed (*Ageratum conyzoides*), buttonweed (*Spermacoce verticillata*) and cape grass (*Sporobolus africanus*), to name a few. Besides invasive vegetation, browsing by introduced mammals poses a secondary threat to a number of native plant species. Rabbits in particular are a widespread problem and are known to graze young shoots of ferns growing in more open terrain. A more in depth analysis of the multiple invasive species threats facing the cloud forest system can be found in [7].

11. Climate change & severe weather: habitat shifting & alteration	Impact: UNKNOWN
Anthropogenic climate change poses a potentially significant threat to cloud forests worldwide through predicted changes in both temperature and cloud formation [4,10–12]. A combination of rising global temperatures and a simultaneous reduction in low-level cloudiness are widely expected to result in the displacement of many peak-residing cloud forests by lower altitude ecosystems [4,10,12], and appear to already be affecting at least one region [11]. In the case of Ascension Island, even a relatively small increase in the altitude of cloud formation would be enough to ensure that Green Mountain lacked a mist region for much of the year, fundamentally altering the hydrology and ecology of the montane ecosystem. Epiphytes and other aerial plants would be most affected by reductions in relative humidity [4] and extinctions of some range-restricted endemics such as *Stenogrammitis ascenionensis* and *Ptisana purpurascens* would be highly likely. However, while a global temperature rise of several degrees by 2100 now seems inevitable [13], local changes in cloud formation and rainfall are far more difficult to predict with any certainty. Indeed, modelling studies indicate significant geographical variation, with some cloud forests experiencing a lifting of the cloud base and others experiencing a substantial lowering [14,15]. In the case of oceanic islands, changes may be very slight due to the continuously high relative humidity [15]. Clearly, improved climate monitoring and modelling at a local scale will be needed to properly assess threats to Ascension Island's cloud forest zone.	
*Threats are classified and scored according to the IUCN-CMP Unified Classification of Direct Threats [16]	

6. Relevant policies & legislation

The mist region ecosystem is entirely contained within the boundaries of Green Mountain National Park which was established in 2005 under the National Protected Areas Ordinance and subsequently expanded under the National Protected Areas Order, 2014. In addition, all species of endemic, vascular plants occurring within the mist region are protected under the Wildlife Protection Ordinance, 2013.

7. Actions needed

The conservation needs of individual, endemic plant species are addressed more thoroughly in dedicated species action plans available on the BAP website and in the 2009 "Plan for the conservation of endemic and native flora of Ascension Island" [7]. The actions below provide a distillation of ideas contained therein and are concerned primarily with habitat-level approaches to managing the mist region ecosystem.

1. Conserve the remaining fragments of semi-native vegetation.

These small areas are now of high biodiversity value, supporting a large proportion of the populations of several threatened higher plant species along with potentially important bryophyte, lichen and invertebrate assemblages. Preventing further encroachment by introduced weeds is a high priority and requires immediate attention. Manual control will be necessary until more sustainable solutions can be developed (see below), but this should be achievable with existing resources provided that habitat degradation is not allowed to progress too far. The following actions are recommended:

a) Designate a series of spatially-explicit 'Important Plant Areas' within the mist region following, objective internationally-recognised criteria. This measure will help to focus minds on those areas that require attention and provide the policy-backing needed to ensure sustained action.

b) Produce site management plans for each of the above, with clearly defined work programmes for controlling invasive species. Again, this measure is critical to ensure continuity of action.

c) Initiate research into the invertebrate, lichen and lower plant components of these communities to assess the wider ecological benefits of preserving intact areas of native vegetation.

2. Develop and refine habitat restoration techniques.

Assuming that existing native habitat can be secured, consideration should be given to restoring areas currently overgrown by invasive vegetation. However, this is not a trivial undertaking and further development work on a small scale will be needed to ensure that restored habitats are functional and self-sustaining to the highest degree possible. A fenced restoration site/field nursery has already been established in a clearing close to the summit of

Green Mountain, but this has proven difficult to maintain in a weed free condition and natural regeneration has been very limited. Availability of plants has also limited restoration options as the dominant, habitat-forming native species such as *Histiopteris incisa* and *Ptisana purpurascens* still cannot be cultivated from spore. Clearly, addressing this shortfall will be a prerequisite for any large-scale habitat programme. Experimentation with different planting schemes and species mixes is also needed to identify the most resilient combinations. Elsewhere, establishing a tight, native sward with continuous ground cover has proved reasonably effective at excluding undesirable species [7] and this should be trialled within existing restoration sites. However, the potential for natural recruitment within such a dense matrix is currently unclear. Until the regeneration cycles of the native species concerned are better understood it will not be possible to determine the most appropriate restoration strategy. The following specific actions are recommended:

a) Develop horticultural protocols for cultivating *H. incisa* and *P. purpurascens* from spore.

b) Experiment with different planting schemes in existing restoration areas, with the results to be carefully monitored and reported.

c) Initiate research into the regeneration cycles of key native species, in particular the conditions under which seedling recruitment occurs.

3. Explore biological control options for permanently reducing the competitiveness of key invasive plant species.

The increasing dominance of the montane flora by a few vigorous, invasive weeds can be partly attributed to a lack of the natural enemies that normally regulate their populations (e.g. see [17] for a discussion of ecological release in Koster's Curse). Introducing specialised pests and diseases from a species native range can therefore be a sustainable and cost-effective way of achieving lasting control. Biological control has already been successfully applied to some invasive plants on Ascension Island and could be expanded to address some of the more problematic weeds currently affecting the mist region [18]. Shell ginger (*Alpinia zerumbet*) and Koster's curse (*Clidemia hirta*) have been identified as particularly promising targets because 'off-the-shelf' biocontrol agents have already been developed elsewhere [18]. However, testing of suitable agents is currently in progress for a number of other species, including *Buddleja* spp. and *Clerodendrum chinense* [18]. Biological control will not be a standalone solution, but could effectively complement other forms of habitat management and should be considered as part of a holistic approach to restoring the ecological balance of Green Mountain.

4. Expand the cloud forest.

While the conventional goal of habitat restoration is to recreate predominantly native communities, this may not always be achievable. In the case of the mist region ecosystem, the limited functional diversity amongst the native flora is a major obstacle to any restoration scheme as the original fern and bryophyte-dominated communities typically lack the canopy-forming and ground cover species needed to exclude vigorous, invasive weeds. With this in mind, it may be necessary to experiment with the use of relatively benign, non-native species to supplement the development of stable, mature communities [7]. A good example of this approach has been provided by the colonisation of the man-made cloud forest by a number of endemic ferns and native bryophytes. Despite having formed around conspicuously non-native trees, the cloud forest now contains important populations of two endemic ferns which utilise branches or gaps in the understory. Moreover, because the canopy effectively excludes the vast majority of invasive shrubs, weeds and grasses, the resultant communities are relatively stable and require little or no management. Maintaining the current cloud forest and attempting to expand the canopy into low-grade, shrub-dominated land would therefore seem a viable management strategy for a number of native species.

a) Map the current distribution of old-growth trees and assess levels of natural regeneration.

b) Establish a tree nursery to provide material for c).

c) Select a suitable area, or areas, for cloud forest expansion trials and attempt the introduction of tree species already present in the cloud forest zone and known to provide habitat for native plants.

5. Establish a broadly-based climate monitoring system

Irrespective of the final management regime that is adopted, climate change has the potential to irretrievably alter the nature Ascension Island's mist region ecosystem. Climate change is a global problem requiring global solutions and there are few (if any) actions that can be taken locally to slow its progress. However, early detection of trends in the abiotic and biotic environment may allow the development of adaptation plans to lessen its impacts. At the very least, a series of altitudinally-graded meteorological stations on Green Mountain are needed to monitor changes in temperature and the altitude of the lifting condensation level. Monitoring the distribution of sensitive indicator species, such as epiphytes, may also give some indications of the advancement of climate change and could be easily integrated into existing endemic plant monitoring programmes (e.g. for *S. ascensionensis*).

References

1. Duffey E (1964) The terrestrial ecology of Ascension Island. *Journal of Applied Ecology* **1**, 219–251.
2. Gray A, Pelembe T & Stroud S (2005) The conservation of the endemic vascular flora of Ascension Island and threats from alien species. *Oryx* **39**, 449.
3. Ashmole NP & Ashmole MJ (1997) The land fauna of Ascension Island: new data from caves and lava flows, and a reconstruction of the prehistoric ecosystem. *Journal of Biogeography* **24**, 549–589.
4. Foster P (2001) The potential negative impacts of global climate change on tropical montane cloud forests. *Earth-Science Reviews* **55**, 73–106.
5. Jarvis A & Mulligan M (2011) The climate of cloud forests. *Hydrological Processes* **25**, 327–343.
6. Cronk QCB (1980) Extinction and survival in the endemic vascular flora of Ascension Island. *Biological Conservation* **17**, 207–219.
7. Lambdon P, Stroud S, Clubbe C, Gray A, Hamilton M, Niissalo M, Pelembe T & Renshaw O (2009) *A plan for the conservation of endemic and native flora on Ascension Island*.
8. Davis DR & Mendel H (2013) The genus Erechthias Meyrick of Ascension Island,including discovery of a new brachypterous species (Lepidoptera, Tineidae). *Zoo Keys* **341**, 1–20.
9. IUCN (2014) *The IUCN Red List of Threatened Species. Version 2014.3.* [accessed 2015 Aug. 4].
10. Still CJ, Foster PN & Schneider SH (1999) Simulating the effects of climate change on tropical montane cloud forests. *Nature* **398**, 608–610.
11. Pounds JA, Fogden MP & Campbell JH (1999) Biological response to climate change on a tropical mountain. *Nature* **398**, 611–615.
12. Ponce-Reyes R, Reynoso-Rosales V-H, Watson JEM, VanDerWal J, Fuller RA, Pressey RL & Possingham HP (2012) Vulnerability of cloud forest reserves in Mexico to climate change. *Nature Climate Change* **2**, 448–452.
13. IPCC (2013) Summary for Policymakers. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (eds. T. F. Stocker D. Qin G.-K. Plattner M. Tignor S. K. Allen J. Boschung A. Nauels Y. Xia V. Bex & P. M. Midgley). Cambridge University Press, Cambridge, UK. pp. 1–30.
14. Sperling FN, Washington R & Whittaker RJ (2004) Future climate change of the subtropical North Atlantic: implications for the cloud forests of tenerife. *Climatic Change* **65**, 103–123.
15. Foster P (2010) Changes in mist immersion. In: *Tropical Montane Cloud Forests: Science for Conservation and Management* (eds. L. A. Bruijnzeel F. N. Scatena & L. S. Hamilton). Cambridge University Press, Cambridge, UK. pp. 57–66.
16. Salafsky N et al. (2008) A Standard Lexicon for Biodiversity Conservation: Unified Classifications of Threats and Actions. *Conservation Biology* **22**, 897–911.
17. DeWalt SJ, Denslow JS & Ickes K (2004) Natural-enemy release facilitates habitat expansion of the invasive tropical shrub Clidemia hirta. *Ecology* **85**, 471–483.
18. Maczey N, Tanner R & Shaw R (2012) *Understanding and addressing the impact of invasive non-native species in the UK Overseas Territories in the South Atlantic: A review of the potential for biocontrol. Preliminary results Ascension Island.* Unpublished report. CABI.