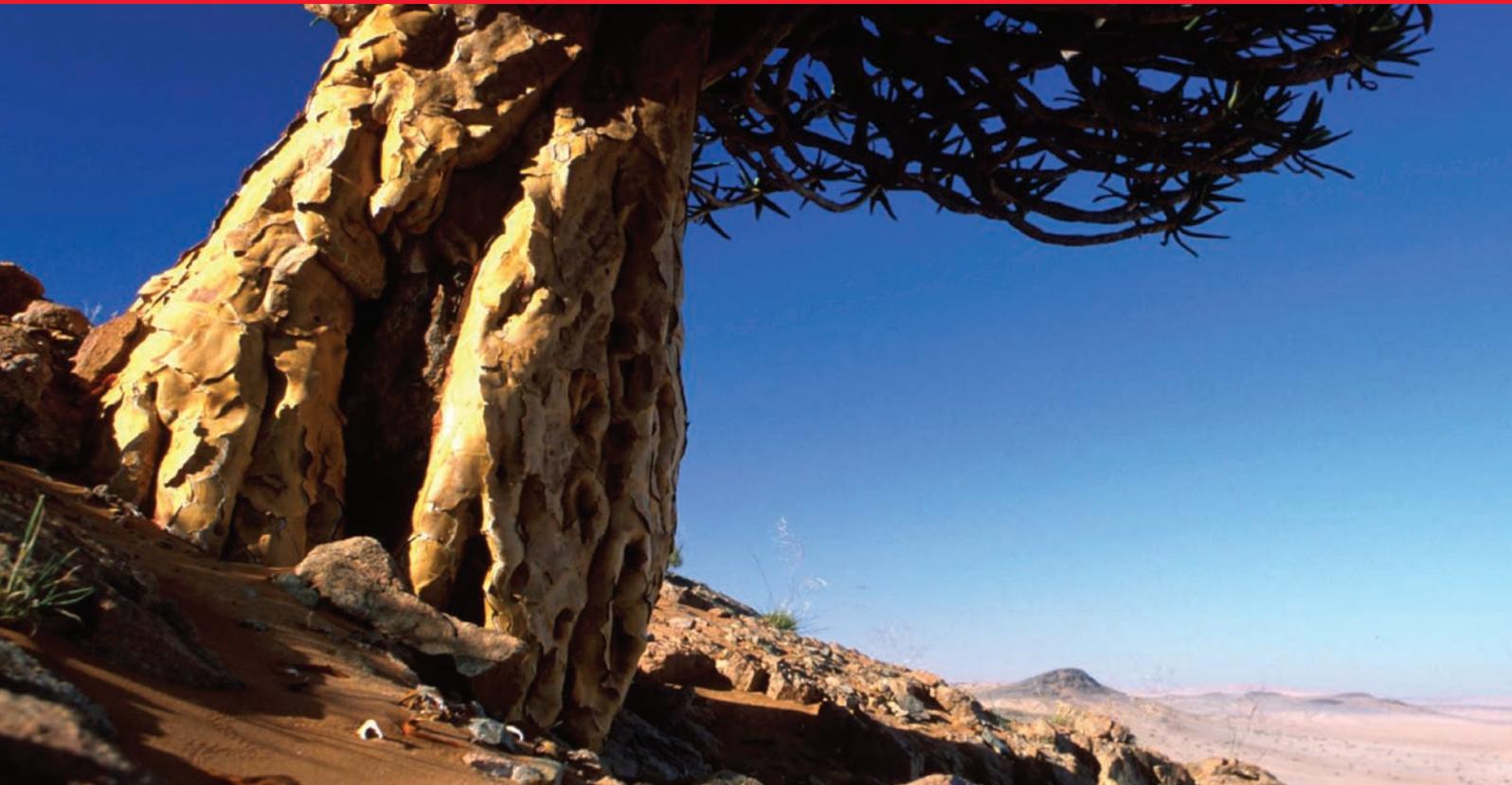


QUIVER TREES AND CLIMATE CHANGE

Desert giants feel the heat



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Summary

- The Quiver Tree, a long-lived giant tree Aloe, is iconic in the Namib Desert region of southern Africa. This region is projected to experience increasing droughts due to climate change.
- The Quiver Tree seems to be responding to this warming by shifting its distribution range towards higher latitudes (closer to the poles) and higher altitudes (tops of mountains), where conditions are typically cooler and moister.
- The Quiver Tree is slowly losing equator-ward parts of its range due to climate change, but populations are flourishing on its pole-ward range edge. This pattern is typical of species undergoing a pole-ward range shift.
- To keep up with a shifting climate, the Quiver Tree must, in time, colonise new pole-ward areas that are now becoming suitable. Sadly, no new populations have yet been found.
- The Quiver Tree highlights the problems that all plants and slow-moving species face in keeping up with rapidly accelerating changing climate.

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The Quiver Tree (*Aloe dichotoma*) is one of the best known desert plant species of southern Africa. Reaching heights of up to 10 metres, it is the largest, and arguably most striking, floral element of its native landscape.

Traditionally, Quiver Trees are used by indigenous San Bushmen hunters to construct quivers to carry their arrows. Due to their pulpy, water retentive 'wood', dead trunks are often hollowed out and used as natural refrigerators. Other reported uses include the use of the bark as building material and the wood pulp as a source of drinking water.

As far back as 1685 and 1861 eminent historic figures such as Simon van der Stel (the Dutch explorer and first governor of the Cape Colony) and Thomas Baines (the English artist and explorer) respectively noted Quiver Trees as being conspicuous and defining elements of the landscape. In more recent times Quiver Tree 'forests' have become popular tourist attractions. The Quiver Tree has been named the national plant of Namibia and appears on the country's 50c coins.

Within their ecosystem, the Quiver Trees' nectar-rich flowers provide food for a number of species including insects, birds and even large mammals such as baboons. Quiver Trees also provide important nesting sites for birds including perches for raptors and support for the massive nests of Sociable Weavers. Such roles are of particular importance in the Quiver Trees' otherwise often treeless and barren desert landscapes.

What do we know about Quiver Trees?

Quiver Trees grow in arid regions of South Africa and Namibia. Within these two countries, the species is found predominantly in the west, and occurs throughout much of the Succulent Karoo Biodiversity Hotspot.

As a desert species, the Quiver Tree has well adapted to its environment through water-storing succulent leaves and shallow root systems that can quickly absorb water following rare rainfall events and even when condensed ocean fog drips from their own branches and leaves. Like other members of the *Aloe* genus, Quiver Trees use a special internal adaptation known as 'CAM metabolism', which allows them to photosynthesise without losing much water to the hot and dry environment.

How is climate change affecting Quiver Trees?

Weather station records from across the Quiver Tree's range show that average temperatures in the region have increased over past decades. Regional climate predictions suggest accelerating temperature increases and rainfall decreases in the near future.

Because they live so long (approximately 350 years) and continue to grow larger throughout their lives, Quiver Trees provide an invaluable living record of past climatic



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events. By examining the sizes of trees in a Quiver Tree population, it is possible to estimate when the infrequent wet periods suitable for seedling survival occurred. In addition, because the decay of dead trees happens slowly in the hot, dry desert conditions, the number of tree deaths can be reasonably accurately recorded. This makes Quiver Trees ideal for examining the ongoing impacts of climate change.

Distribution range shift:

By 2001, large die-offs of Quiver Trees were occurring, generating concern amongst the people of Namibia and South Africa. Scientists found that most of these die-offs were occurring in the hotter equator-ward areas of the Quiver Tree's range, and that these were most likely to be caused by drought stress. In contrast, populations on the pole-ward range areas and at the tops of high mountains were growing and reproducing.

Species are known to respond to climatic warming by shifting their ranges closer to higher latitudes and higher altitudes, where conditions are typically cooler and moister. For mobile species, this is apparent as individuals migrate away, but for plants and other immobile organisms, individuals that are 'left behind' by their shifting ranges are unlikely to reproduce successfully and eventually die.

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In contrast, pole-ward range areas that were previously unsuitably cold or wet can become newly suitable. Collectively, such areas may be known as the 'leading edge' of the species' range. Mobile species can quickly take advantage of these new conditions, but immobile species like plants rely on rare long distance seed dispersal events to colonise new areas. Mapping patterns of population die-off across the Quiver Tree's range, revealed just such a pattern of a pole-ward range shift in response to warming. High die-offs are generally occurring on the equator-ward and low altitude parts of the species range, while populations on the 'leading edge' and on mountain tops have been flourishing increasingly over the past decades.

Can Quiver Trees adapt to climate change?

Genetic studies show that pole-ward, leading edge populations are generally more genetically poorer than equator-ward populations. This has two implications; firstly, it suggests that the pole-ward populations are younger and may have descended from the older equator-ward populations. This could be due to a range shift over a long time period such as following the last ice age, and suggests that, if pace of climate change is sufficiently slowed, the species may yet keep up.

Secondly, die-off of equator-ward populations would lead to loss of a disproportionate percentage of Quiver Trees' genetic diversity, including the lineages that are adapted to the hottest and driest conditions.

Scientists have not found any new Quiver Tree populations beyond the established pole-ward leading range edge, despite several decades of warmer, drier conditions. But Quiver Trees in gardens in these areas flourish, suggesting that climate is unlikely to be preventing colonisation, and rather that long distance dispersal may be limiting the Quiver Tree's migration.

This introduces an important and controversial conservation question: should scientists help Quiver Trees to migrate by planting new trees beyond their pole-ward leading range edge – a process known as 'assisted colonisation'? If so, should they simulate natural dispersal, spreading plants from pole-ward populations, or should they use plants from the genetically rich equator-ward populations, risking what some would call 'genetic pollution'? These questions remain the subject of as yet, unresolved debate, and highlight some of the challenges climate change brings to traditional scientific approaches and conservation practices.

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Other threats

Very few other anthropogenic threats to Quiver Trees exist, although their popularity with gardeners makes the removal of juveniles, particularly in populations near towns or main roads, a marginal threat. Natural threats to the Quiver Trees include a fungal disease known as 'Aloe rust', and physical damage caused by baboons and porcupines.

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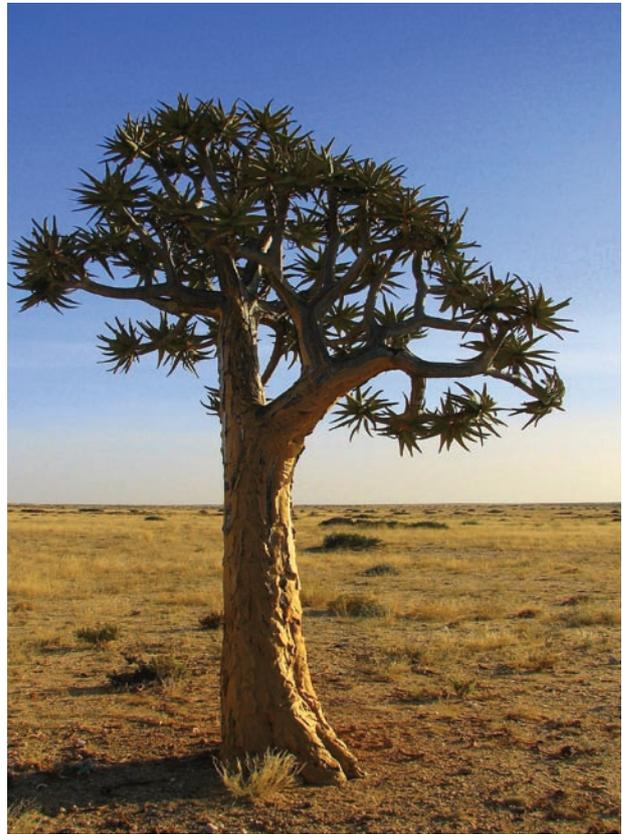


Quiver Tree geographical range – © IUCN Red List

"The Quiver Tree is noted for its drought tolerance and longevity, but in fact, like other desert organisms, it may be operating at the edge of its physiological tolerance.

If the Quiver Tree is declining as a result of climate change, then other smaller-ranged and more sensitive species are likely to be experiencing even worse impacts. But being inconspicuous, their declines may be passing unnoticed."

- Wendy Foden
IUCN SSC Southern African Plant Specialist Group



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