Recent trends in and preparedness for extreme weather events

Introduction

I am a horticultural science graduate and PhD candidate at the University of Melbourne, and former member of the Australian Mycorrhiza, Biology & Ecology Research Group (AMBERG) at the University under Dr. Cassandra McLean. I was a lecturer in horticulture, biology, ecology and soil science at the University of Melbourne for almost ten years.

I make this submission on behalf of the horticulture industry, but also to make reference to wider ecological effects of climate change which have received little coverage in the discussion of climate change mitigation. This lack of attention is due mostly to our relatively poor understanding of the systems involved, even by specialists in the field.

I will talk about the effect of climate change on the agricultural and horticultural industries, and on landscape management, with reference to forests and natural vegetation.

Agriculture

More than half of the landmass of Australia is used for agricultural production, though the total area is down from the area farmed at the end of the 20th century[1]. Agriculture in Australia can be broadly divided into two categories

- Dryland Agriculture
- Irrigated Agriculture

Both these forms of agricultural production have specific problems arising from so-called extreme weather events, and while farmers have become accustomed to the unique climate of Australia over the last two centuries, crop failures have been common and devastating to local and national economies when they have occurred.

Such crop failures will likely increase with continued climate change in a number of possible ways.

Dryland agriculture

The defining feature of dryland agriculture in Australia is the reliance on regular, predictable rainfall. Dryland products include livestock for meat and fibre, the majority of grain production, excluding rice, and other crops such as oilseed (canola) and hay as by-products.

The annual crops such as wheat rely on precipitation to arrive at known times of year, immediately after seed is sown, and during the initial growth phase of the grain. It is then desirable that no rainfall occurs during the harvest period of grain, as spoilage renders the grain unusable, or greatly reduced in value.

Any shift in the rainfall patterns in dryland areas will result in failed or reduced crops. While livestock may be a fallback solution, reduced rainfall may also mean stocking rates will have to be reduced to cope with lack of watering capability. Even where rainfall is not absent but reduced in volume will result in reduced harvest, and possibly higher evaporation due to ambient temperature increases.

Rainfall during harvest periods or ripening periods for grain crops will increase the risk of fungal and bacterial outbreaks in standing crops. Wet grain can undergo fermentation or other microbial infection, which reduces its usefulness to stock feed, rather than high quality products for human consumption, such as flour. It will also drive up prices of dryland commodities due to shortage.

Potential solutions for dryland agriculture

While changes in the weather have always been an issue for dryland farmers in Australia, extended periods of drought will continue to push marginal farmland into untenable land for any traditionally productive purpose. Such land could potentially be bought back by governments or private enterprise and replanted with mixed species vegetation for carbon offset purposes.

Where high conservation values may be restored, local indigenous species may be used. In other cases, while the land may be unsuitable for annual cropping, perennial species may produce commercial crops, after a period of establishment, including fruit, nuts or livestock feed. Timber and vegetable-based oils, such as Eucalyptus and Melaleuca oil are other potential income sources.

On farms where production remains viable, income can be supplemented by planting in peripheral or marginal land within farms. When tree species are used on farms they will also help keep water tables low, and reduce salination of farmland, and reduce wind and water erosion, and fertiliser runoff.

Towns in dryland agricultural areas should also plant their immediate areas with supplementary plants, especially high return fruits and nuts, and specifically non-flammable species to reduce bushfire risk and damage. Local communities will be better prepared to deal with shortages in production in a direct way by having food and produce available directly from their planned environment.

Irrigated Agriculture

Irrigated agriculture is reliant on the availability of irrigation water from collected runoff in dams and waterways in inland Australia, predominantly Murray Darling basin which accounts for more than two thirds of the water used for irrigation in Australia[2].

Almost half of the total irrigation water used in Australia is for dairy grazing and cotton production. The volume of water used for irrigation has increased in recent years, as has the amount of land under irrigation[2].

The biggest problem facing irrigated agriculture is a reduction in rainfall. Catchment can receive rainfall for redistribution only after natural vegetation has used what it needs from the total rainfall. Reductions in rainfall can translate into much larger reductions in runoff, as the standing vegetation does not reduce its water requirements, so less runoff is available for storage. This problem also relates to water storage for urban water supplies.

Potential solutions for irrigated agriculture

The main solution for irrigated agriculture is to reduce dependence on water use. It will be an unpopular decision among dairy and cotton growers, and rice producers, but reduction in irrigated pasture for dairy herds is possible, and production of cotton and rice in the areas it is presently grown is not the best use of water resources.

Where water is drawn from natural catchments, the release of maximum amounts of water for natural ecosystems such as wetlands and estuaries will give those systems the best possible chance of adapting to changes in climate and severe weather. Any amount used for agriculture is reducing the "natural" state of fisheries, bird and animal habitats that rely on river flows for reproduction and survival.

The best option for irrigated agriculture is to seek alternative water sources, either by processing grey water from cities or industry, or by desalinating water on the coast and piping it inland for production purposes. This is the only real long term course of action for ongoing irrigated agriculture in Australia, but relies on efficient technology and renewable energy sources for the treatment of sea or grey water to further reduce emissions. Such treated water could also be used for urban and rural forestry projects to further increase carbon sequestration.

Horticulture

The Australian horticulture industry has been reducing production in recent years due to increased competition from cheaper overseas produce, and a reduction in local fruit and vegetable preserving and processing operations.

As much horticultural production is reliant on supplemental irrigation, the same issues that affect irrigated agriculture will impact on horticultural production as far as reduced water availability[3].

In addition, climate will have a direct affect on many horticultural crops, particularly those that have a chilling requirement. Many fruit trees, particularly stone fruits such as Cherries and Peaches, as well as pome fruits including Apples, and Pears to a lesser extent, require a certain period of chilling during their dormant phase. This chill requirement is quite precise, and not enough time below a certain temperature, usually 7° C, will result in poor flower and leaf bud development, and in turn, poor fruit quality and quantity[4].

The chill requirement is usually cumulative, and each day when temperatures dip below the critical temperature adds to the total chill hours the tree has received, and in areas where these crops are produced, a winter will usually have enough cold hours to produce good harvests. However, in many cases where trees are subjected to temperatures above a certain threshold, the accumulated hours are lost, and the chill period must begin again[4].

The critical thresholds are only a few degrees apart, and a change in winter maximum and minimum temperatures in fruit growing areas will have a massive impact on the productivity of orchards. Similar effects can be expected on viticulture and nut growing operations, as well as having an effect on cut flower growing operations, especially bulbs like Tulips[4].

Potential solutions for horticulture

As with agriculture, potential solutions for horticultural operations are for increased planting of perennial crop plants. Diversification of horticulture plantings by using mixed planting of any species with a harvestable product in any location it will survive will ensure a harvest of something no matter what the annual conditions are like.

Perennial plantings have the advantage of resilience over annual, high maintenance crops such as annual vegetables. They can be damaged by catastrophic events without a complete loss of production, or with a relatively short recovery period. Perennial plants, especially trees, are more resistant to flooding events, and many productive exotic broadleaf plants can provide a degree of protection from bushfire in developed areas.

Inclusion in orchards of marginal species, for example tropical fruits in the subtropics, and sub-tropical fruits in warm temperate areas will ensure that as climate shifts, fruit supplies will shift with them, as warmer climate species may be able to absorb some of the demand as cool areas become warmer, but only if they are planted in the short term for longer term preparedness.

Similar solutions apply to ornamental horticulture as climates change. Established plants need to be already growing to fill in the gaps as cool climate species begin to fail in street tree plantings and parks & gardens.

Ecological issues

It is with ecological issues that we face the most uncertainty, and for land-based ecosystems predicting outcomes for systems with many thousands of components is far more difficult than the projections for relatively simple agricultural landscapes.

Urban areas

In urban areas, replanting native vegetation is rarely the best use of open space. Urban areas are predominantly used by people, and the vegetation should reflect this. The catastrophic potential of Australian native forests in urban areas has been repeatedly shown in fires in the ACT, NSW, and Victoria in only the last few years.

Urban areas are never going to return to being native bushland, they are modern spaces, and should be planted with species that best provide for high density human populations into the future. The soils in urban areas are highly modified, and no longer possess the nutritional or structural properties that once supported the indigenous vegetation. As such, putting these plants back is a difficult, labour intensive process, and not guaranteed to succeed.

Urban areas are also concentrated sources of potentially re-usable water, post-domestic and industrial “first use”, and nutrients in the form of biological wastes from industrial and domestic sources. These potential pollutants can be converted into useful fertiliser and soil amelioration without massive amounts of technology or transport by applying them locally where they are produced. The reduction in infrastructure pressures will have positive effects on overall emissions and even traffic congestion.

Also, except in circumstances where continuous connection of vegetation is possible, such as along riverbanks, disconnected natural vegetation creates further problems for migrating wildlife, including crossing roads, and interfering with non-native planting. By far the best option in my opinion is to fill urban and suburban landscapes with plants and animals of direct benefit to the human inhabitants. This may reduce expansion pressure on rural landscapes, and allow undamaged ecosystems to recover and even potentially expand.

Selected exotic species can greatly reduce the risk of fire and fire damage, as well as potentially providing short and long term food a resource security to cities and towns without such great reliance on transport of goods from often remote locations. This will also create employment opportunities in maintaining and harvesting resources in urban environments, as well as processing, marketing and retailing those products.

Undeveloped landscapes

Where natural environments are concerned, the effect of changes in climate is the most difficult to predict. The effect of temperature variations on individual species of plants and animals can be estimated; population sizes can be directly measured and charted. Animal and plant responses to environmental changes can be recorded and trends observed, but ecosystems are far more sensitive than the visible world.

Most plants species reproduce according to environmental cues, as do animals. These will be affected by minor changes in temperature, especially among flowering plants and insects. Natural fire cycles change the makeup of a forest in broadly understood cycles, and the succession of species from a newly burnt forest to a mature climax community are well known.

Less understood is the role that soil microbes may play in the bigger picture of succession. While a catastrophic event produces a version of succession, from pioneer species to established forest trees, succession is an ongoing process regardless of disturbance.

Over 90% of land plants possess a fungal symbiotic partner in their roots. My Honours year and PhD project have been spent studying the fungi in Australian native plant roots. Most plants have more than one fungal partner, and most fungi have associations with more than one plant. The associations of these fungi and the plant hosts are not equal, however. Some fungi gain more benefit from a particular plant species, while giving more benefit to another, for instance[7].

This interaction is the driver of non-destructive succession in forest systems, and the effect of temperature change on those relationships is completely unknown. Carbon cycling plays a huge role in the symbiosis, and the makeup of forests across the globe will be affected by the success or failure of the mycorrhizal fungi in response to changing climate. They are very sensitive to temperature changes, as are plants, and plants are sensitive to atmospheric carbon levels[7].

It has also been supposed that the fungi in turn have relationships with bacteria in the soil, so the potential of changed interactions only increases the more is understood about the complexity of natural ecosystems.

Changes in forest makeup will be exacerbated by events such as fire and drought, and the effect of these in the long term on the beneficial and pathogenic microbes in forest soils are poorly understood. The long term stability of natural systems and their general unchanging state make ecological responses to extreme events very difficult to predict.

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