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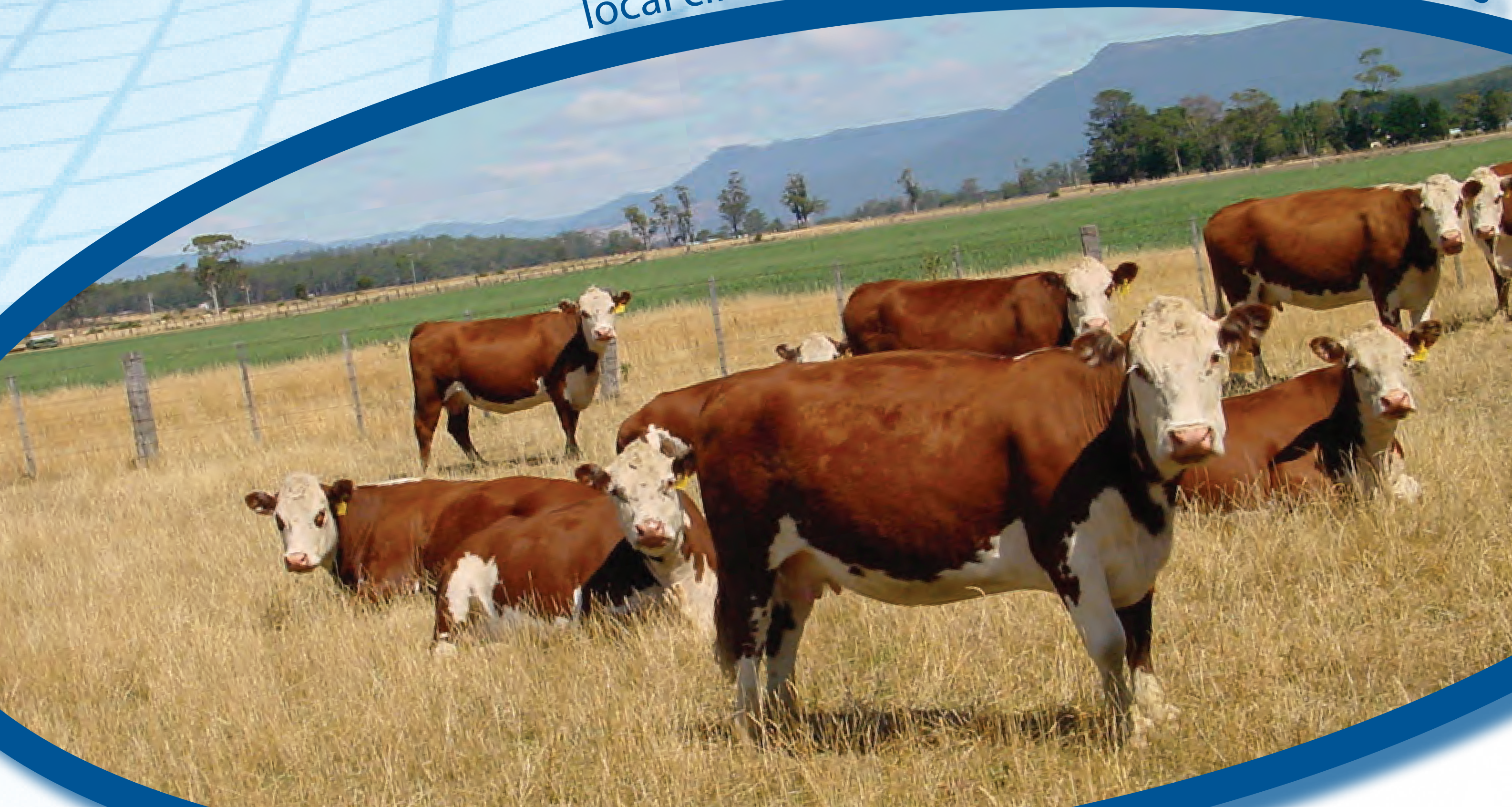
climate futures for tasmania

impacts on agriculture


impacts on agriculture

the summary

local climate information for local communities



Agriculture in Tasmania

Agriculture is an important component of Tasmania's economy with the gross value of agricultural production at the farm gate (crops and livestock) contributing $984 million in 2006-07[1] and that equals 5% of gross state product, the largest proportion of gross state production of any Australian state[2]. The total food revenue to the state (including seafood) at that time was $3,109 million[3], which is 3.2 times the farm-gate value. The total contribution of agriculture to the Tasmanian economy is estimated to be around 16% of gross state product[4].

- Agriculture is an important component of Tasmania's economy. Projected changes to the Tasmanian climate due to rising greenhouse gases will have significant impacts on agricultural enterprises at farm, industry and regional scales.
- Temperature has historically been a major driver for the choice and management of crops. Temperatures across the state are projected to increase by around 2.9 °C by the end of the century under the high greenhouse gas emissions scenario.

Projected changes to the climate will have significant impacts on agricultural enterprises at farm, industry and regional scales. The projected increases in both minimum and maximum temperatures are likely to require changes to agricultural practices, including changes to crop choices, reduced time to crop maturity, changes to crop yields and crop quality, and changes in the incidence and severity of weeds, pests and diseases. Farm management, choice of crops and land use could all change substantially as a result of these impacts.

Climate Futures for Tasmania has produced some of the most advanced fine-scaled climate projections available for the agricultural regions of the state. These projections are at a scale that will enable government, business and farmers to better understand the negative and positive impacts of a changing climate on agriculture, and the merits and costs of adaptation strategies. Policy makers will be in a position to take advantage of opportunities and to plan for and offset changes to existing industries and farming systems.

[1] ABS, Value of Agricultural Commodities, Cat. No. 7503.0
[2] ABS, Australian National Accounts, State Accounts, Cat. No. 5220.0
[3] DPIPWE, Tasmanian Food and Beverage Industry ScoreCard 2007-08
[4] TFGA, The Contribution of Agriculture to the Tasmanian Economy

Modelling agricultural futures

Downscaled climate modelling outputs are used to calculate climate indices and as inputs for biophysical models. These indices and models are useful tools for measuring the impacts of a changing climate on agriculture and for planning adaptation strategies. Climate indices include simple thresholds of crop requirements, such as mean annual temperature or rainfall ranges, and more complex calculations, such as growing degree days and chill hours. Biophysical models can simulate crop or pasture growth, or the distribution and dynamics of pests.

Bias-adjusting modelling output

When modelling errors occur consistently and predictably they are called biases. All climate model simulations contain biases. Often these biases are caused by the model's resolution. For example, the 10 km resolution of the Climate Futures for Tasmania simulations means that the effect of steep ridgelines may not be captured, so the resulting rain shadow on one side of the ridge is not represented in the simulation. The lack of resolution leads to the model consistently under or over estimating the rainfall at some locations.

When talking about climate trends, and for most places where climate modelling output is used as input to other tools, the biases in the projected climate simulations have little impact. However, in applications for agricultural modelling, these biases could result in unrealistic estimates of future impacts.

Therefore, for agricultural applications, the climate simulations are bias-adjusted; a scientific method for handling consistent differences between observations and simulations. This involves scaling the climate modelling outputs to the same range as observations, over the period for which there are observations. In Climate Futures for Tasmania, we used observations from the Australian Water Availability Project (AWAP) dataset.

The bias-adjustment process assumes that the biases in the climate models are constant throughout the length of the model simulations, 1961-2100.

Modelling Tasmania's future climate

- To generate useful information about likely changes to Tasmania's climate under greenhouse warming, we simulated future climate with six downscaled global climate models.
- The ouput from global climate models is at a resolution of 200 km to 300 km. This is too coarse for understanding changes in rainfall and temperature over Tasmania. To overcome this problem, ouput from global climate models is put through another climate model that creates the detailed regional climate information at a local scale. This process is called downscaling.
- Our climate modelling program generated fine-scale climate simulations at a resolution of 0.1-degree (approximately 10 km) grid over Tasmania
- We considered two greenhouse gas emissions scenarios for the 21st century – the A2 (high emissions) and B1 (low emissions) scenarios from the Intergovernmental Panel on Climate Change's *Special Report on Emissions Scenarios.*
- The projected changes included in this summary snapshot for agriculture use the high emissions scenario and are relative to the baseline period of 1961-1990.

Climate projections

Climate indices and biophysical models are essential tools needed to estimate the impacts of a changing climate on agriculture. These mostly require only daily minimum and maximum temperature and rainfall, while others use potential evapotranspiration, solar radiation and relative humidity. Climate Futures for Tasmania used the following key climate variables to understand the possible impacts on agricultural activities.

Temperature

The average temperatures across Tasmania are projected to rise by up to 2.9 °C over the 21st century. The rise is seen in both overnight minimum and daytime maximum temperature, and is relatively uniform across the state, though the north and east increase slightly more than the west and south.

Evapotranspiration

Water lost from the land surface is both evaporated and transpired by plants. In combination this is called evapotranspiration. Potential evapotranspiration is projected to increase in all regions of the state but proportionately less in the east and more in the west. These regional differences are driven by changes to cloud cover, relative humidity and solar radiation in summer, the season when most of the annual evaporation occurs.

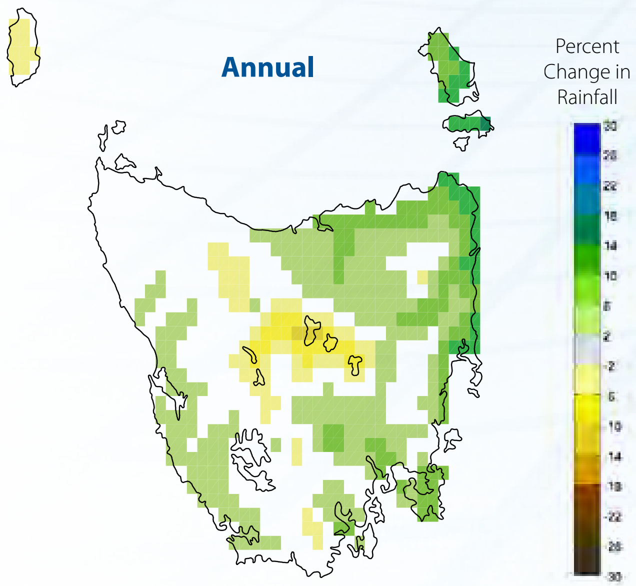
Solar radiation

Solar radiation (sunshine) is projected to change by less than 5%, with a decrease on the east coast and an increase on the west coast. This is mostly due to changes in cloud cover during the summer months.

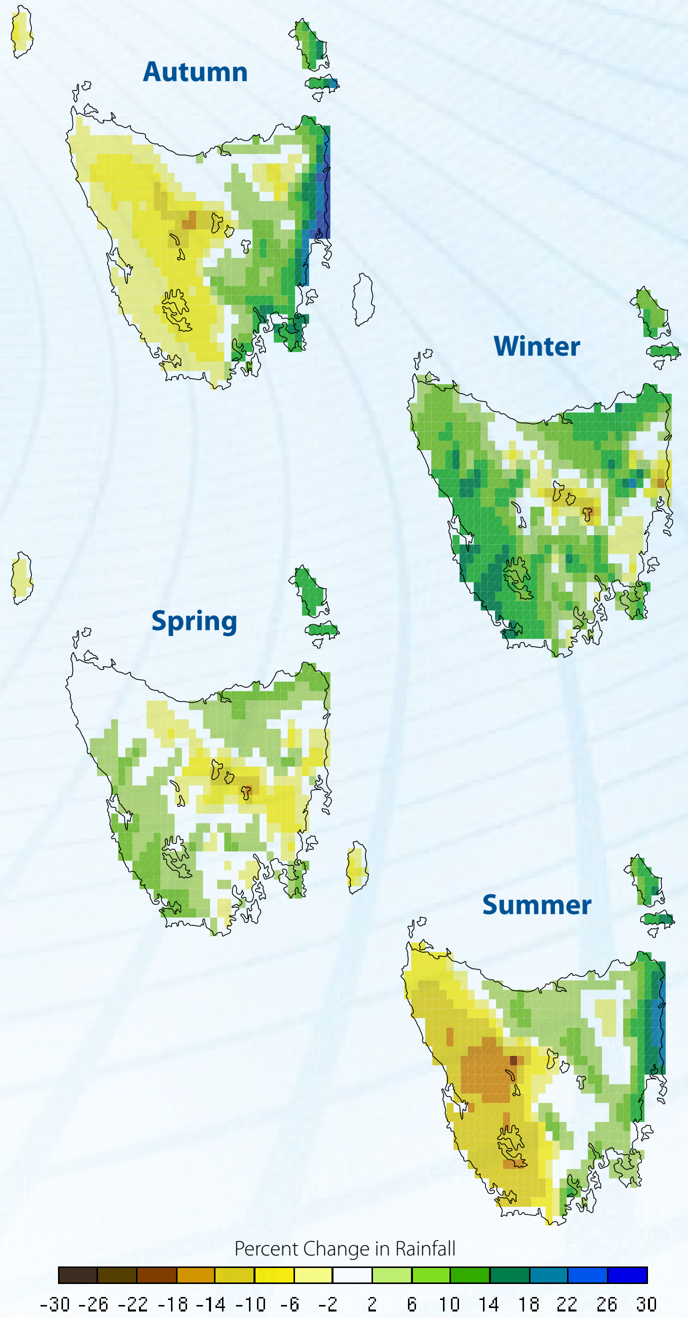
Relative humidity

Relative humidity is projected to increase around the coasts and decrease over inland, high-altitude regions of Tasmania with a different pattern in each season. Under the high emissions scenario a 0.5% to 1.5% increase is projected over much of Tasmania except for the central highlands, where there is a slight decrease in relative humidity.

Changes to Annual Rainfall



Changes to Seasonal Rainfall



Changes to Rainfall

The map of Tasmania at left shows the pattern of the annual rainfall change projected for 2071-2100 (compared to 1961-1990). Note the general increase in the east, a decrease for the central plateau and smaller increases in the south-west. The increases in the east range from 2% to 18%. The decreases in the central plateau range from 2% to 14%.

The above maps of projected seasonal rainfall for 2071-2100 (compared to 1961-1990) are for the high emissions scenario calculated from the six downscaled simulations. Note the general increase over Tasmania in the winter, except for the central plateau. In summer, there are large increases of rainfall in the east of up to 20% and large decreases in the west of up to 18%.

Rainfall

Through the 21st century, annual mean rainfall for the whole of Tasmania is projected to remain within the historical range (1390 ± 200 mm). However, significant changes are projected in the seasonal cycle. These include increases of 20%-30% in summer and autumn rainfall along the east coast, 15% increases in winter and 18% decreases in summer rainfall on the west coast. Reductions in rainfall on the central highlands are projected in all seasons.

Extreme rainfall events

Increasing energy in the atmosphere resulting from increases in greenhouse gases means that there will be changes to the frequency and severity of extreme events. Rainfall intensity is projected to increase across Tasmania. For example, at St Helens, a high daily rainfall event that currently occurs on average once in 200 years is projected to occur about once in 20 years by 2100. The number of days when daily rainfall exceeds 20 mm is projected to increase in many of the agricultural areas of the state. This could increase the risk of flooding and in cropping areas, the potential for soil erosion.

Runoff

Changes to the amounts, timing and characteristics of rainfall and to evaporation will affect runoff across Tasmania. There is projected to be a slight increase in the total amount of runoff in the state by 2100, though there are different responses in different regions. For example, runoff is projected to decrease in the central highlands but is likely to increase in the east of the state, the Derwent Valley and the midlands. A potential impact on agriculture is that irrigation storages fed from runoff from the central highlands are likely to have reduced inflows by 2100, while there are likely to be increased inflows to farm dams in areas with increased runoff.

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Agricultural climate indices

Impacts of a changing climate on agriculture are complex but insights can be gained by using agricultural indices. In Tasmania, relevant indices include chill hours, frost, drought and growing degree days.

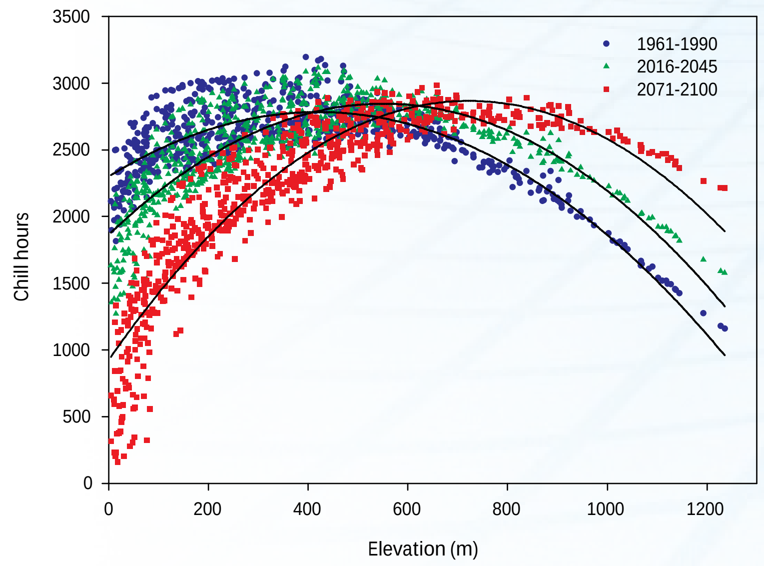
- Chill hours are projected to decrease in lower elevation warmer regions and increase at higher elevations.
- There is likely to be limited impact on the majority of crops that require a od of cold before they can bud, flower and set fruit, though current varieties of blackcurrants may be better suited to higher elevations in the future.

Chill hours

Temperate, deciduous fruit trees (apples, pears, cherries and apricots), berry crops (strawberries, raspberries and blackcurrants) and nuts (hazelnuts and walnuts) become dormant in winter as a way of dealing with damaging cold temperatures and frosts. After a period of cold temperatures (called chill hours) the dormancy is broken, leading to spring bud burst, flowering and fruit set. This is called vernalisation. Insufficient chill hours may lead to fewer buds, delayed and uneven bud burst, sporadic flowering and fruit set, irregular fruit size, and reduced fruit yields and quality. Therefore, chill hours is an important index in horticulture.

Chill hours are projected to decrease at sites below 400 m to 500 m elevation but increase at higher elevation sites through the 21st century. In most areas in Tasmania, the decrease in chill hours in lower elevations sites is likely to have limited impact on the majority of crops (including apples and pears) that require less than 1300 chill hours. However, blackcurrants that have high chill requirements may be forced to higher elevation sites. In the warmer lower elevation and coastal areas, yields and quality of high-chill fruit varieties, such as some cherries, may be adversely affected later this century.

Chill Hours and Elevation



Chill hours are projected to decrease at sites below 500 m but increase at higher elevations. The above graph shows the relationship between accumulated chill hours and elevation for the periods 1961-1990, 2016-2045 and 2071-2100 for one downscaled simulation.

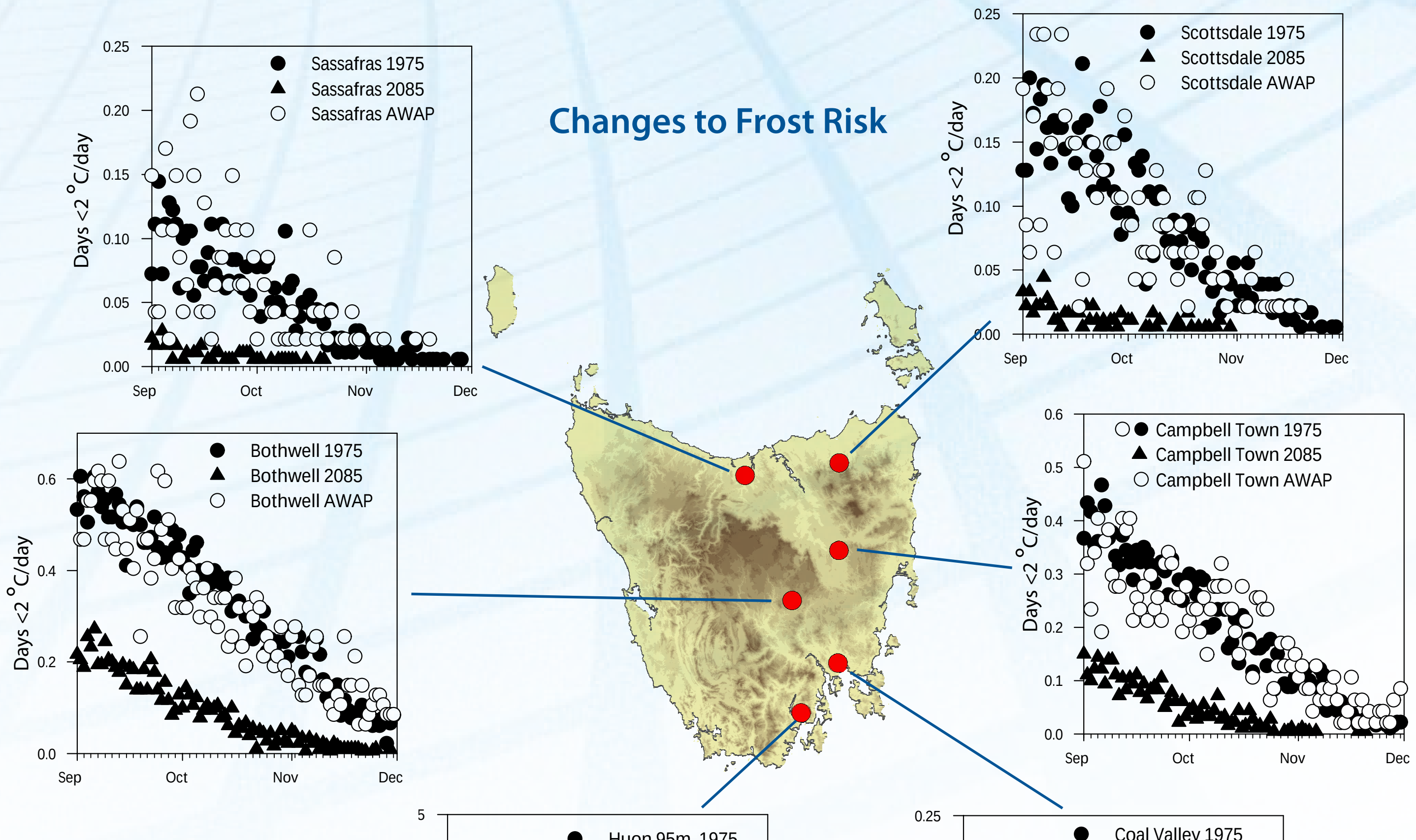
Frost

Changes to the incidence and severity of frosts are an important consideration for many agricultural and horticultural crops. While many crop and pasture species grown during frost-prevalent periods are relatively tolerant to low temperatures, there are times during a crop's development when it is particularly sensitive. Just one severe frost at a critical time, such as flowering of fruit trees in the period from October to November, can be very significant to an industry, even if it occurs only once every 5 to 10 years. Despite the widely perceived negative impacts of frost, cold events and frost also play a positive role in agricultural systems by providing breaks in life cycle development of pests and diseases.

- The incidence of frost is projected to reduce by about half by the end of the century. For many areas in Tasmania, the period of frost risk is also projected to shorten from March-December to May-October.

The incidence of frost is projected to reduce substantially by the end of the century, with many sites in Tasmania likely to experience less than half the current number of frosts. The period of frost risk is projected to shorten from March-December to May-October, but there may still be damaging late winter and spring frosts.

Changes to Frost Risk



Changes to Frost Risk

The graphs plot the frequency of days less than 2 °C for each calendar day during spring. Open circles are the observations of frost for the current climate. The filled circles/triangles are the simulated frequencies of frost for 1975 (circles) and 2085 (triangles). Note that the simulated frosts agree with observations and the frequency of frosts decreases markedly by 2085.

Drought

The incidence of drought is projected to be similar to historical experience in most of the agricultural regions of Tasmania. Indices of meteorological and agricultural drought indicate the episodic and regional nature of drought events will continue.

The models project a wide range of possibilities for the future, but general trends suggest a reduction in the proportion of time subject to meteorological drought in the south-east, north-east and south-west of the state and an increase in the central highlands to north-west regions.

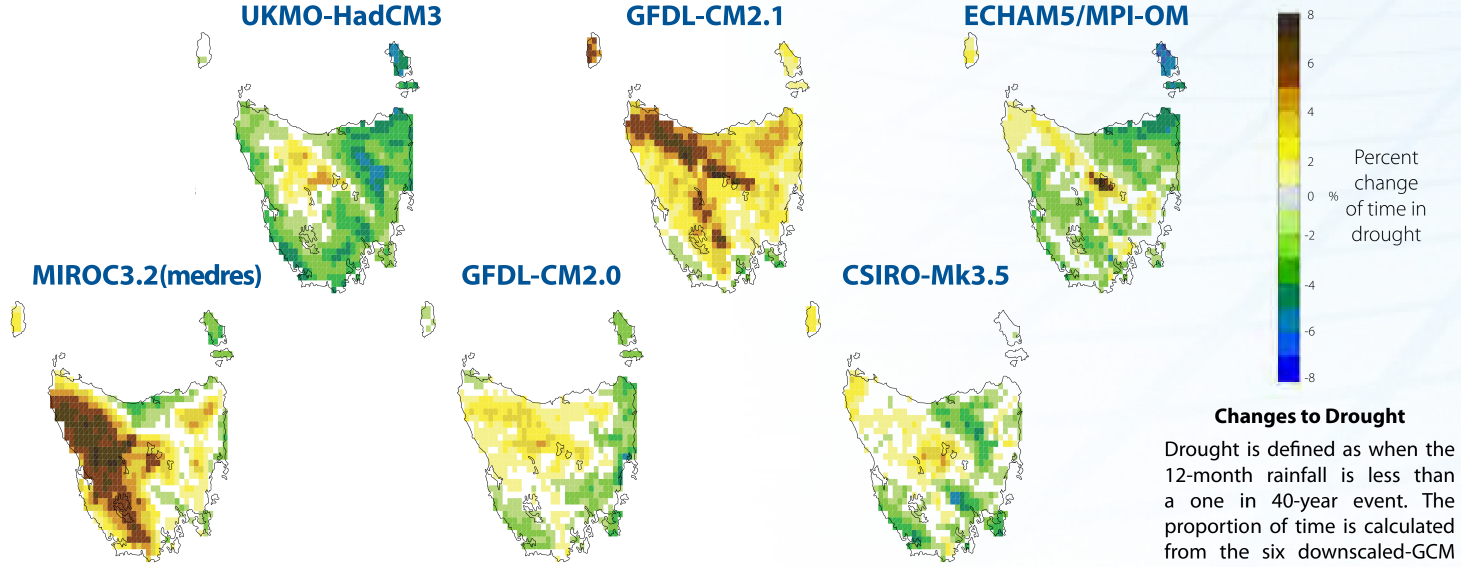
When is a 'drought' a drought?

Drought can be defined in a number of ways:

- *Meteorological drought is a period of low rainfall.*
- *Agricultural drought is a period of low soil moisture at a critical time in the growing season of a crop or pasture that prevents or reduces production.*
- *Hydrological drought refers to a period of reduced surface and subsurface water supply, and low lake and dam levels.*
- *Socio-economic drought refers to a period of low economic returns and impacts on human well-being as a result of low production.*

We modelled meteorological and agricultural drought.

Change in Meteorlogical Drought from 1961-2010 to 2051-2100 for Six Climate Models



Changes to Drought

Drought is defined as when the 12-month rainfall is less than a one in 40-year event. The proportion of time is calculated from the six downscaled-GCM simulations for the high emissions scenario. Note that change in drought varies between climate models, but that the patterns of change are similar.

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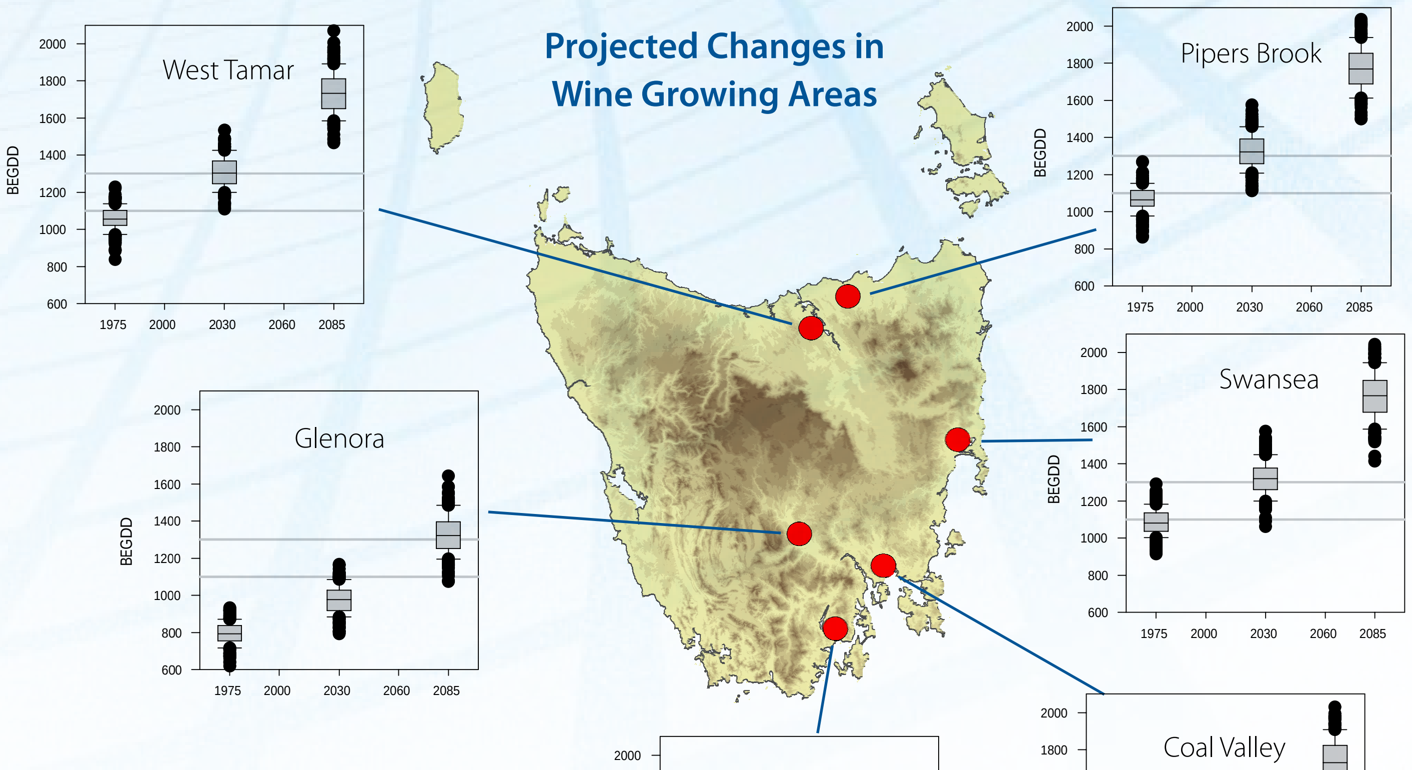
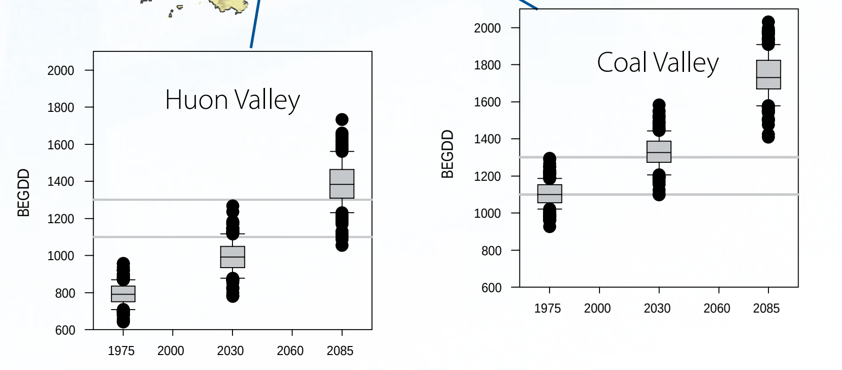
Growing degree days

Temperature is an important determinant of the rate of development of crops. Warmer temperatures mean reduced times to crop maturity, allow different choices of crop varieties, and affect crop yield and quality. Growing degree days (GDD) is a valuable thermal index that quantifies the relationship between temperature and plant development, and also in some cases, changes to the incidence and severity of pests.

- Projected increases in available heat in growing degree days are likely to require to changes in crop types and varieties.
- By the latter part of the 21st century, parts of Tasmania could experience conditions similar to the present day growingconditions in the Coonawarra wine growing region in South Australia and the Rutherglen wine growing region in Victoria.

Large increases in the number of growing degree days are projected by 2085 (in some regions by a factor of two). By 2030, a crop requiring 1000 (10 °C base) GDD is projected to mature approximately one month earlier than the baseline period of 1961-1990 and two months earlier by the end of the century. Wine varieties such as cabernet sauvignon are projected to ripen reliably by the middle of the century in current grape-growing regions. By 2085, varieties such as pinot noir are likely be harvested around mid-February, more than two months earlier than the baseline period. These changes are likely to have significant implications for wine quality and suitable vineyard locations.





Projected Changes to Wine Growing Areas

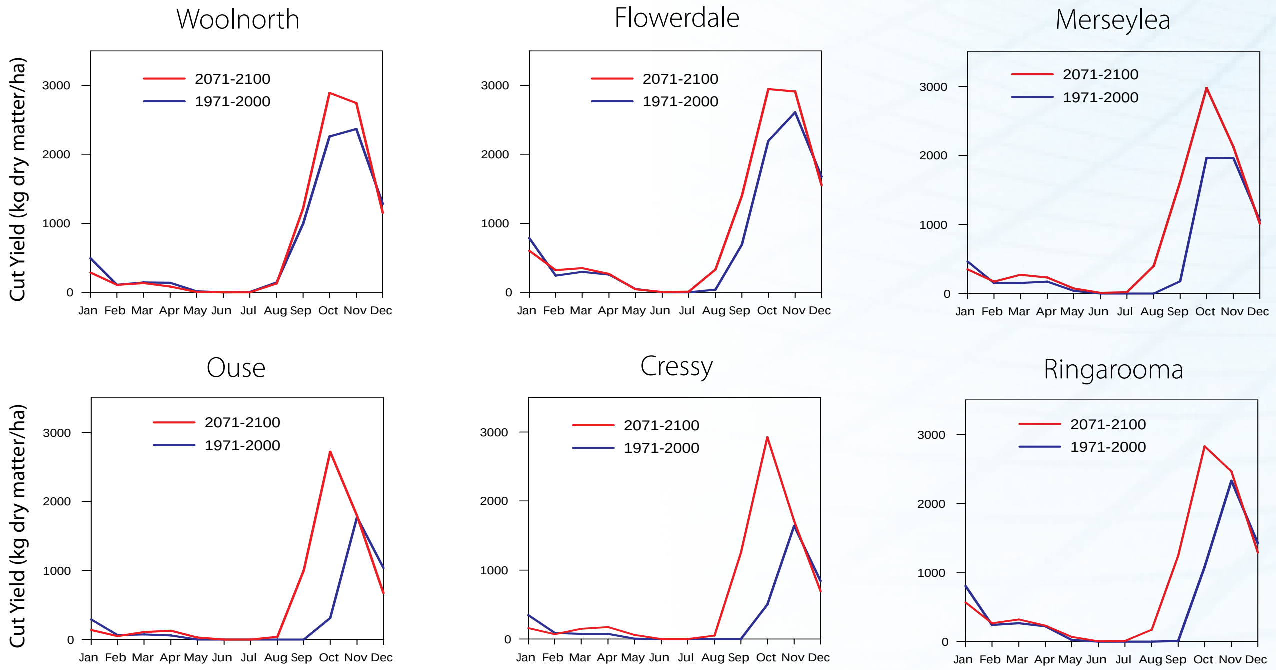
Box plots of a thermal index (Biologically Effective Growing Degree Days from October to April) for 30-year periods using six downscaled simulations for six regions in Tasmania for 1975, 2030 and 2085 and the high emissions scenario. The line at 1100 is the heat required for maturation of pinot noir and at 1300 for cabernet sauvignon. Consequently, wine varieties such as cabernet sauvignon will ripen reliably by mid-century in some areas but in all six regions by 2085.

Impacts on pasture production

Most of the livestock production in Tasmania is dependent on pastures used for dairying, beef cattle and sheep. Dairy pastures are based predominantly on perennial ryegrass and white clover. Extensive grazing farming systems also rely on ryegrass and white clover in high rainfall areas, as well as other pasture species including phalaris, cocksfoot and subclover in low rainfall areas such as the midlands.

By 2085, annual dryland pasture production from ryegrass is projected to increase by 10%-100%, depending on the region. Those areas of Tasmania that are currently most temperature limited will have the greatest increases, mainly through an earlier start to spring and higher growth during spring and early summer.

Monthly Ryegrass Yields



Monthly Ryegrass Yields

Monthly cut yield of dryland (non-irrigated) ryegrass (kg dry matter/ha) at six sites across Tasmania for the periods 1971-2000 and 2071-2100. The yield estimates are from pasture simulations using six downscaled-GCM models. The largest changes in ryegrass yield are projected to occur mainly during spring and early summer, with little change in late summer and autumn.

Annual irrigated ryegrass yields are projected to increase by around 20%-30% by 2040, but thereafter decline. This decrease in yield is due to an increase in the number of hot days during summer months. Farmers may have to consider alternatives to meet summer feed demands as increasingly higher temperatures reduce the yield of ryegrass.

Similarly, the annual yield of phalaris-subclover pastures is also projected to substantially increase in the midlands to the middle of the century, but thereafter to decline in response to hot summer days. The contribution from subclover is projected to increase by about 50% throughout the century, as this winter-growing species benefits from increased winter temperatures.

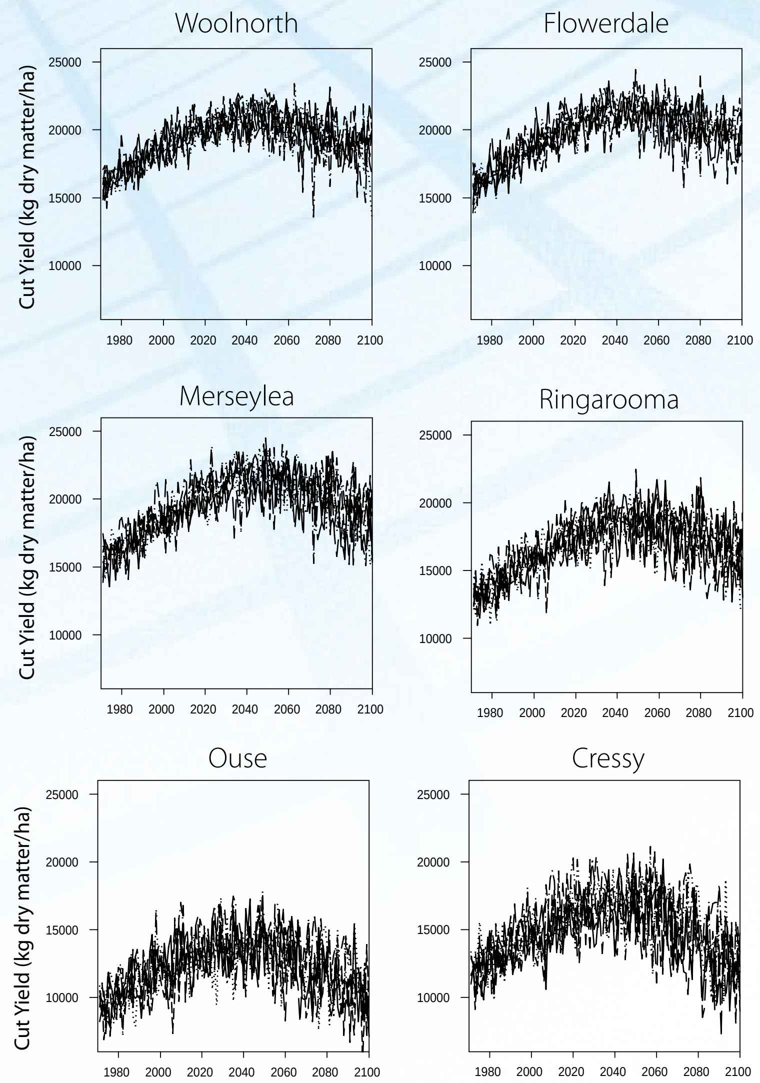
Pasture simulations indicate that the demand for irrigation water from pastures (and most probably other crops) is likely to remain unchanged throughout the century despite substantial increases in yields. Simulations of irrigated kikuyu pastures (a species that will not be growth-limited by the projected high temperatures), suggest that increased water use efficiency resulting from elevated atmospheric carbon dioxide concentrations is likely to offset increased water demand due to higher yields.

Irrigated Ryegrass Yields

Annual cut yield (kg dry matter/ha) of irrigated perennial ryegrass from 1971 to 2100. The yield estimates come from pasture simulations using each of the six downscaled-GCM models. Note that the yield of ryegrass increases in the first half of the 21st century and then decreases in the second half due to an increase in the number of days exceeding 28 °C during the summer months.

- By 2085, dryland pasture production from ryegrass is projected to increase by 10%-100%, depending on region. Areas of Tasmania that are currently most temperature limited will have the greatest increases, mainly through an earlier start to spring and higher growth during spring and early summer.
- Irrigated ryegrass yields are projected to increase by around 20%-30% by 2040 but thereafter to decline to current levels due to increases in the number of hot days during summer months.

Irrigated Ryegrass Yields

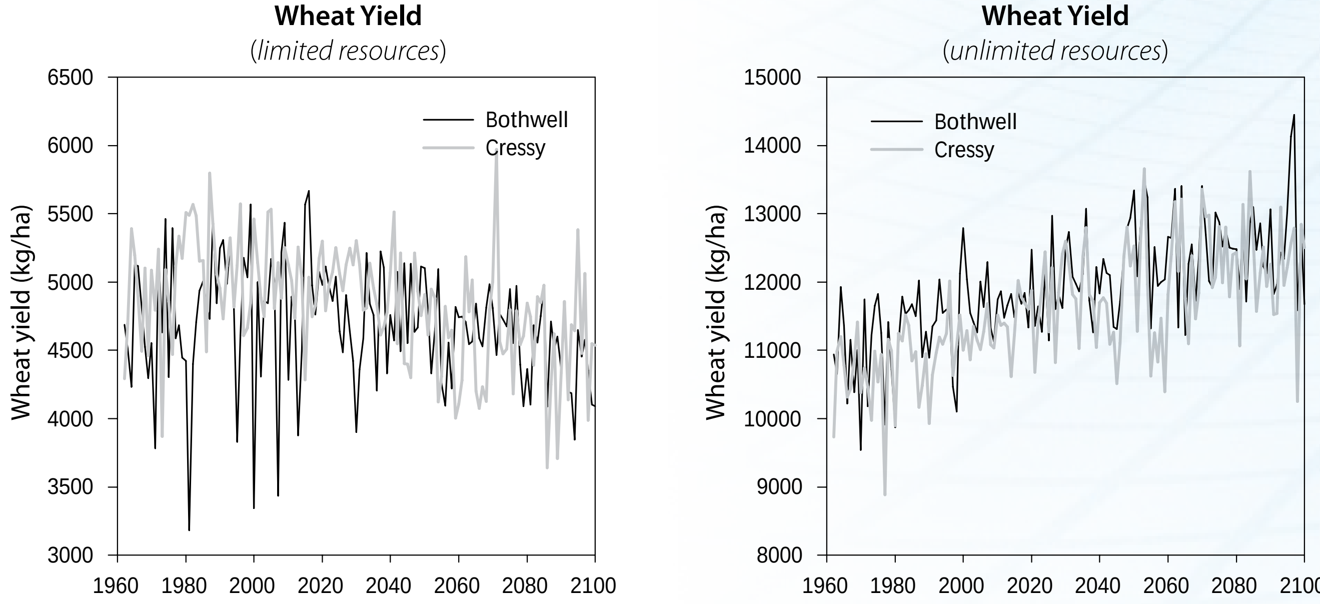


Impacts on grain crops

Simulating the impact of a changing climate on annual crops is complex because of the many management decisions that farmers make each year that are in part responses to the climate they are experiencing. However, simulations of wheat cropping at Bothwell and Cressy suggest there is potential for 10%-15% increases in yields given adequate levels of inputs such as fertiliser and water from irrigation.

Wheat yields from dryland wheat crops simulated with a fertiliser regime comparable to that currently practised by farmers are projected to decrease over the century, mainly due to nitrogen stress.

Simulated Wheat Yields



Simulated Wheat Yields

Wheat yields simulated at Bothwell and Cressy from 1961 to 2100 by the APSIM model under limited resources (that is, dryland and current fertiliser practices) and unlimited resources (irrigated and optimum fertiliser) using one downscaled-GCM simulation. Note the wheat yield decreases when fertiliser applications are unchanged from current practise but yields increase steadily when the crops have access to non-limiting amounts of fertiliser and water.

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Land use change

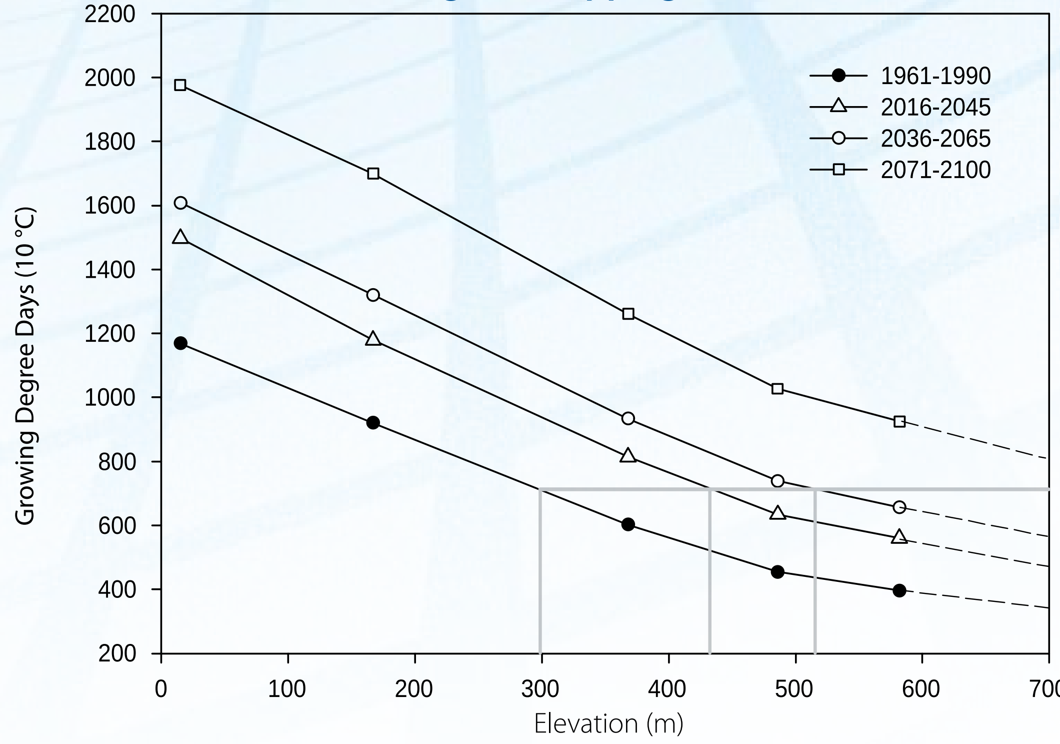
In natural ecosystems, species respond to temperature increases by moving to cooler areas – either poleward or to higher elevation. In Tasmania, there are limited options to move poleward. However, increases in temperature at low elevations can be offset by shifting to higher, cooler elevations.

In the same way, increased temperatures and more growing degree days at higher elevations provide an environment for crops and pastures that have historically been unsuited to the cold conditions in those areas. Of course, these opportunities at higher elevation depend not only on changed temperature profiles but also on adequate rainfall, suitable soils and a workable topography.

Agricultural production in many elevated areas in Tasmania is limited by unsuitable soils and steep slopes. However, there are some areas with soils and appropriate slopes capable of more agricultural production where warmer temperatures are projected. These areas include a strip along the north-west coast, with parts of the north-east above Ringarooma, parts of central Tasmania from Bothwell across to Tarraleah and some areas in the Huon Valley.

- Simulations of wheat cropping suggest there is potential for 10%-15% increases in yields, given adequate levels of inputs such as fertiliser and irrigation.
- Land use is likely to change in response to changes in the climate. Temperature increases on land that is currently temperature-limited land (in particular, high elevation areas) will allow for more land use choices and are likely to lead to changes to land uses with higher economic returns.

Change in Cropping Potential



Changes in Cropping Potential

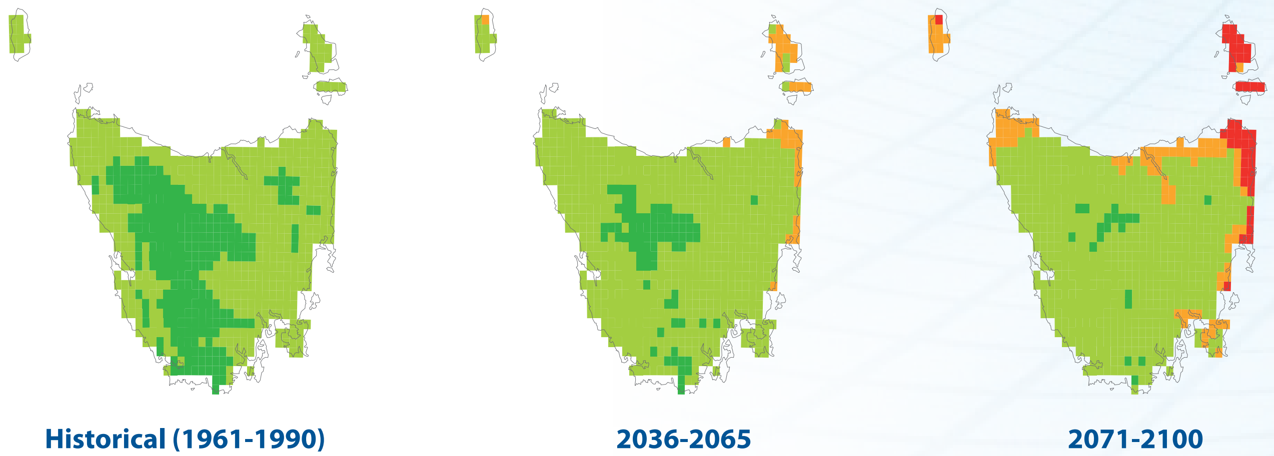
Projected cropping potential in growing degree days (10 °C) as a function of elevation for 1961-1990, 2016-2045, 2036-2065 and 2071-2100 for a north-south transect on the north-west coast of Tasmania. Growing degree days are calculated from an average of six downscaled-GCMs. Most agricultural cropping during the baseline period was undertaken below 300 metres, but by 2050 the same crops could be grown at above 500 m and by 2085, at elevations of up to 700 m.

Biosecurity

There is no doubt that changing climate, in particular increasing temperatures, will result in changes to Tasmania's biosecurity. It is likely that a range of weeds, vertebrate and invertebrate pests, and pathogens will find the future climate in Tasmania more suitable than current conditions.

For example, the Tasmanian climate is currently unsuitable for the persistence of Queensland fruit fly. However, with a warming climate, populations could establish on the Bass Strait islands and in the north and north-east of the state.

Potential Distribution of Queensland Fruit Fly



Potential Distribution of Queensland Fruit Fly

Climatic risk of Queensland Fruit Fly (*Bactrocera tryoni*) establishing in Tasmania for 1961-1990, 2036-2065 and 2071-2100 using one downscaled-GCM model (ECHAM5/MPI-OM). Red regions on the maps are at risk of supporting permanent populations of fruit fly, while orange areas are suitable but populations may be subject to periodic extinctions. The light green regions on the maps represent areas suitable for transient populations of greater than one generation and dark green regions are not suitable for more than one generation of fruit fly. Note that by 2071-2100, the north and east of Tasmania has a climate that is suitable for permanent populations.

- Suitable for permanent populations
- Suitable for the establishment of semi-permanent populations that are at risk of periodic extinction
- Suitable for the establishment of transient populations
- Not suitable

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Climate change

There is overwhelming scientific evidence that the earth is warming and that increased concentrations of greenhouse gases caused by human activity are contributing to our changing climate.

Change is a feature of the 21st century global climate. The need to understand the consequences and impacts of climate change on Tasmania and to enable planning for adaptation and mitigation of climate change at a regional level has been recognised by both the state and federal governments.

Increased temperatures are just one aspect of climate change. Global warming also causes changes to rainfall, wind, evaporation, cloudiness and other climate variables. These changes will not only become apparent in changes to average climate conditions but also in the frequency and intensity of extreme events such as heatwaves, flooding rains or severe frosts.

While climate change is a global phenomenon, its specific impacts at any location will be felt as a change to local weather conditions. This means we need regional studies to understand the effects of climate change to specific areas. Climate Futures for Tasmania is one such regional study, producing fine-scale climate change projections that will allow for the analysis of climate impacts at different locations within Tasmania, and of changes to seasonality and extreme events.

The Climate Futures for Tasmania project is the Tasmanian Government's most important source of climate change information at a local scale. It is a key part of Tasmania's climate change strategy as stated in the Tasmanian Framework for Action on Climate Change and is supported by the Commonwealth Environment Research Facilities as a significant project.

This project has used a group of global climate models to simulate the Tasmanian climate. The project is unique in Australia: it was designed from conception to understand and integrate the impacts of climate change on Tasmania's weather, water catchments, agriculture and climate extremes, including aspects of sea level, floods and wind damage. In addition, through complementary research projects supported by the project, new assessments were made of the impacts of climate change on coastal erosion, biosecurity and energy production, and the development of tools to deliver climate change information to infrastructure asset managers and local government.

As a consequence of this wide scope, Climate Futures for Tasmania is an interdisciplinary and multi-institutional collaboration of twelve core participating partners (both state and national organisations). The project was driven by the information requirements of end users and local communities.

'The Summary' is an at-a-glance snapshot of the Impacts on Agriculture Technical Report. Please refer to the full report for detailed methods, results and references.

The Climate Futures for Tasmania project complements climate analysis and projections done at the continental scale for the Fourth Assessment Report from the Intergovernmental Panel on Climate Change, at the national scale in the Climate Change in Australia Report and data tool, as well as work done in the south-east Australia region in the South Eastern Australia Climate Initiative. The work also complements projections done specifically on water availability and irrigation in Tasmania by the Tasmania Sustainable Yields Project.

Climate Futures for Tasmania is possible with support through funding and research of a consortium of state and national partners.

Enquiries

Find more information about Climate Futures for Tasmania at:

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www.acecrc.org.au

To access the modelling outputs:

www.tpac.org.au

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Technical Reports

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Project reports and summaries are available for download from:

www.climatechange.tas.gov.au