

Department of Primary Industries
and Regional Development

Queensland Fruit Fly

Results Report

Climate Vulnerability Assessment



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Acknowledgement of Country

The Department of Primary Industries and Regional Development acknowledges that it stands on Country which always was and always will be Aboriginal land. We acknowledge the Traditional Custodians of the land and waters and show our respect for Elders past, present and emerging. We are committed to providing places where Aboriginal people are included socially, culturally and economically through thoughtful and collaborative approaches to our work.

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Table of Contents

Introduction.....	2
Climate within NSW.....	2
Queensland fruit fly in NSW	4
Climate Vulnerability Assessment framework	5
Interpreting the results.....	10
Projected changes in climate suitability for Queensland fruit fly	13
Overall climate impacts	14
Changes in monthly climate suitability	16
Climate impacts on life stages	20
Key findings and insights from a changing climate	26
Expected challenges for primary industries	27
Queensland fruit fly: Where to from here?.....	28
Conclusion	29
Appendix	31

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Introduction

Primary industries in New South Wales operate a wide variety of production systems within diverse landscapes, while facing the challenges of a changing and highly variable climate. The Primary Industries Climate Change Research Strategy invested \$29.2 million in projects to help the state's primary industries adapt to climate change. As part of this work, the Climate Vulnerability Assessment Project undertook impact assessments for primary industries in the broadacre cropping, marine fisheries, forestry, extensive livestock, and horticulture and viticulture sectors, and key related biosecurity risks, to improve our understanding of the impacts of climate change.

The Climate Vulnerability Assessment has delivered consistent and comparable understandings of potential climate change impacts across the state, providing a deep insight into sectoral impacts. This strategic information is invaluable for policymakers and industry bodies, providing insights into 28 commodities and 14 biosecurity risks considered valuable or important to NSW.

This comprehensive assessment allows primary industries to understand the risks ahead, to prepare for and adapt to identified climate vulnerabilities, and to take advantage of future opportunities to expand in NSW.

Purpose of this report

This report contains the results of the Queensland fruit fly model from the Climate Vulnerability Assessment. The report introduces the Queensland fruit fly in NSW and provides an overview of the model and its key features, assumptions, and exclusions. The main results and findings provide insights into future increases and decreases in climate suitability for Queensland fruit fly.

Climate within NSW

The climate in NSW varies across the state, influenced by topography, weather patterns, and proximity to the Great Dividing Range and the Tasman Sea. The state's diverse climates include arid and semi-arid inland regions, humid subtropical coastal areas, temperate coastal regions and alpine areas.

Queensland fruit fly significantly impact horticulture production. The suitability of land for horticulture is determined by climate, topography and water availability. Due to the variety of climate needs of different horticultural crops, horticulture is found across NSW, from macadamia and blueberry production on the North Coast to almonds and grapes in the western Riverina.

A changing climate is impacting primary industries

Australia has one of the world's most variable climates, and its primary producers have always managed climate variability. Now, they are planning for and adapting to climate change arising from anthropogenic greenhouse gas emissions. These changes in long-term climate patterns at global and regional scales are adding a new dimension to the challenge of producing food and fibre in Australia. Changes in climate include increasing temperatures and alterations to rainfall patterns, alongside increasing challenges from extreme events.

This NSW \$23.1 billion sector supports economic growth and development, contributes to food security at the state and national levels, and plays a vital role in biosecurity management. Biosecurity risks threaten primary industries. Climate change will likely worsen their impact in NSW by altering their range, distribution and ability to spread. Industries with permanent plantings or geographic constraints are particularly vulnerable.

Adapting to these challenges requires a deep understanding of how climate change affects both commodities and the associated biosecurity risks. More research is needed to assess additional biosecurity risks, including those not currently present in NSW, to strengthen the resilience of primary industries in the face of climate change.

Projected climate change impacts

A review of research literature on the impacts of projected climate change on primary industries in Australia revealed disparities in research efforts across the primary industry sectors and in our understanding of what is likely to occur.

Biosecurity risks have been well-researched in Australia. It is, nonetheless, challenging to draw a consistent and comprehensive understanding of the effects of climate change from these studies because of the differences in methodology, assumptions and projection data used¹. A literature review of research on climate change impacts for primary industries revealed that biosecurity research was dominated by weed and insect threats (41 of 55 papers) whilst overlooking some important biosecurity risks to Australia altogether¹. The studies we reviewed have revealed significant collective impacts of climate change. As temperatures increase, we can expect species to experience southward range shifts^{2,3} and to see those currently restricted by cool temperatures in lower altitudes moving into higher altitude areas^{3,4}. Climate change is likely to expand the range of some biosecurity risks while further constraining others. The literature on this topic has largely overlooked how these changes

may impact primary industries, which will be affected by evolving biosecurity risks under climate change⁵.

Assessing the impacts of climate change

To address these issues, the Climate Vulnerability Assessment examined the potential impacts of climate change on a wide range of economically important primary industry commodities and biosecurity risks. This enabled us to identify those industries most at risk and, thus, most in need of adaptation strategies, as well as those where climate change might bring new opportunities and relief from existing challenges.



¹ Darbyshire, R. O., Johnson, S. B., Anwar, M. R., Ataollahi, F., Burch, D., Champion, C., Coleman, M. A., Lawson, J., McDonald, S. E., & Miller, M. (2022). Climate change and Australia's primary industries: factors hampering an effective and coordinated response. *International journal of biometeorology*, 1-12.

² McFadyen, R. (2007). Invasive plants and climate change. Briefing notes. Cooperative Research Centre for Australian Weed management, Adelaide. 2 pp.

³ Bellard, C., Jeschke, J.M., Leroy, B., Mace, G.M. (2017). Insights from modelling studies on how climate change affects invasive alien species geography. *Ecology and Evolution* 8:5688-5700.

⁴ Taylor, S., Kumar, L., Reid, N. and Kriticos, D.J. (2012). Climate change and the potential distribution of an invasive shrub, *Lantana camara* L. *PLoS (Public Library of Science) One* 7, e35565.

⁵ De La Rocque, S., Rioux, J.A. & Slingenbergh, J. 2008. Climate change: effects on animal disease systems and implications for surveillance and control. *Rev. sci. tech. Off.int. Epiz.* (2) 339-354.

Queensland fruit fly in NSW

Queensland fruit fly (*Bactrocera tryoni*) is a horticultural pest that poses a serious biosecurity risk to fruit and vegetable production in eastern Australia. It has the potential to significantly affect NSW's exports. In 2016, fruit fly was estimated to cost Australian horticultural industries \$300 million per year for control measures and international trade restrictions⁶.

Fruit flies cause damage by laying eggs in the flesh of fruit and vegetables, which are then consumed when the larvae hatch, damaging the interior of the produce.

Queensland fruit fly numbers decrease during winter, with small populations persisting in warmer, protected areas; this is known as 'over-wintering' (see call-out box below). Populations then increase during spring due to rising temperatures and a ready supply of host produce.

What is overwintering?

'Over-wintering' refers to the survival of relatively small populations of a pest through the cold winter months. They survive by sheltering in small pockets where conditions are favourable and provide protection from the cold. These types of areas provide a way for organisms which would not survive low temperatures to persist throughout the year. For insect pests, such as fruit flies, this can allow the establishment of endemic populations. Organisms can use this type of sheltering to survive other hostile climatic conditions such as drought, high rainfall, cold, heat or even bushfire, if appropriate habitat features are available.

In Australia, Queensland fruit fly presence extends from the Northern Territory across to Cape York Peninsula and south through NSW to Victoria. Within NSW, Queensland fruit flies are most prevalent in the east of the state (Figure 1). The Fruit Fly Exclusion Zone was established in 1994 to protect highly productive horticultural areas in NSW and Victoria. This zone has been disbanded, but a cross-border zone known as the 'Greater Sunraysia Pest Free Area' was declared a restricted area for controlling Queensland fruit fly in 2007.

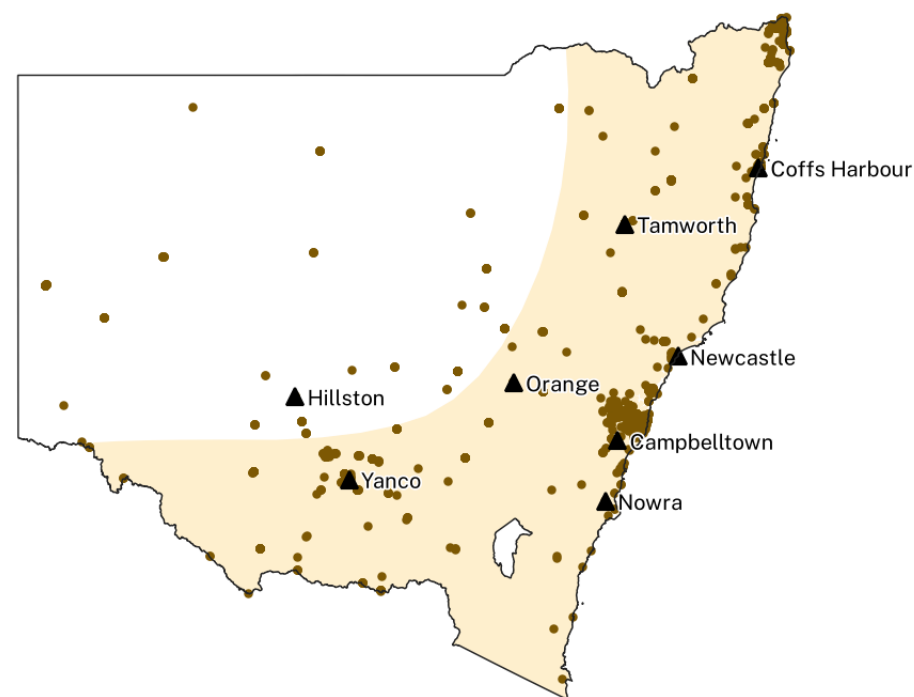


Figure 1: Records of Queensland fruit fly in NSW (brown dots) with the endemic distribution shaded in yellow and important NSW produce locations marked by black triangles. Data was sourced from Atlas of Living Australia⁷ and contains records from 1908 to 2025.

⁶ Horticulture Innovation Australia (2018). Fruit fly fund: Managing risk by identifying fruit fly solutions [Internet]. Available from: <https://www.horticulture.com.au/hort-innovation/our-work/hort-frontiers-strategic-partnership-initiative/fruit-fly-fund/>. Accessed 22 December 2022.

⁷ Atlas of Living Australia occurrence download at <https://doi.org/10.26197/ala.f548b64c-7ef6-498b-9ab9-100b6a1ab7f6> Accessed 19 April 2025

Climate Vulnerability Assessment framework

The Climate Vulnerability Assessment was intended to provide an overview of the impact of future climate change on all stages of production for the commodities and biosecurity risks assessed. To achieve this, a modelling approach was adopted that would produce assessments for commodities and biosecurity risks in a consistent and, therefore, comparable way.



Figure 2: Outline of expert engagement for framework developed by the Climate Vulnerability Assessment. Internal and external experts were involved throughout the process, helping to develop and refine the models of primary industry commodities and biosecurity risks in their area of expertise.

The assessment framework, outlined in Figure 2, provides a rigorous, flexible and transparent process for assessing vulnerability to climate change. The first step is a literature review, used to inform an initial draft model of the commodity or biosecurity risk. External experts review the model at three points during the model development, as a small focus group. The participation of experts throughout the process was critical for integrating expert knowledge into the models developed by the Climate Vulnerability Assessment.

Over 100 Department of Primary Industries and Regional Development staff contributed to this process, and almost 200 additional experts participated in focus groups to support the review and refinement of the models. External experts were drawn from industry bodies, producers, academia and elsewhere.

MCA modelling approach

The steps in the framework developed for the Climate Vulnerability Assessment were designed to identify and compare the climate variables important in the production of each commodity and the survival of each biosecurity risk assessed. The chosen modelling approach, using multi-criteria analysis (MCA) models, allows knowledge obtained about these climate variables from scientific literature, expert focus group knowledge and other sources to be combined in a way that is consistent across all commodities and biosecurity risks.

An MCA model with defined assumptions and exclusions was developed for each biosecurity risk, and these models were developed using a combination of published data, empirical evidence and expert judgment. In the hierarchical structure of an MCA model, the biosecurity risk sits at the top level, with the key lifecycle stages forming the level below. The next level of the model then associates one or more climate variables with each of these life stages.

Each life stage is weighted relative to the others, to reflect the importance of its contribution to the overall success in the survival of the biosecurity risk. The weightings are derived using an analytical hierarchy process⁸, reflecting the consensus reached by the focus group experts.

⁸ Saaty, T.L. (1980) The Analytic Hierarchy Process, McGraw-Hill, New York

The MCA model is not designed as a distribution estimating model but as a climate suitability model. Climate suitability is defined as the extent to which climatic conditions satisfy the requirements of plant or animal growth in the absence of other limiting factors⁹.

Using the model, an assessment of climate suitability (ranging from 'unsuitable' to 'very high') can be made for each life stage, for each climate variable, and for the overall model. Climate suitability was assessed for both historical (recent past) conditions and for projected (near future) climate to understand how the climate suitability for the biosecurity risk may be affected by climate change.

An expert focus group reviewed the historical and future assessments and provided insights and interpretations, highlighting findings of importance for future planning. The following sections of this report provide an overview of the model structure for Queensland fruit fly and key results showing important changes to future climate suitability for Queensland fruit fly, as identified by the assessment.

For further details on the Climate Vulnerability Assessment Project framework, MCA models and climate data (historical observations and future projections), please refer to the [Climate Vulnerability Assessment Methodology Report](#).

The project scope and exclusions are briefly summarised to the right, and the Queensland fruit fly model-specific assumptions are summarised on the next page.

Project limitations

The scope was limited to the assessment of vulnerability to future climate change. The assessment captures the response of Queensland fruit fly to changes in future average climatic conditions. The project was designed to support policy and regional investment decisions, not provide farm-scale advice. The following were not considered:

- soil properties and topography,
- other biophysical parameters, and
- socio-economic factors.

These factors should be considered alongside the project's findings when examining the ongoing or future viability at a given location.

Project exclusions

Certain climate data were excluded due to future climate projection data limitations. Models excluded wind due to its variability on short timescales and the use of relative humidity on timescales shorter than a month. Extreme weather events such as intense rainfall, heatwaves, storms, drought, flood and bushfire were also excluded due to their unpredictable nature and the complexities of their interaction with the climate. Future work, incorporating more sophisticated future climate projections as they become available, is likely to provide an improved capacity for describing the impacts of climate variability.

⁹ Zhao, J., Yang, X., Liu, Z., Lv, S., Wang, J. and Dai, S. (2016) Variations in the potential climatic suitability distribution patterns and grain yields for spring maize in Northeast China under climate change. *Climatic Change*, 137:29-42.

Overview of the Queensland fruit fly model

For more information about the MCA modelling used in this project, see the [Climate Vulnerability Assessment Methodology Report](#).

Climate variables

The climate variables used in this model were minimum temperature (T_{min} , °C), mean temperature (T_{mean} , °C), maximum temperature (T_{max} , °C) and rainfall (Rain, mm).

Categorising climate variables

The hierarchical structure of the MCA model (Figure 4) categorises climate variables to assess their impact on Queensland fruit fly. Each category (for example, a temperature between 15 and 30°C) is assigned a rating, R, between 0 and 1 that indicates how well it suits Queensland fruit fly, from unfavourable ($R=0$) to optimal ($R=1$). This is repeated for each life stage.

Modules used in Queensland fruit fly MCA

The Queensland fruit fly MCA model uses the following standardised techniques, referred to as ‘modules’, to produce ratings from the climate variables. Four modules were used in this model:

- **Proportional module:** examines the duration (in days) spent in each climate category during a given month.
- **Threshold module:** examines the number of days spent below or above a key climate threshold during the given month.
- **Lethal conditions:** Define extreme climate conditions that are fatal to the life stage. If these limits are reached, then the life stage dies (indicated by an $R = -2$ in Figure 4). During each month, if the

threshold for lethal conditions is reached, then climate suitability is set to zero for that entire month.

- **Matrix module:** Matrices capture the interaction between two climate variables. For adult fly, these were monthly mean temperature and cumulative rainfall. This module was used for stages that are particularly sensitive to the interplay between two climate variables. The matrix categories define different combinations of climate conditions, for example, temperatures between 12 and 25°C with cumulative rainfall of between 48 and 170 mm. The matrix ratings identify the suitability of each specific combination from unfavourable to optimal conditions.

The ratings for each climate variable, together with the weighting assigned to each branch in the hierarchical structure and the climate data itself, produce the climate suitability index for Queensland fruit fly.

Queensland fruit fly model assumptions

A model represents a simplified version of reality. Assumptions and exclusions simplify complex systems by reducing the number of influencing factors, enabling model development. In addition to the project assumptions and exclusions, the assumptions for the Queensland fruit fly model were:

- a specific organism is described,
- all lifecycle stages, adults mature and lay eggs,
- susceptible host fruit available,
- no treatment or control for fruit flies is applied, and
- host crops are not irrigated.

Queensland fruit fly life stages

The Queensland fruit fly model has been divided into key life cycle stages, and the model has been repeated each month, as the flies' life cycle is short and multiple cycles can occur within a month (Figure 3). Using model monthly outputs allows us to assess the influence of climate during any given month on the Queensland fruit fly individual life stages and to explore potential changes in population dynamics. Furthermore, the fine temporal scale allows for an assessment of how changing climate suitability may impact Queensland fruit fly hosts, informing planning for future education and management. The life stages used in this modelling are egg, larvae, pupae and adult. Climate conditions were considered for each month and life stage.

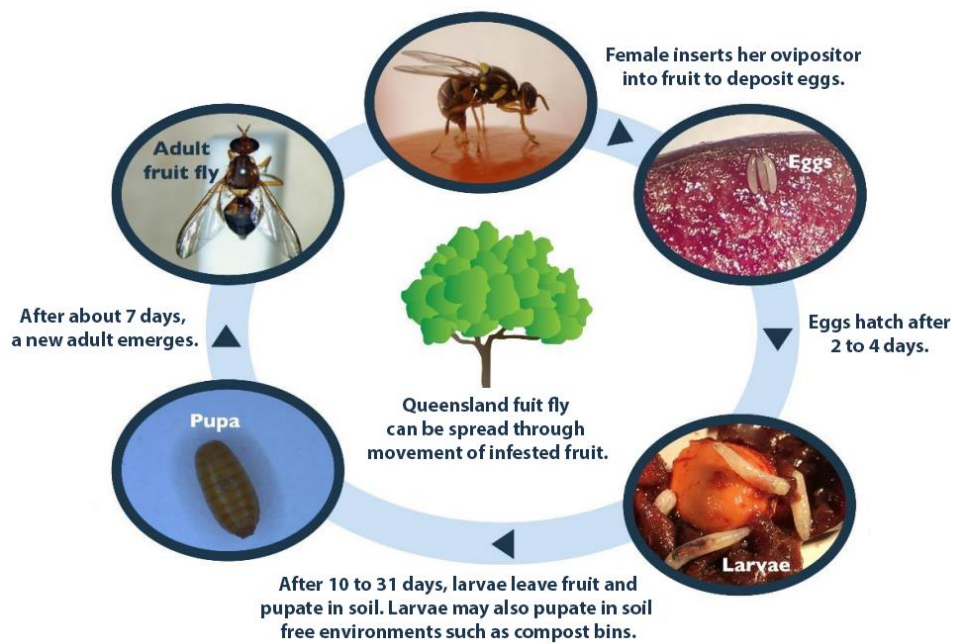


Figure 3: The lifecycle of Queensland fruit fly¹⁰.

¹⁰ Modified for NSW from Blake, M. 2019. [Report of the Independent Review of the Queensland Fruit Fly incursion in Tasmania](#), accessed 19 April 2025.

Table 1: The life stages of the Queensland fruit fly life cycle assessed in the model.

Life stage	Description
Egg	Eggs are laid under the skin in the fruit of the host plant and hatch into larvae in 2 to 4 days.
Larvae	Larvae can live and feed inside the fruit for 10 to 31 days. The activity of the larva and bacteria causes the fruit to rot internally and often fall prematurely from the tree.
Pupae	Fully mature larvae leave the fruit and burrow into the soil to pupate. Adult flies emerge from pupae in about 7 days in warm temperatures, although they take longer in cool conditions or winter.
Adult Fly	The pupal development threshold is 12 to 34°C. Adults develop over 1 to 2 weeks. After feeding and mating, adult females search for suitable ripe fruit to lay their eggs inside.

Final Queensland fruit fly model

The main MCA model structure with weightings for Queensland fruit fly is shown on the following page (Figure 4). The model has been divided into the key life stages for Queensland fruit fly: egg, larvae, pupae and adult. Each life stage has a number of climate variables that impact climate suitability. Climate variables are categorised into ideal conditions and further categorised to capture conditions less than or greater than the ideal.

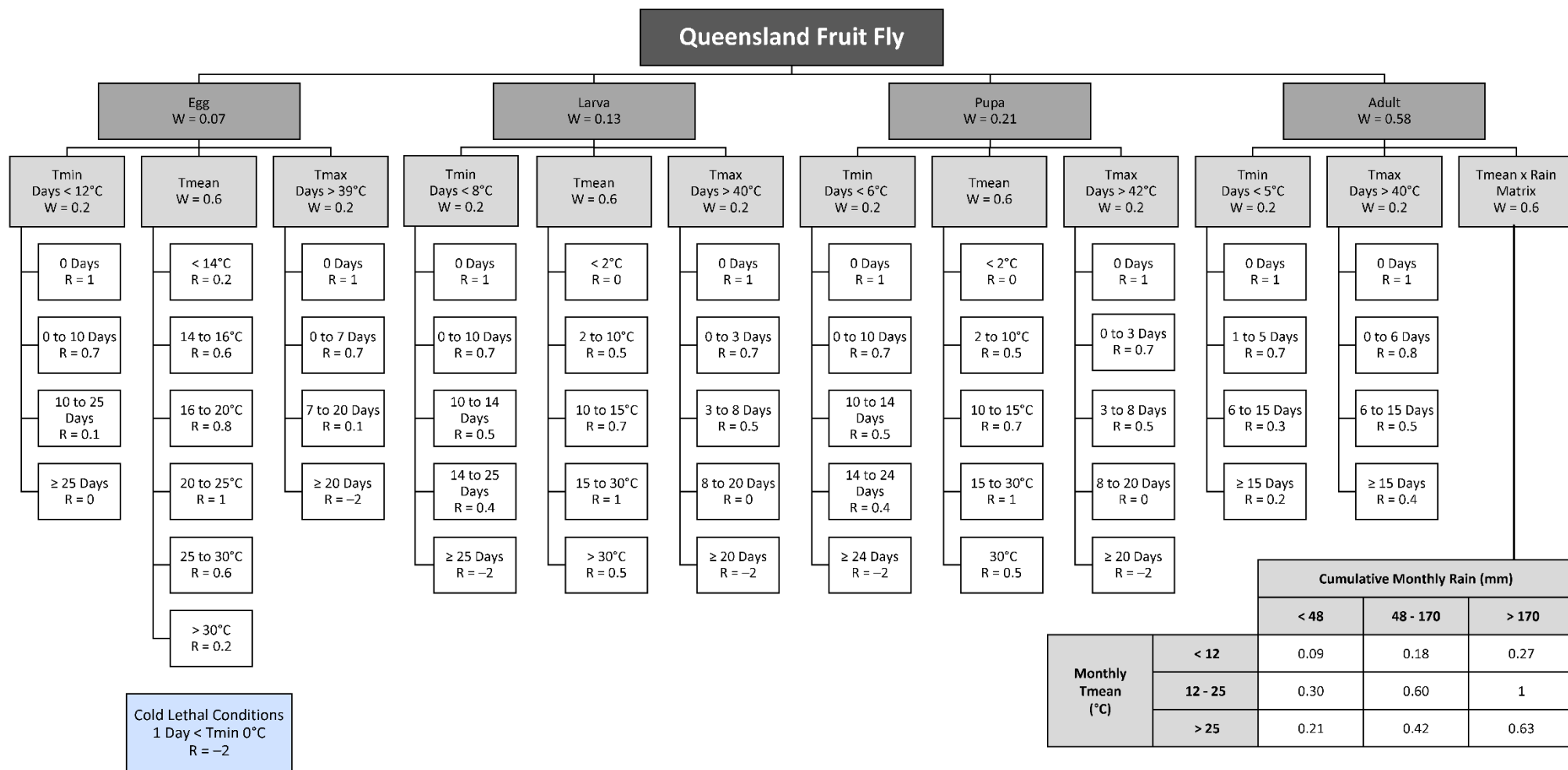


Figure 4: MCA model hierarchical structure and model components for Queensland fruit fly. The top level of the hierarchy is the biosecurity risk. The second level contains the life stages identified as climate-sensitive by the literature review and expert judgment. The third level contains climate variables which affect each life stage.

Interpreting the results

The results are presented as panels of 7 maps, comparing historical climate suitability with climate suitability under the two future emissions scenarios (RCP4.5, an intermediate emissions scenario and RCP8.5, a high emissions scenario). For the future emissions scenarios, maps of change and confidence in change in climate suitability are also presented. Polygons and key sites are displayed on each map to indicate the areas where the biosecurity risk is currently found in NSW or is of concern.

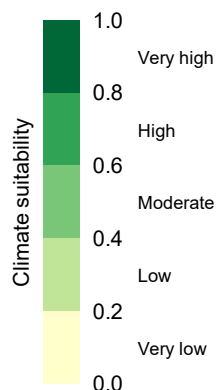


Figure 5: Colour scheme for the climate suitability maps

Historical and future climate suitability maps

The 'climate suitability' maps show the climate suitability on a scale of 0 to 1. Pale yellow is very low suitability, and dark green is very high suitability.

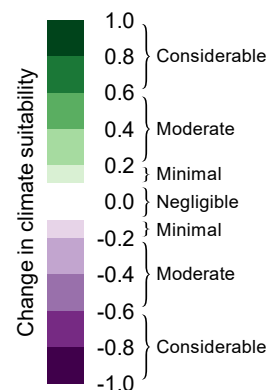


Figure 6: Colour scheme for the change in climate suitability maps

Change in climate suitability maps

The 'change in climate suitability' maps use a green-white-purple colour scheme with 11 categories: positive change, where the future climate becomes more suitable, is shown in shades of green; negative change is shown in shades of purple. Negligible change is represented by white and occurs for values between -0.1 and 0.1; in these areas, the future climate suitability will be very similar to the historical suitability.

The historical climate suitability map shows the mean suitability for 30 years (1981 to 2010). For future projections, the mean suitability for 30 years (2036 to 2065) was calculated for 8 global climate models¹¹, and the median of these models was used to produce ensemble future projection climate suitability maps.

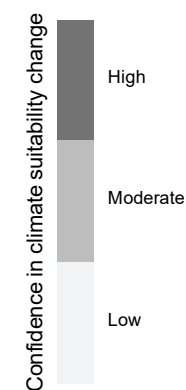


Figure 7: Colour scheme for the confidence in the change in climate suitability maps

Confidence in the change in climate suitability maps

The 'confidence in change in climate suitability' maps represent the level of agreement across the ensemble of 8 global climate models on the direction and magnitude of change in climate suitability. The lightest shade of grey represents low confidence, and the darkest shade of grey represents high confidence.

¹¹Data was sourced from Climate Change in Australia: Application Ready Data.

Interpreting the number of highly suitable months

The number of highly suitable months per year is defined as the average number of months with high or very high climate suitability. The results are presented as panels of maps, comparing the historical number with future numbers under each of the two emissions scenarios.

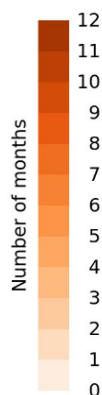


Figure 8: Colour scheme for the number of highly suitable months maps

Historical and future number of highly suitable months maps

The 'number of highly suitable months' maps show the mean number of highly suitable months on a scale of 0 to 12. Pale Orange corresponds to a low number of highly suitable months, and dark orange to a high number of highly suitable months. The values represent the mean over all years and thus may be any value between 0 and 12.

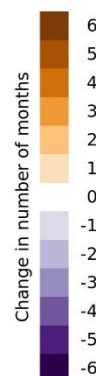


Figure 9: Colour scheme for the change in the number of highly suitable months maps

Change in the number of highly suitable months maps

The 'change in the number of highly suitable months' maps uses a purple-white-orange colour scheme with 11 categories ranging from 6 to -6. Shades of Orange indicate an increase in the number of highly suitable months; shades of purple indicate a decrease in the number of highly suitable months. Negligible change is represented by white and occurs for values between -0.5 and 0.5; in these areas, the future number of highly suitable months will be very similar to the historical number.

Maps of change in the number of highly suitable months (see colour scheme in Figure 9) and confidence (see colour scheme in Figure 10) in the change are also presented. Polygons and key sites are displayed on each map to indicate the areas where the biosecurity risk is currently found in NSW or is of concern.

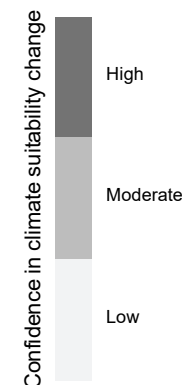


Figure 10: Colour scheme for confidence in the change in the number of highly suitable months maps

Confidence in change in the number of highly suitable months maps

The 'confidence in the change in the number of highly suitable months' maps represent the level of agreement between the ensemble of 8 global climate models on the direction and magnitude of change in the number of highly suitable months. These maps use a grey colour scheme with three categories: the lightest grey represents low confidence, and the darkest grey represents high confidence.

Interpreting calendar plots

Calendar plots for biosecurity risks were made for individual sites of interest. These plots provide a visual comparison of the change in climate suitability over the year, comparing the mean historical climate suitability with the median future climate suitability for each emissions scenario (RCP4.5 and RCP8.5). Calendar plots are included for the biosecurity risk overall and each life stage.

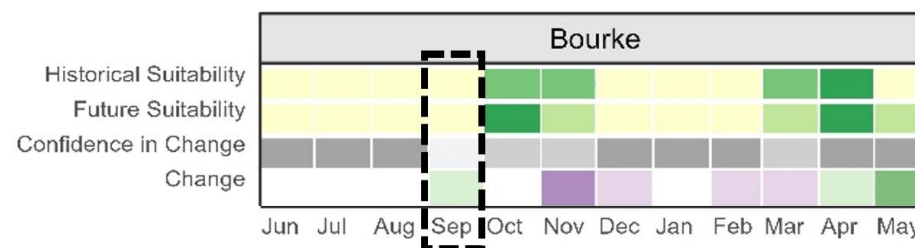
Calendar plots use the same colour categorisation as the climate suitability panels (see page 10, 'Interpreting climate suitability colour schemes'), except that the 'change' scale uses 7 colours instead of 11, condensing them into the following categories: negligible, minimal, moderate and considerable.

There are two important points to note when interpreting calendar plots:

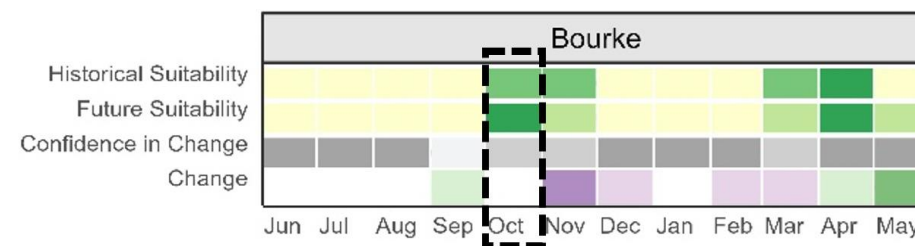
One occurs when the historical and future climate suitability categories are the same, but the 'change in suitability' is non-negligible (green or purple). This situation is shown in **Example 1** and has arisen from a historical September climate suitability of 0.000 and a future climate suitability of 0.125. Both fall into the 'very low' suitability category, shown as pale yellow, but the change in the value of +0.125 falls into the 'minimal' change category, shown as pale green.

The other occurs when the change from historical to future climate suitability is negligible (white), but the climate suitability is in different categories. This situation is shown in **Example 2** and has arisen from a historical October climate suitability of 0.577 and a future climate suitability of 0.666. The category changes from 'moderate' to 'high' (pale green to green), but the change in the value of +0.089 falls into the 'negligible' change category (white).

Example 1. The calendar plot in this example for Bourke shows a "minimal" change in climate suitability for September, but the historical and future climate suitability categories are the same ("very low"). The amount of change has not been enough to change the suitability classification for this site. This also occurs in December, February, and April.



Example 2: The calendar plot in this example for Bourke shows a "negligible change" in suitability for October, but when comparing the historical and future suitability rows, there has been an increase in suitability from "moderate" to "high". The suitability category assigned to this site has changed, but the magnitude of change is small.



Projected changes in climate suitability for Queensland fruit fly

Changes in climate suitability for Queensland fruit fly are likely to create challenges for horticultural industries in NSW.

This section provides a selection of key results for the Queensland fruit fly climate vulnerability assessment. It begins with an overview of the overall climate impacts and a breakdown of the climate impacts on each life stage, followed by the relevant maps and calendar plots. The interpretation and findings are provided in the text on the bottom left corner of each map panel and on the right side of the calendar plot panels. The findings have been summarised with key figures and additional maps provided in the Appendix.

Analysis of the model outputs has been undertaken spatially across NSW, presented as maps, and over time (on a monthly basis), presented as calendar plots. Each map includes the outline (in blue) of key Queensland fruit fly-related regions in NSW. These regions are shown in Figure 11, and will be referred to as the 'eastern' and 'southwestern' regions in the results section of this report. The southwestern region represents the former Fruit Fly Exclusion Zone.

The locations shown in Figure 11 are used to study the annual changes for Queensland fruit fly. These sites were selected because they align with surveillance locations for Queensland fruit fly in NSW, and they represent some of the key horticultural areas where Queensland fruit fly has an impact.



Figure 11: The endemic distribution of Queensland fruit flies across southwestern (yellow) and eastern (brown) regions in NSW. Locations marked by black dots show existing trapping and surveillance sites.

Overall climate impacts

Annual climate suitability trends: impacts on different regions in NSW

Within NSW, different areas have very suitable climate conditions for Queensland fruit fly. The number of months each year in which the climate suitability is classified as 'highly suitable' ('high' or 'very high') is used as a measure of overall climate suitability for Queensland fruit fly. This varies between different regions of the state, as shown in Figure 12.

By 2050, the number of highly suitable months in the eastern and southwestern regions of the state is likely to increase by 1 to 2 months per year under both emissions scenarios (*low to high confidence*).

Conversely, some areas in the state's northwest region are likely to have fewer highly suitable months in the high emissions scenario. Other areas will remain similar to historical levels under both emissions scenarios (*low to high confidence*).



Queensland fruit fly: number of highly suitable months

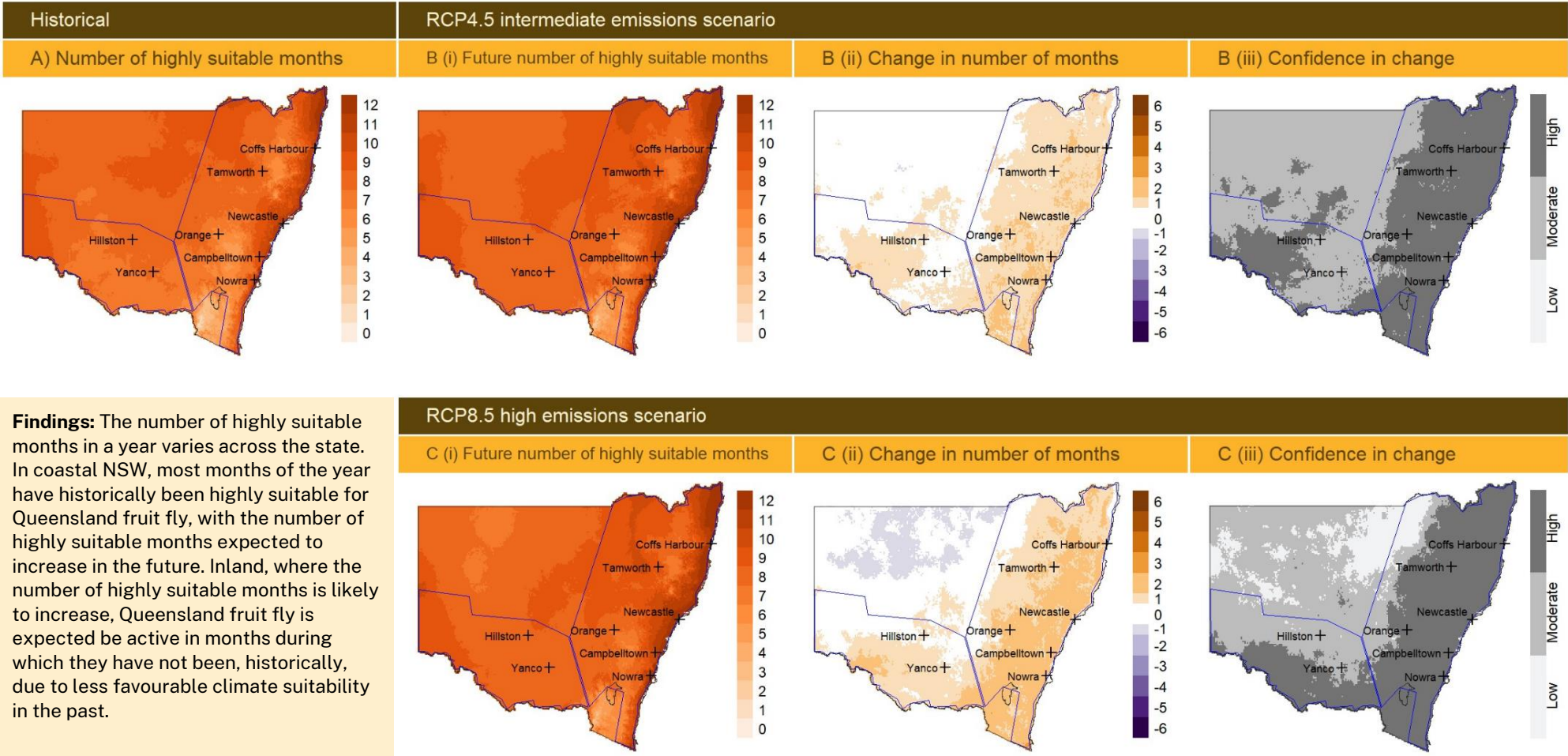


Figure 12: Number of highly suitable months for Queensland fruit fly. The number of highly suitable months measures the months in which climate suitability is greater than or equal to 0.6. The panel is comprised of 7 maps: A) shows the historic number of highly suitable months; B) and C) show the future number of highly suitable months for the intermediate and high emissions scenarios, respectively; i) shows future number of highly suitable months, ii) shows the projected change in number of months as negligible (white), increasing (orange) or decreasing (purple) change and iii) shows the level of confidence in this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

Changes in monthly climate suitability

Spatial trends: How climate change will alter Queensland fruit fly distribution across NSW.

The preceding pages have analysed trends in climate suitability for Queensland fruit fly across the year. In this section, the spatial distribution of Queensland fruit fly based on climate suitability is examined for key months of the year. Potential changes in the eastern and southwestern endemic Queensland fruit fly regions (Figure 11) include:

- **April to October** – there are likely to be minimal to moderate increases in climate suitability in both regions. The increases are likely to be greatest under the high emissions scenario (*moderate to high confidence*). For May and September, see Figures 13 and 14, respectively; for other months see Appendix Figures A8, A10, A11, A12 and A14.
- **November** – there are likely to be minimal to moderate increases in climate suitability in the eastern region. The increase is expected to be greatest under the high emissions scenario (*moderate to high confidence*) (see Appendix Figure A15).
- **January** – there are likely to be minimal decreases in climate suitability in the southwestern region. The decrease is likely to be greatest under the high emissions scenario (*moderate to high confidence*) (see Appendix Figure A5).
- **February, March and December** – climate suitability in both regions is expected to remain similar to what has been historically experienced under both emissions scenarios (*moderate to high confidence*) (see Appendix Figures A6, A7 and A16)

Monthly trends at Queensland fruit fly sites: How climate change will alter climate suitability throughout the year.

Figure 15, the overall calendar plot, shows the expected temporal change in monthly climate suitability throughout the year around sites of importance for Queensland fruit fly. Coffs Harbour, Tamworth, Newcastle, Orange, Campbelltown and Nowra, are within the eastern endemic region, while Hillston and Yanco are in the southwestern region for Queensland fruit fly in NSW (Figure 11). An analysis of future climate suitability around these sites provides insights into potential future monthly trends by 2050.

- Under both emissions scenarios, the climate suitability for Queensland fruit fly is expected to increase during the cooler months for Coffs Harbour, Tamworth, Orange, Campbelltown, Nowra, Hillston and Yanco (*moderate to high confidence*).
- The climate suitability in Newcastle is expected to remain similar to the historical suitability in both emissions scenarios (*low to high confidence*)

Queensland fruit fly – overall climate suitability for May

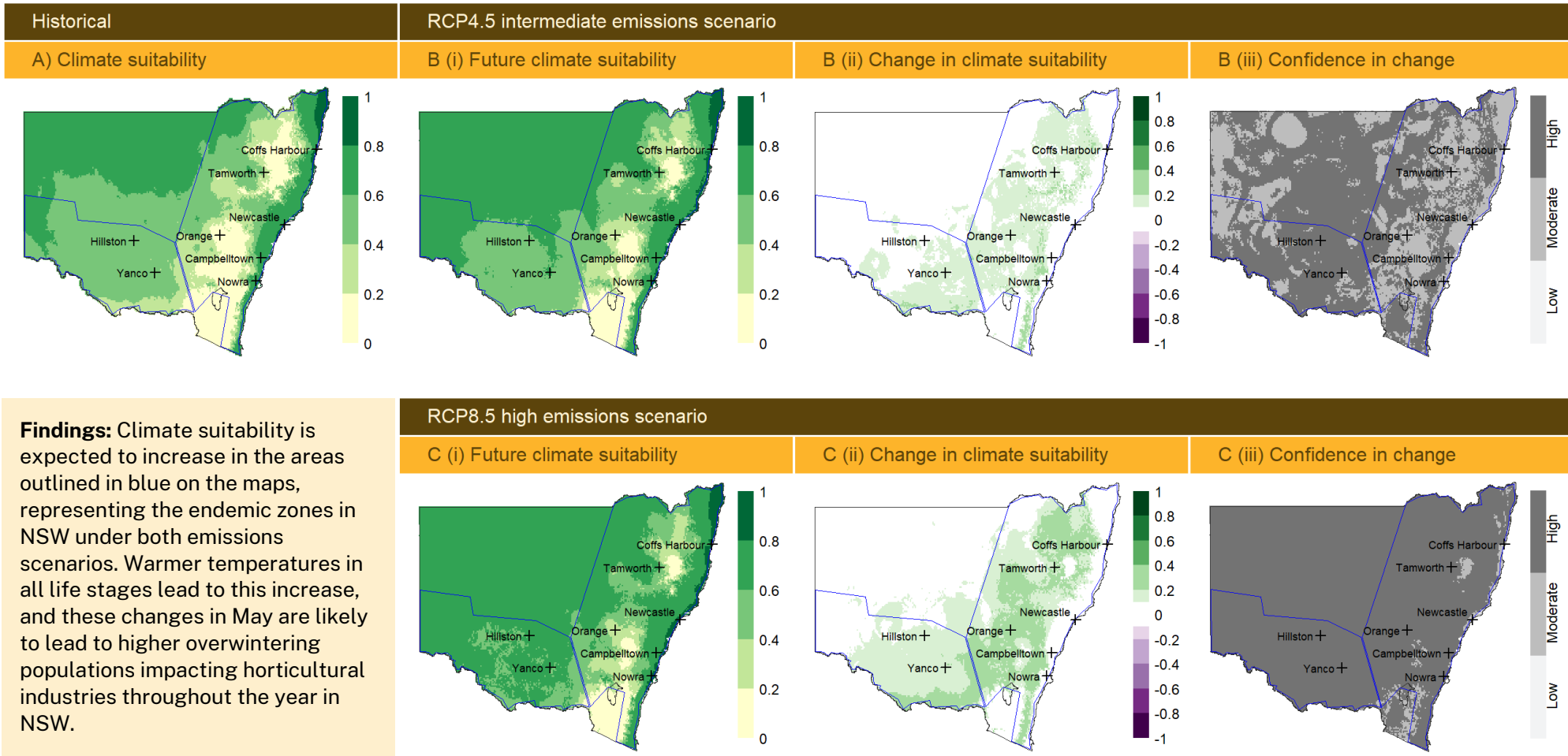


Figure 13: Overall climate suitability for Queensland fruit fly in NSW for May. The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

Queensland fruit fly – overall climate suitability for September

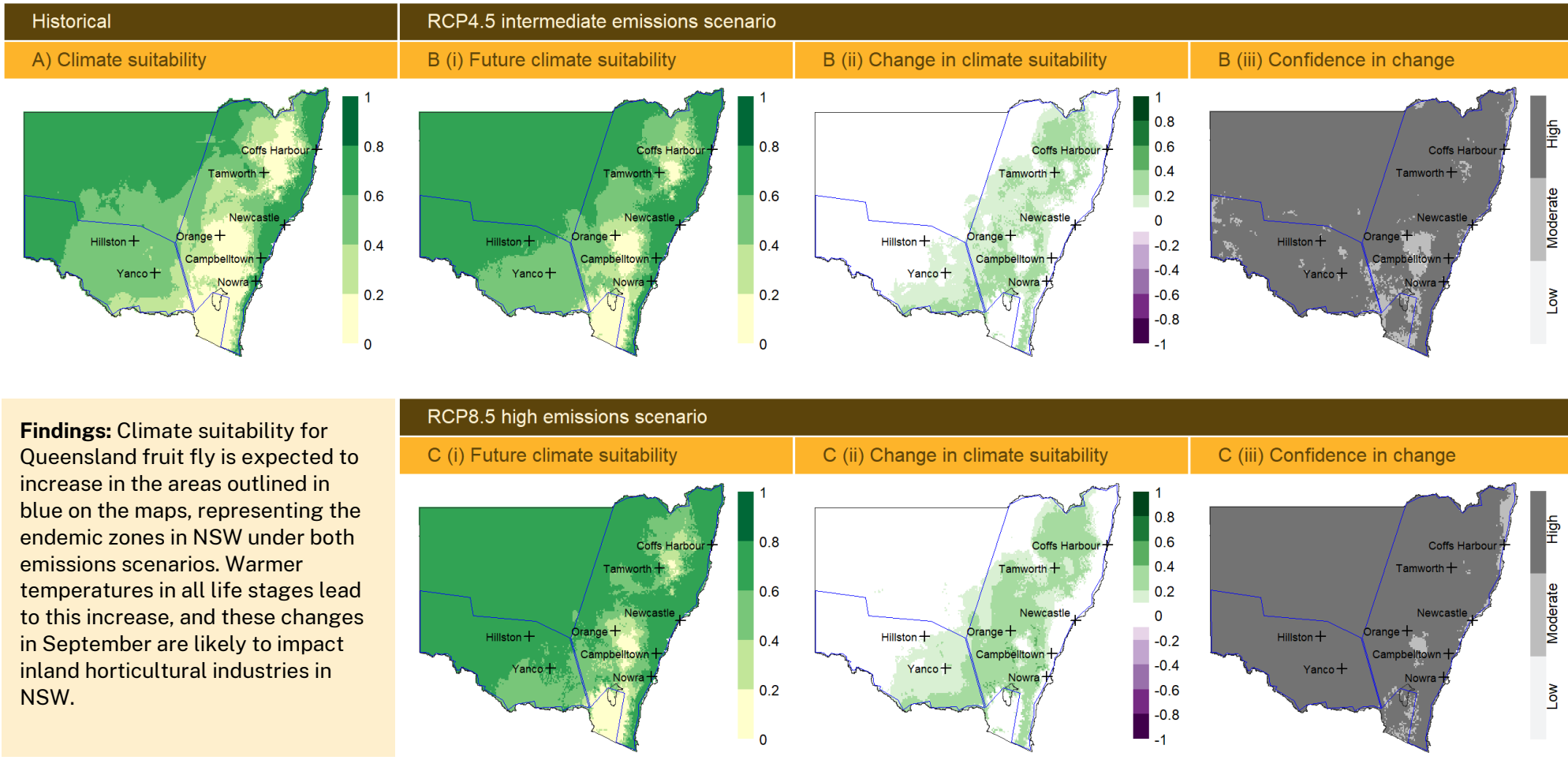


Figure 14: Overall climate suitability for Queensland fruit fly in NSW for September. The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

Queensland fruit fly: climate suitability calendar

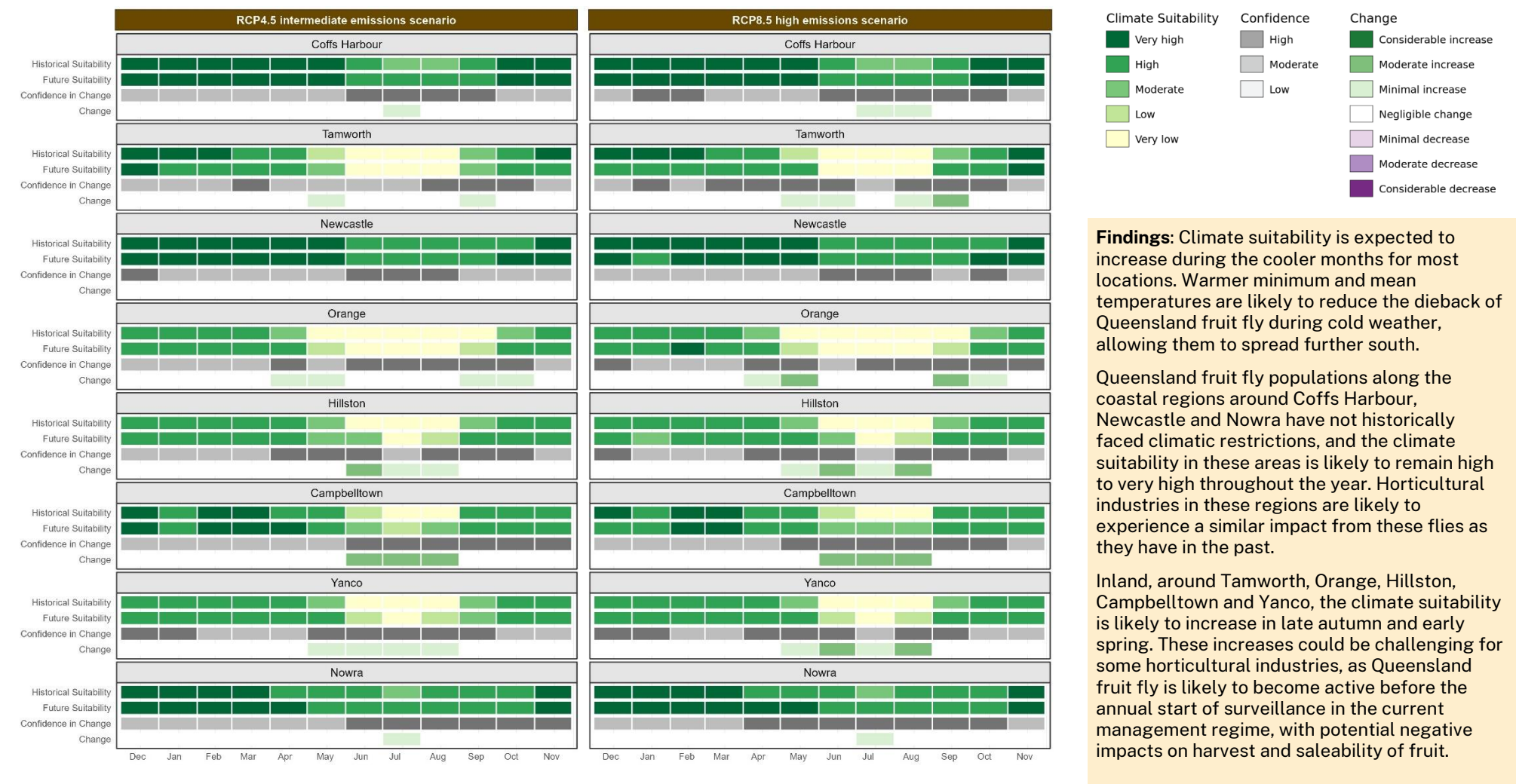


Figure 15: Queensland fruit fly overall climate suitability calendar. The calendar plot displays the historical and future climate suitability, change in suitability and confidence in change for each site of interest. It shows two emissions scenarios, the intermediate emissions scenario, RCP4.5, on the left and the high emissions scenario, RCP8.5, on the right. The climate suitability categories represent median values within a 10km radius of each location.

Climate impacts on life stages

Changes in climate suitability are likely across all key life stages of Queensland fruit fly by 2050 under both emissions scenarios.

Eggs

Eggs are laid under the skin of the fruit of the host plant where they hatch into larvae. This stage is sensitive to cool temperatures during winter and extreme heat during summer.

The number of highly suitable months each year for the egg life stage is likely to increase by 1 to 2 months in the eastern and southwestern regions. A small area in the northwest of NSW bordering Queensland may have fewer suitable months, and the remaining western areas of NSW are likely to retain historical numbers of highly suitable months under both emissions scenarios (*low to high confidence*) (Appendix Figure A1).

Figure 16, the egg calendar plot, shows the expected change in monthly climate suitability throughout the year around sites of importance for Queensland fruit fly. These changes in climate suitability are:

- **increased climate suitability** in the cooler months for Coffs Harbour, Tamworth, Newcastle, Orange, Hillston, Yanco and Nowra under both emissions scenarios, and for Campbelltown under the high emissions scenario (*moderate to high confidence*);
- **decreased climate suitability** in January for Hillston under the high emissions scenario (*high confidence*);
- **maintain historical climate suitability** throughout the year for Campbelltown under the intermediate emissions scenario (*low to high confidence*).

Larvae

The larvae live and feed inside the fruit. This activity can result in bacterial infection which may cause the fruit to rot internally and often fall prematurely from the tree. The larvae are sensitive to cooler temperatures during winter and extreme heat during summer.

The number of highly suitable months each year for the larval stage is likely to increase by 1 to 2 months in the eastern and southwestern regions of the state. A part of the northwest region bordering Queensland may have fewer suitable months, and the remaining western areas of NSW are likely to retain historical numbers of highly suitable months under both emissions scenarios (*low to high confidence*) (Appendix Figure A2).

Figure 17, the larvae calendar plot, shows the expected change in monthly climate suitability throughout the year around sites of importance for Queensland fruit fly. These changes in climate suitability are:

- **increased climate suitability** in the cooler months for Coffs Harbour, Tamworth, Orange, Hillston, Campbelltown and Yanco under both emissions scenarios and Nowra under the high emissions scenario (*moderate to high confidence*);
- **decreased climate suitability** in January for Hillston under the high emissions scenario (*high confidence*);
- **maintain historical climate suitability** throughout the year for Newcastle under both emissions scenarios (*high confidence*) and Nowra under the intermediate emissions scenario (*high confidence*).

Pupae

The larvae migrate from the fruit and burrow into the soil to pupate. This stage is less sensitive to climate due to its limited exposure to air temperatures.

The number of highly suitable months each year for the pupae stage is likely to increase by 1 to 2 months in the eastern and southwestern regions of the state. A small part of the northwest region bordering Queensland may have fewer suitable months, and the remaining western areas of NSW are likely to have historical numbers of highly suitable months under both emissions scenarios (*low to high confidence*) (Appendix Figure A3).

Figure 18, the pupae calendar plot, shows the expected change in monthly climate suitability throughout the year around sites of importance for Queensland fruit fly. These changes in climate suitability are:

- **increased climate suitability** in the cooler months for Tamworth, Orange, Hillston and Campbelltown under both emissions scenarios and Newcastle and Nowra under the high emissions scenario (*high confidence*);
- **maintain historical climate suitability** throughout the year for Coffs Harbour and Yanco under both emissions scenarios and Newcastle and Nowra under the intermediate emissions scenario (*low to high confidence*).

Adult flies

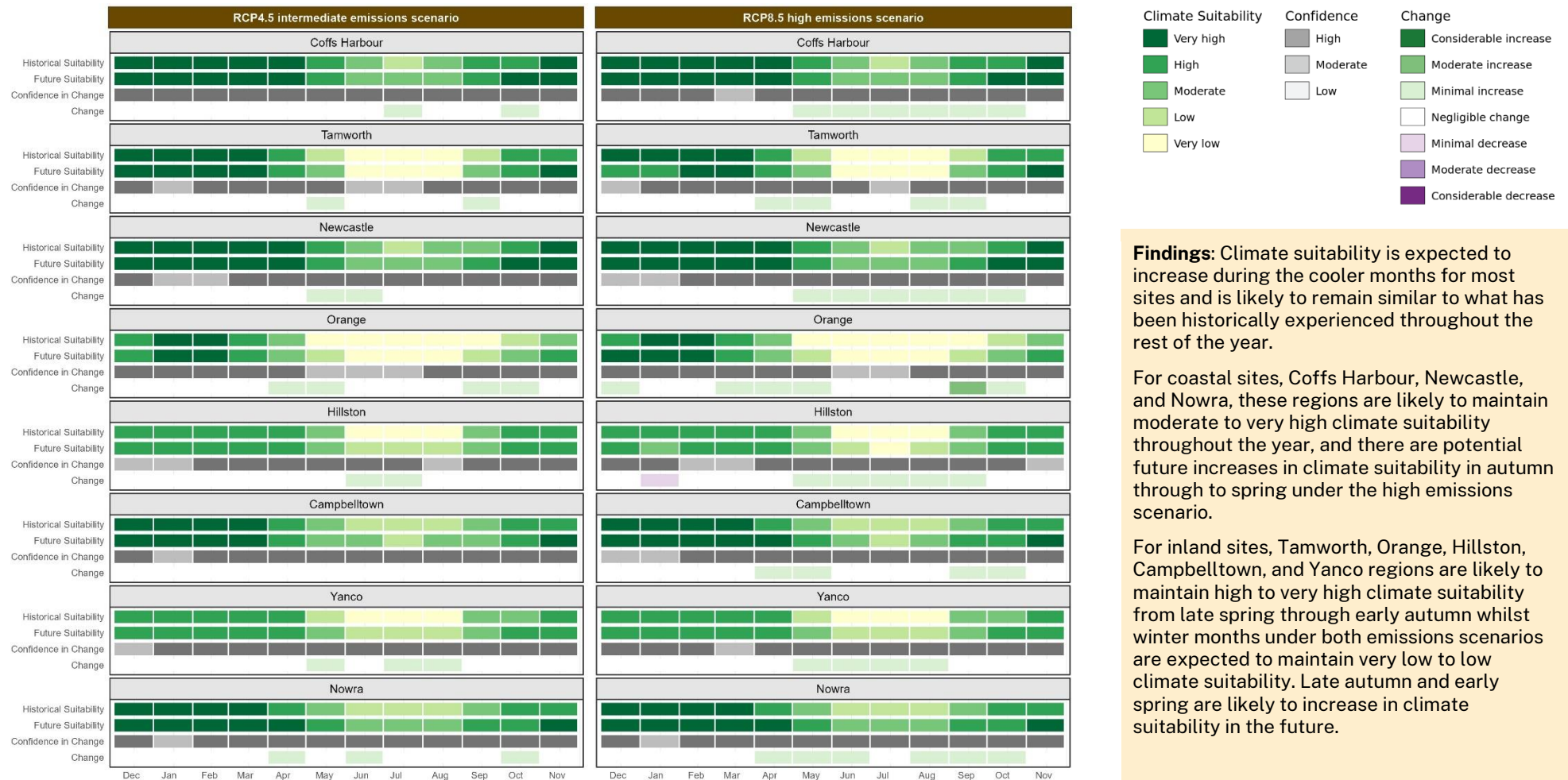
The adult fly is sensitive to cooler temperatures during winter and extreme heat during summer. The fly relies on microclimates to over-winter and shelter during unsuitable conditions where it can re-emerge once conditions improve. Adults mature in 1-2 weeks, feeding and mating. Adult females then search for suitable ripe fruit to lay their eggs inside.

The number of highly suitable months each year for the adult fly is likely to increase by 1 to 2 months along the Great Dividing Range and eastern NSW. There are likely to be small areas in the northeast region bordering Queensland that may have fewer highly suitable months. Western NSW is also likely to have a similar number of highly suitable months to historical numbers under both emissions scenarios (*low to high confidence*) (Appendix Figure A4).

Figure 19, the adult fly calendar plot, shows the expected change in monthly climate suitability throughout the year around sites of importance for Queensland fruit fly. These changes in climate suitability are:

- **increased climate suitability** in the cooler months for Campbelltown and Nowra under both emissions scenarios and in October for Orange under the high emissions scenario (*high confidence*);
- **maintain historical climate suitability** throughout the year for Coffs Harbour, Tamworth, Newcastle, Hillston and Yanco under both emissions scenarios and Orange under the intermediate emissions scenario (*low to high confidence*).

Queensland fruit fly – egg calendar plot



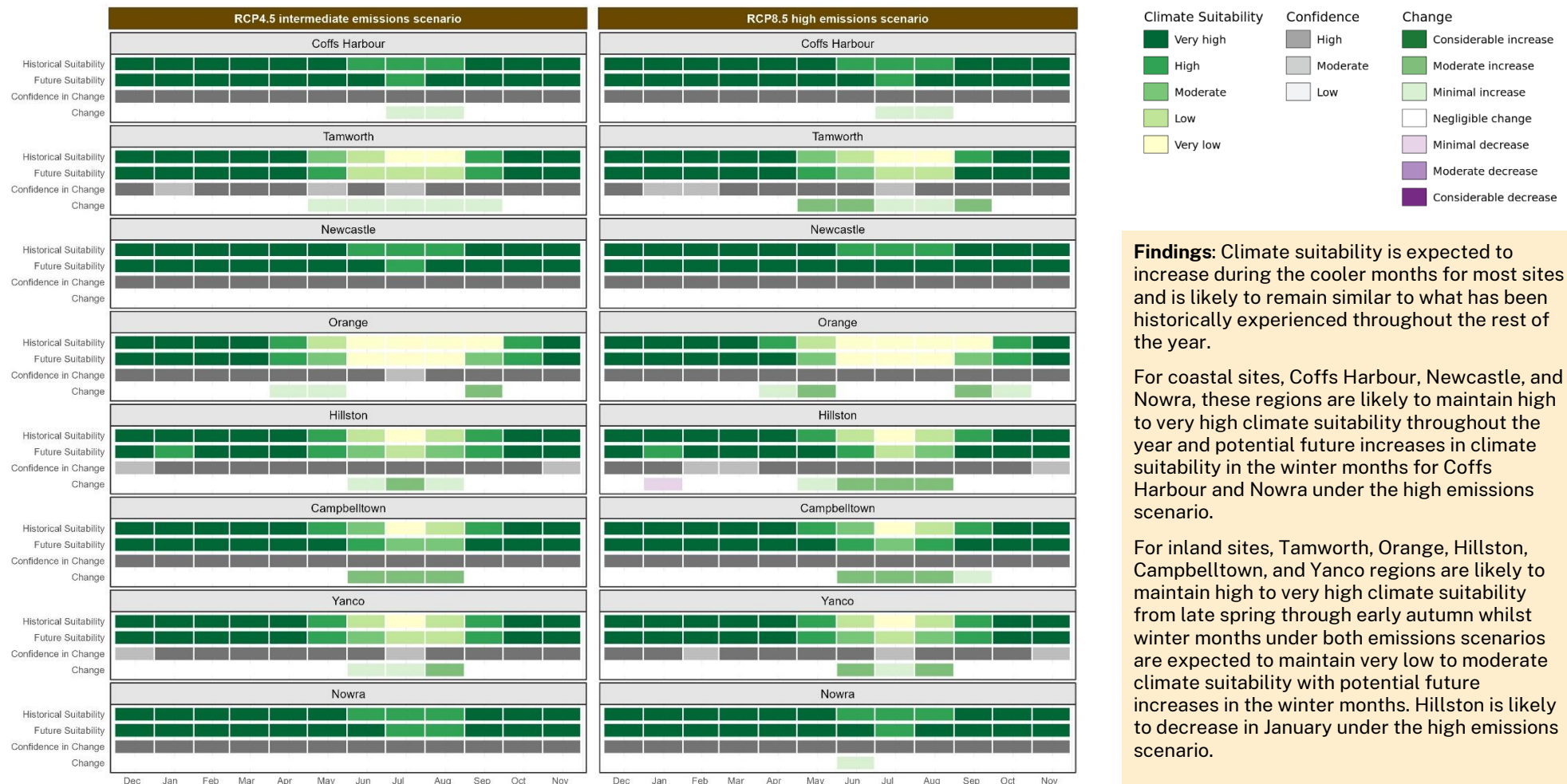
Findings: Climate suitability is expected to increase during the cooler months for most sites and is likely to remain similar to what has been historically experienced throughout the rest of the year.

For coastal sites, Coffs Harbour, Newcastle, and Nowra, these regions are likely to maintain moderate to very high climate suitability throughout the year, and there are potential future increases in climate suitability in autumn through to spring under the high emissions scenario.

For inland sites, Tamworth, Orange, Hillston, Campbelltown, and Yanco regions are likely to maintain high to very high climate suitability from late spring through early autumn whilst winter months under both emissions scenarios are expected to maintain very low to low climate suitability. Late autumn and early spring are likely to increase in climate suitability in the future.

Figure 16: Queensland fruit fly egg climate suitability calendar. The calendar plot displays the historical and future climate suitability, change in suitability and confidence in change for each site of interest. It shows two emissions scenarios, the intermediate emissions scenario, RCP4.5, on the left and the high emissions scenario, RCP8.5, on the right. The climate suitability categories represent median values within a 10km radius of each location.

Queensland fruit fly – larvae calendar plot



Findings: Climate suitability is expected to increase during the cooler months for most sites and is likely to remain similar to what has been historically experienced throughout the rest of the year.

For coastal sites, Coffs Harbour, Newcastle, and Nowra, these regions are likely to maintain high to very high climate suitability throughout the year and potential future increases in climate suitability in the winter months for Coffs Harbour and Nowra under the high emissions scenario.

For inland sites, Tamworth, Orange, Hillston, Campbelltown, and Yanco regions are likely to maintain high to very high climate suitability from late spring through early autumn whilst winter months under both emissions scenarios are expected to maintain very low to moderate climate suitability with potential future increases in the winter months. Hillston is likely to decrease in January under the high emissions scenario.

Figure 17: Queensland fruit fly larvae climate suitability calendar. The calendar plot displays the historical and future climate suitability, change in suitability and confidence in change for each site of interest. It shows two emissions scenarios, the intermediate emissions scenario, RCP4.5, on the left and the high emissions scenario, RCP8.5, on the right. The climate suitability categories represent median values within a 10km radius of each location.

Queensland fruit fly – pupae calendar plot

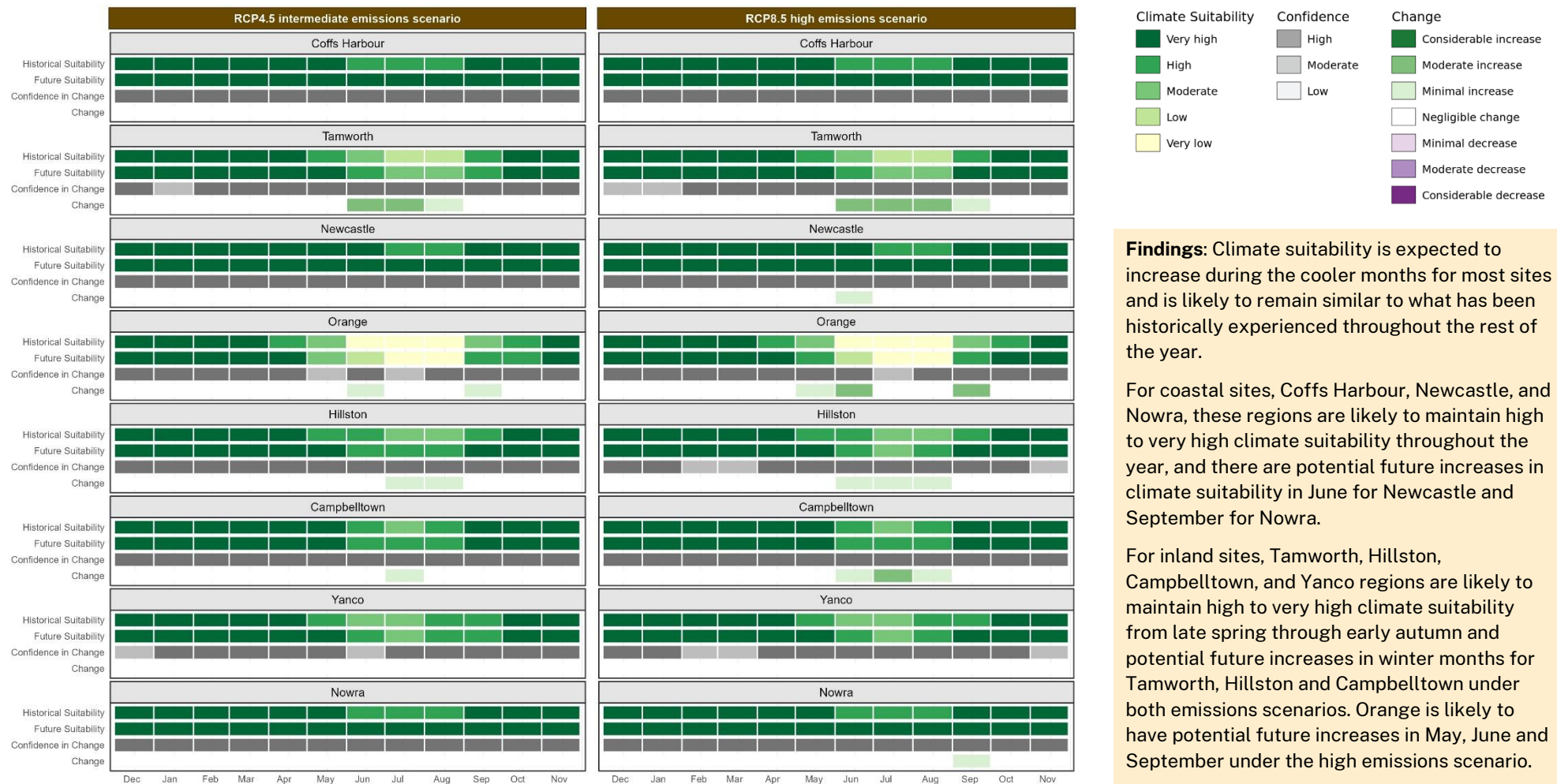


Figure 18: Queensland fruit fly pupae climate suitability calendar. The calendar plot displays the historical and future climate suitability, change in suitability and confidence in change for each site of interest. It shows two emissions scenarios, the intermediate emissions scenario, RCP4.5, on the left and the high emissions scenario, RCP8.5, on the right. The climate suitability categories represent median values within a 10km radius of each location.

Queensland fruit fly – adult fly calendar plot

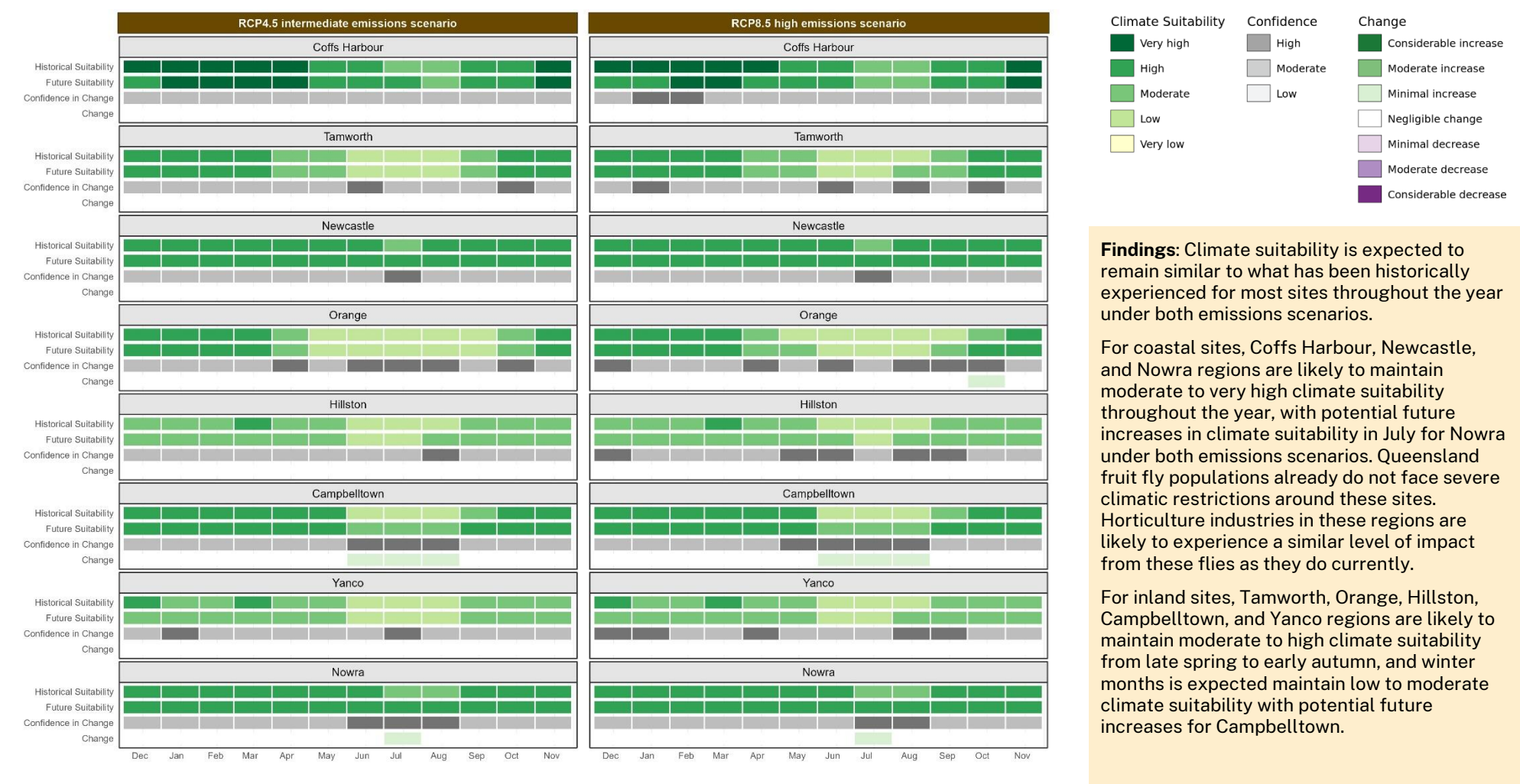


Figure 19: Queensland fruit fly adult climate suitability calendar. The calendar plot displays the historical and future climate suitability, change in suitability and confidence in change for each site of interest. It shows two emissions scenarios, the intermediate emissions scenario, RCP4.5, on the left and the high emissions scenario, RCP8.5, on the right. The climate suitability categories represent median values within a 10km radius of each location.

Key findings and insights from a changing climate

The results of this study provide valuable insights into the historical and potential future climate suitability of Queensland fruit fly regions and life stages.

Key insights for the Eastern region

Queensland fruit fly is endemic in NSW, with a strong presence in the east of the state (Figure 12). A key observation is that the eastern region consistently has a high number of highly suitable months, and the number of highly suitable months is likely to increase by 2050. The future projections show increased year-round climate suitability, especially around Coffs Harbour, Newcastle, Nowra. Similarly increases in year-round suitability are expected for the surrounding areas where the insect is already well established and where the limiting factor is low temperatures (for example, along the Great Dividing Range).

An increase in highly suitable months results from the milder winters and higher mean temperatures; these conditions mean that all life stages are likely to experience more favourable climate suitability in the coming years. The most suitable areas are those where populations already do not face severe climatic restrictions.

Another key observation is that the eastern region sites consistently have a high number of months with high to very high climate suitability, from October to May (Figure 13). For instance, historically, Coffs Harbour, Campbelltown, and Nowra demonstrated high suitability in these months, and in winter, they reduced climate suitability. However, future projection trends indicate climate suitability is likely to increase from June to August (Figure 13).

Key insights for the Southwestern region

A key observation in the southwestern region is that the number of highly suitable months is likely to increase by 2050 (Figure 12). The future projections show increased climate suitability in the former fruit fly exclusion zone south of Hillston and Yanco. An increase in highly suitable months results from the milder winters and higher mean temperatures; these conditions mean that all life stages are likely to experience more favourable climate suitability in the coming years.

There are a high number of months with high climate suitability from October to April around Hillston and Yanco with reduced climate suitability in winter. However, future projection trends indicate climate suitability is likely to increase from May to August (Figure 13).

Key findings across life stages

Changes in climate suitability for each life stage are likely to shift the spatial and temporal distribution of Queensland fruit fly across NSW.

An increase in climate suitability due to milder winters and higher mean temperatures may result in all life stages experiencing more favourable climate suitability in the future, with the most suitable areas being those where populations already do not face severe climatic restrictions (Figures 16-19).

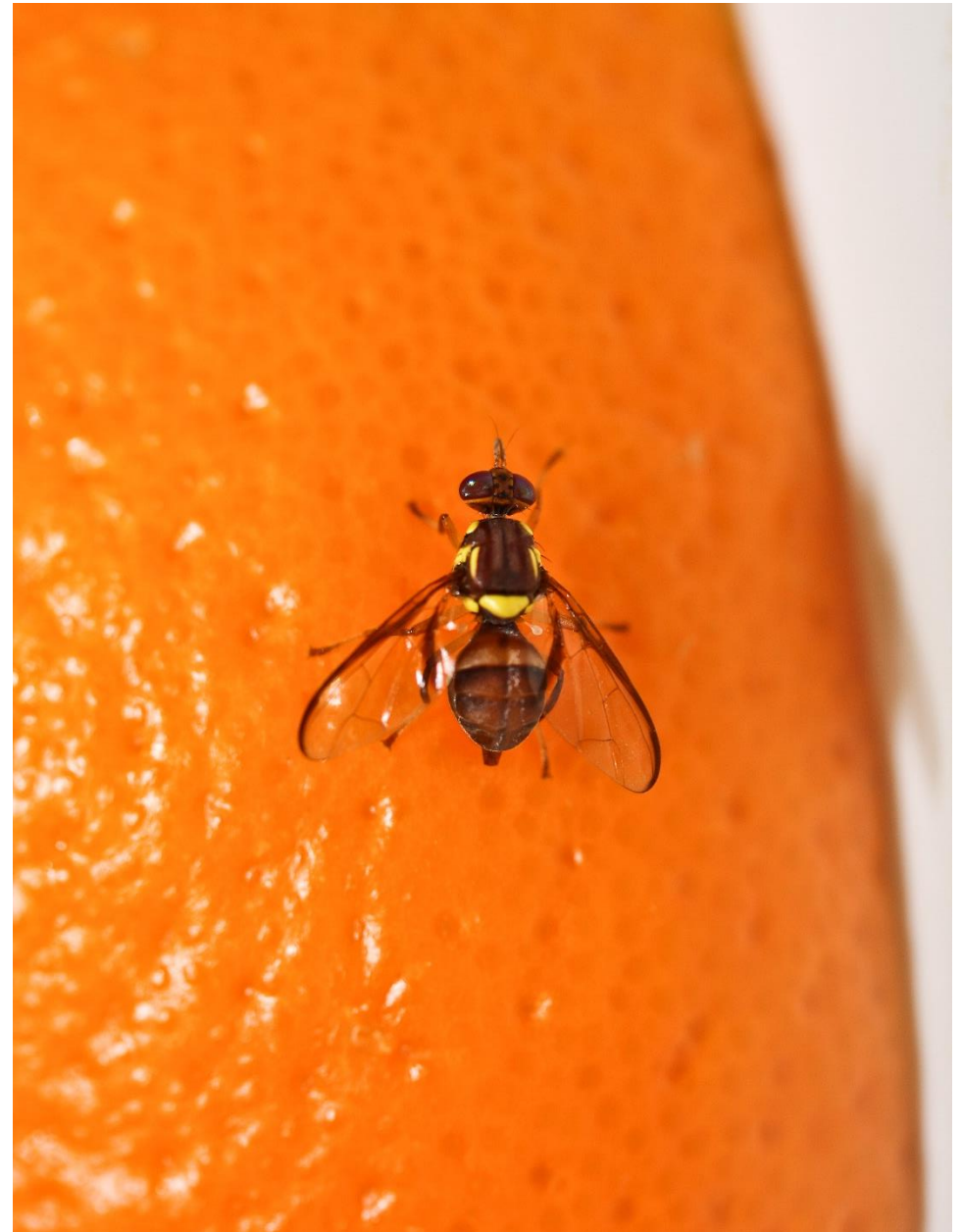
Expected challenges for primary industries

The effects of Queensland fruit fly on horticultural industries in NSW will depend on the following:

- the future distribution of those industries,
- changes in production timings and
- the overlap between susceptible life stages of commodities and the lifecycle of Queensland fruit fly.

Increased suitability under a warmer climate is likely to lead to a greater impact of Queensland fruit fly on horticultural industries in NSW. Climate suitability is likely to increase along the Great Dividing Range from the Queensland border to southern NSW during September due to higher mean and minimum temperatures during winter. This could result in fruit flies being active before the commencement of surveillance, so monitoring and surveillance programs in 2050 may need to start earlier than now.

Current strategies to manage the pest are likely to remain effective. Still, treatment costs are likely to increase as warmer temperatures and changes in rainfall support the southward and inland spread of Queensland fruit fly. Due to the large number of potential hosts and large areas potentially affected, the horticultural industry may need to consider broad-reaching Queensland fruit fly education programs to raise awareness of the increased risks and management strategies.



Queensland fruit fly: Where to from here?

Future priorities

We have assessed the future climate suitability for Queensland fruit fly as it is a prerequisite for making effective planning decisions and developing management strategies to address future climate change impacts.

The results presented in this report have identified changes in climate suitability for Queensland fruit fly that are likely to have a moderate impact on the horticultural industry in NSW. More research is needed to best advise impacted industries on adaptations and new management techniques for Queensland fruit fly, looking forward to 2050. Effective management approaches must be carefully planned, evaluated, and deployed to minimise disruptions and costs. The horticulture industry may need to consider starting surveillance earlier in spring and implementing broad-reaching Queensland fruit fly education programs. These programs would raise awareness of the increased risk and provide management strategies for regions that have not previously been affected.

Additional work is needed to understand the financial and market access impacts of increased pressure from Queensland fruit fly.

Addressing the gaps, barriers and challenges

The new information generated by this project has helped to identify expected future changes in climate suitability for Queensland fruit fly. However, many knowledge gaps were identified during the development of the MCA model.

In some cases, these knowledge gaps were barriers to developing the models, leading to the exclusion of key climate criteria because there were no data to justify their inclusion in the model. The following areas are deemed key knowledge gaps in need of further research:

- impact of maximum temperatures on survival of all life stages of Queensland fruit fly,
- impact of mean temperatures on adult flies, and
- interaction between temperature and rainfall for adult flies.

Many studies have been conducted under lab conditions which may not reflect the field observations. These studies also lack clarity on whether stated temperatures were minimum, mean or maximum.

This report aims to highlight these gaps to assist in directing future research and project development. It was not possible to cover all biosecurity risks that are important to NSW. Consideration should be given to modelling other significant biosecurity risks, like those listed in the national priority list of exotic environmental pests, weeds and diseases¹². Expanding the range of the current modelling to be Australia-wide would provide valuable information for future industry planning and assist with inter-jurisdictional engagement if climate change is likely to shift biosecurity risks into new geographic regions.

¹² The National Priority List of Exotic Environmental Pests, Weeds and Diseases, <https://www.agriculture.gov.au/biosecurity-trade/policy/environmental/priority-list>

Conclusion

The Climate Vulnerability Assessment provides important baseline information to support state, regional and strategic industry-level planning for climate change, highlighting where management and investment should be prioritised to sustain and enhance horticulture and limit the impacts of climate change on Queensland fruit fly.

The results presented in this report provide a comprehensive assessment of how climate suitability is likely to shift under climate change for this key biosecurity risk in NSW. This research also sets out the challenges ahead, which will require investment in management strategies and education to underpin the horticultural industry's future growth and sustainability.

DPIRD will use these findings to work with industry to prioritise future efforts, strategic partnerships, and networks across the state to support effective policies and programs that keep primary industries resilient and productive in a changing climate.

For more information

For detailed information on the methodology used in this project, please see the [Climate Vulnerability Assessment Methodology Report](#).

Results from other commodities and biosecurity risk assessments can be found in the [Climate Vulnerability Assessment Summary Report](#) or on the [website](#).

Other Climate Vulnerability Assessments that may be of particular interest to Queensland fruit fly are the impacted hosts:

- [Cherries](#)
- [Blueberries](#)

An accompanying report on [NSW Drought in a Changing Climate](#) provides a comprehensive understanding of how drought frequency and duration will change as a result of climate change.

Contact us

For further information, please get in touch with vulnerability.assessment@dpi.nsw.gov.au

Acknowledgements

We thank the four experts who participated in the Queensland fruit fly focus groups. These experts ensured that the model contents reflected published knowledge and lived experiences, and they determined the relative influence or importance of different climate variables in the model.

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Appendix

Figure A1. Number of Highly Suitable Months for Queensland fruit fly egg stage.....	32
Figure A2. Number of Highly Suitable Months for Queensland fruit fly larval stage.	33
Figure A3. Number of Highly Suitable Months for Queensland fruit fly pupal stage.....	34
Figure A4. Number of Highly Suitable Months for Queensland fruit fly adult stage.....	35
Figure A5. January climate suitability for Queensland fruit fly.....	36
Figure A6. February climate suitability for Queensland fruit fly.....	37
Figure A7. March climate suitability for Queensland fruit fly.....	38
Figure A8. April climate suitability for Queensland fruit fly.	39
Figure A9. May climate suitability for Queensland fruit fly.....	40
Figure A10. June climate suitability for Queensland fruit fly.	41
Figure A11. July climate suitability for Queensland fruit fly.....	42
Figure A12. August climate suitability for Queensland fruit fly.....	43
Figure A13. September climate suitability for Queensland fruit fly.....	44
Figure A14. October climate suitability for Queensland fruit fly.....	45
Figure A15. November climate suitability for Queensland fruit fly.	46
Figure A16. December climate suitability for Queensland fruit fly.	47

Figure A1. Number of Highly Suitable Months for Queensland fruit fly egg stage.

The number of highly suitable months measures the months in which climate suitability is greater than or equal to 0.6. The panel is comprised of 7 maps: A) shows the historic number of highly suitable months; B) and C) show the future number of highly suitable months for the intermediate and high emissions scenarios, respectively; i) shows future number of highly suitable months, ii) shows the projected change in number of months as negligible (white), increasing (orange) or decreasing (purple) change and iii) shows the level of confidence in this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

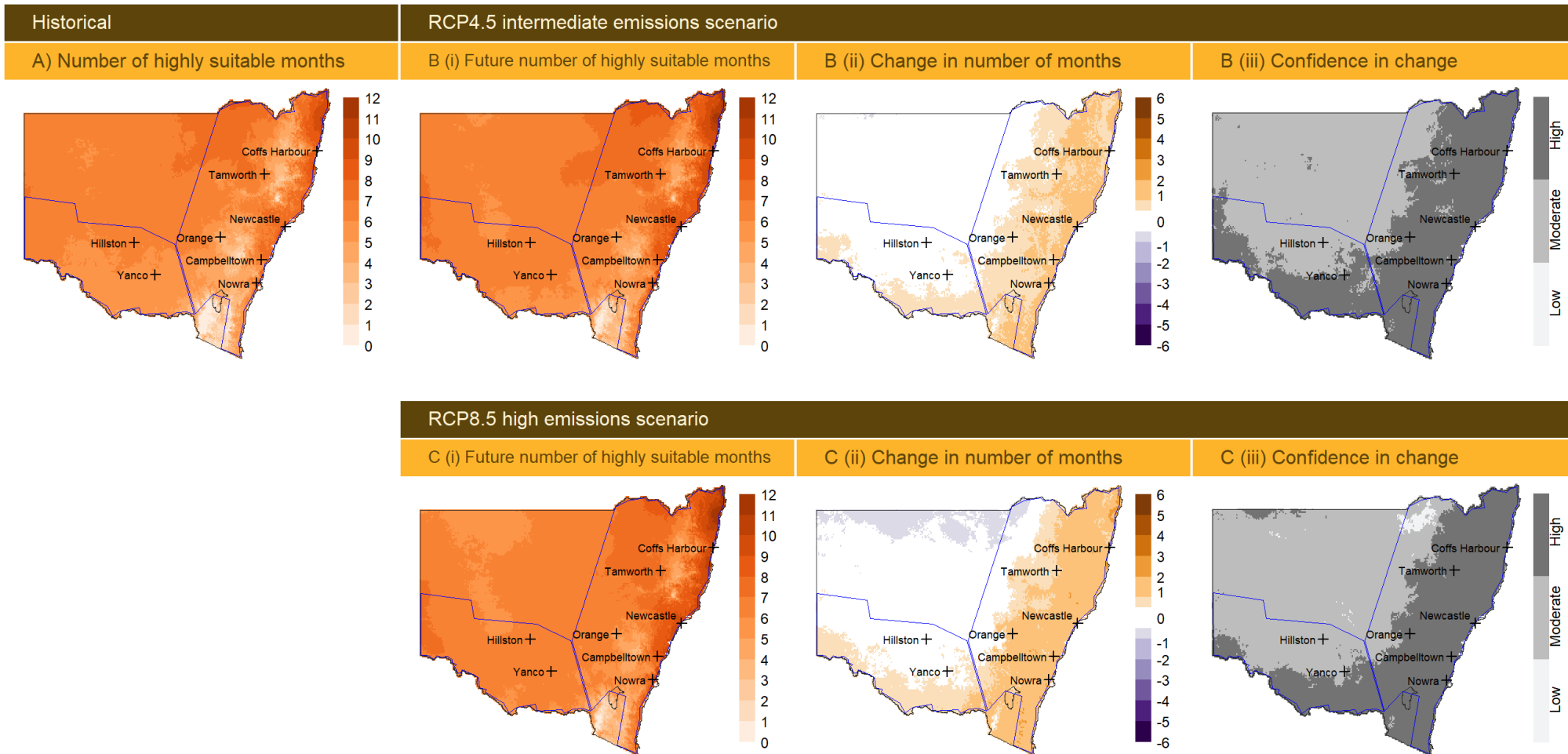


Figure A2. Number of Highly Suitable Months for Queensland fruit fly larval stage.

The number of highly suitable months measures the months in which climate suitability is greater than or equal to 0.6. The panel is comprised of 7 maps: A) shows the historic number of highly suitable months; B) and C) show the future number of highly suitable months for the intermediate and high emissions scenarios, respectively; i) shows future number of highly suitable months, ii) shows the projected change in number of months as negligible (white), increasing (orange) or decreasing (purple) change and iii) shows the level of confidence in this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

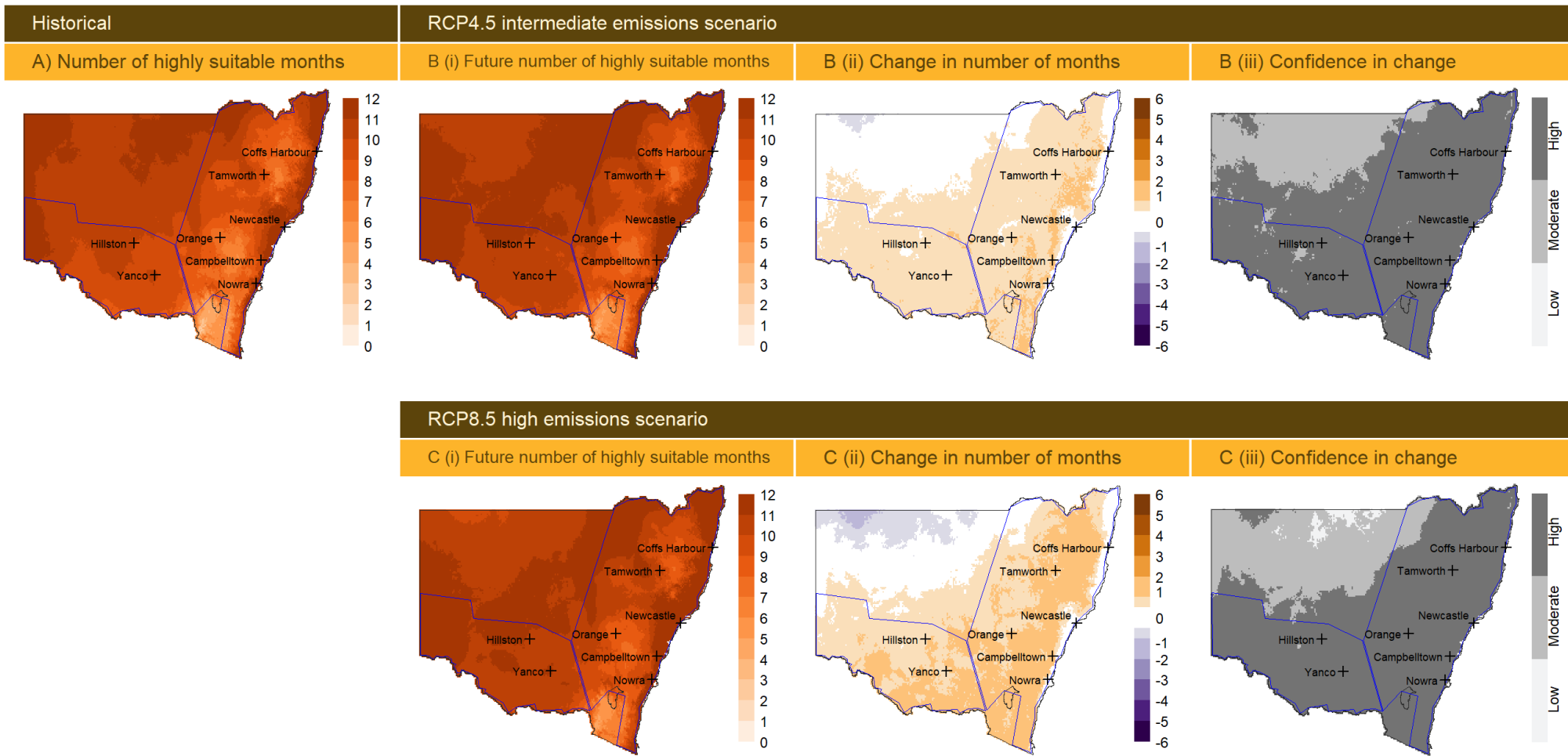


Figure A3. Number of Highly Suitable Months for Queensland fruit fly pupal stage.

The number of highly suitable months measures the months in which climate suitability is greater than or equal to 0.6. The panel is comprised of 7 maps: A) shows the historic number of highly suitable months; B) and C) show the future number of highly suitable months for the intermediate and high emissions scenarios, respectively; i) shows future number of highly suitable months, ii) shows the projected change in number of months as negligible (white), increasing (orange) or decreasing (purple) change and iii) shows the level of confidence in this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

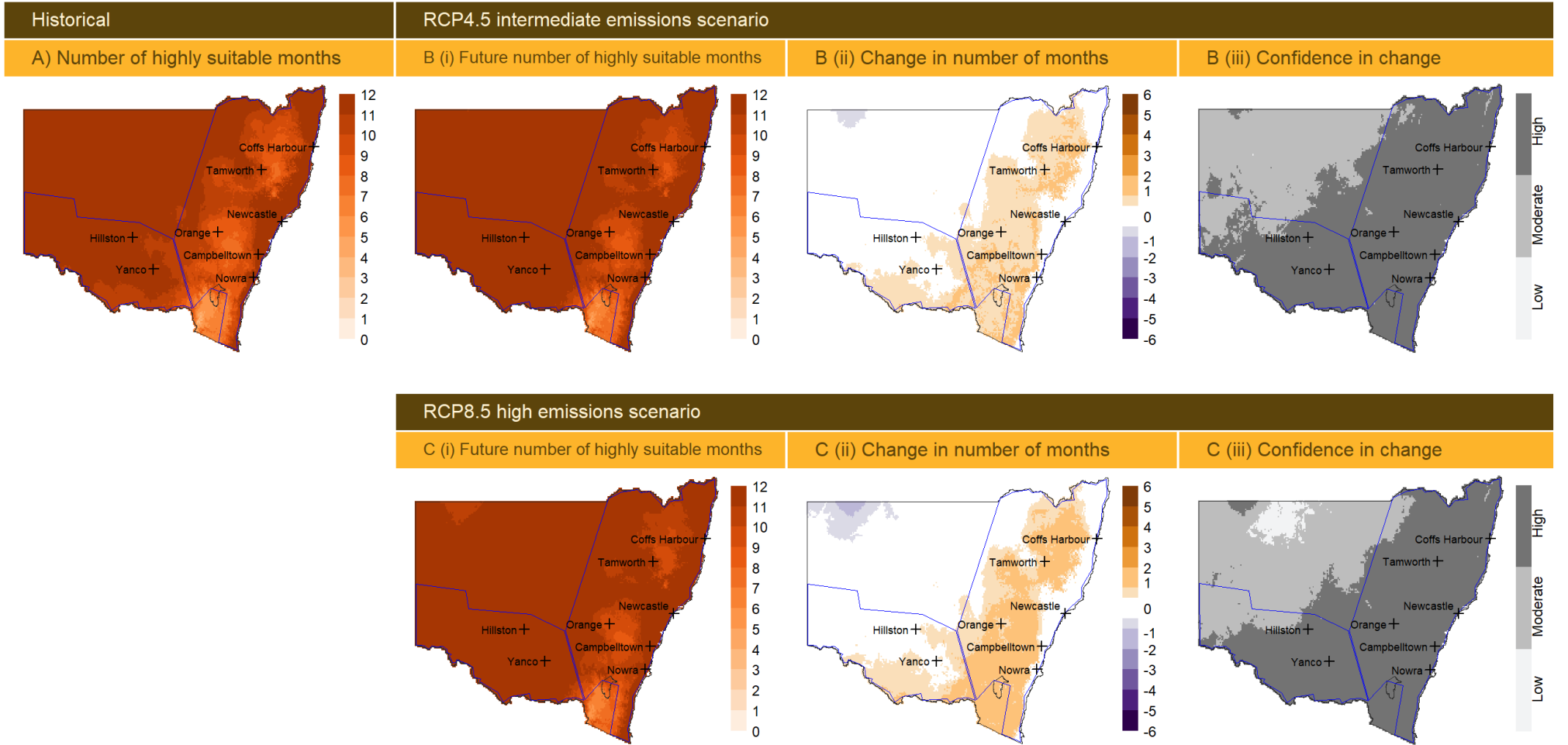


Figure A4. Number of Highly Suitable Months for Queensland fruit fly adult stage.

The number of highly suitable months measures the months in which climate suitability is greater than or equal to 0.6. The panel is comprised of 7 maps: A) shows the historic number of highly suitable months; B) and C) show the future number of highly suitable months for the intermediate and high emissions scenarios, respectively; i) shows future number of highly suitable months, ii) shows the projected change in number of months as negligible (white), increasing (orange) or decreasing (purple) change and iii) shows the level of confidence in this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

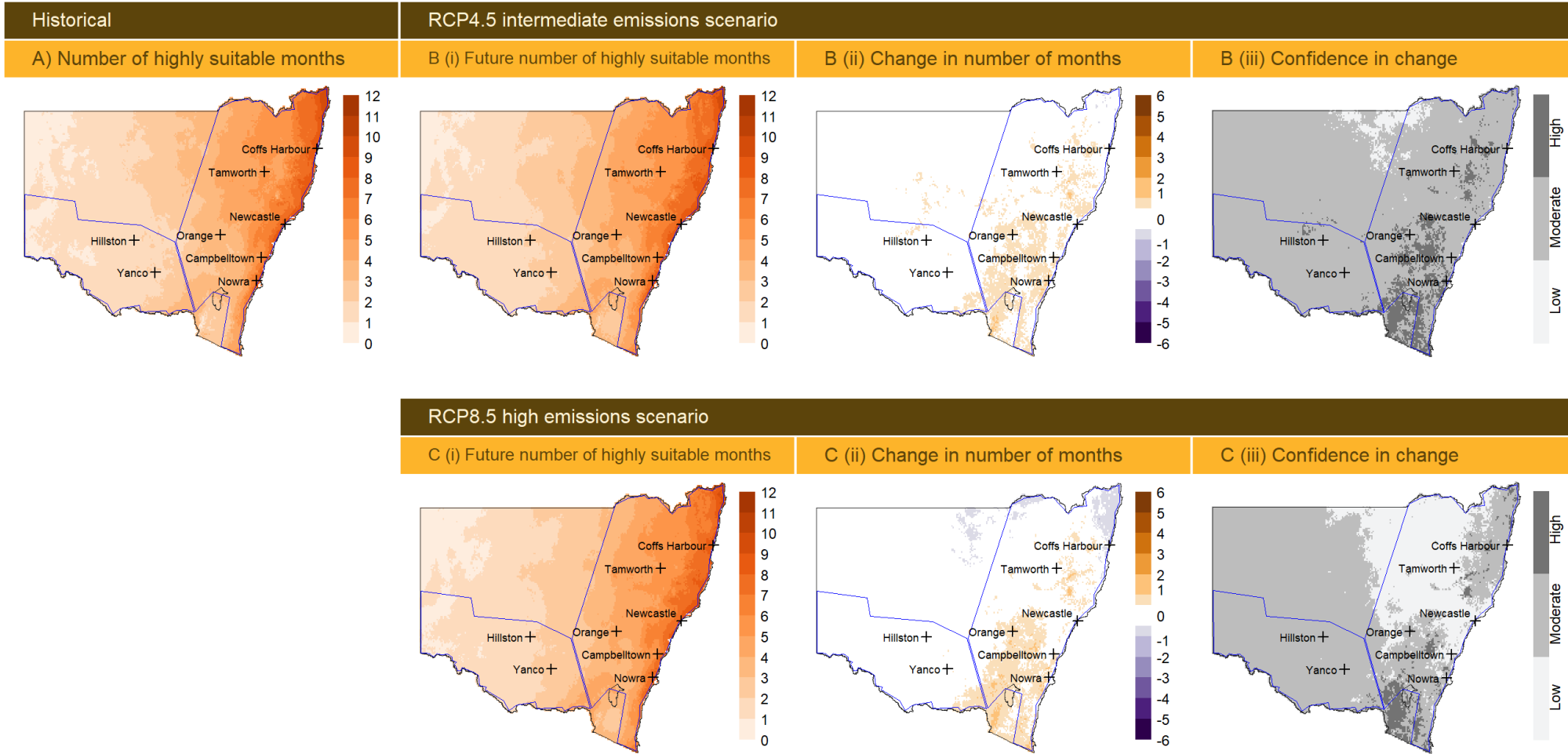


Figure A5. January climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

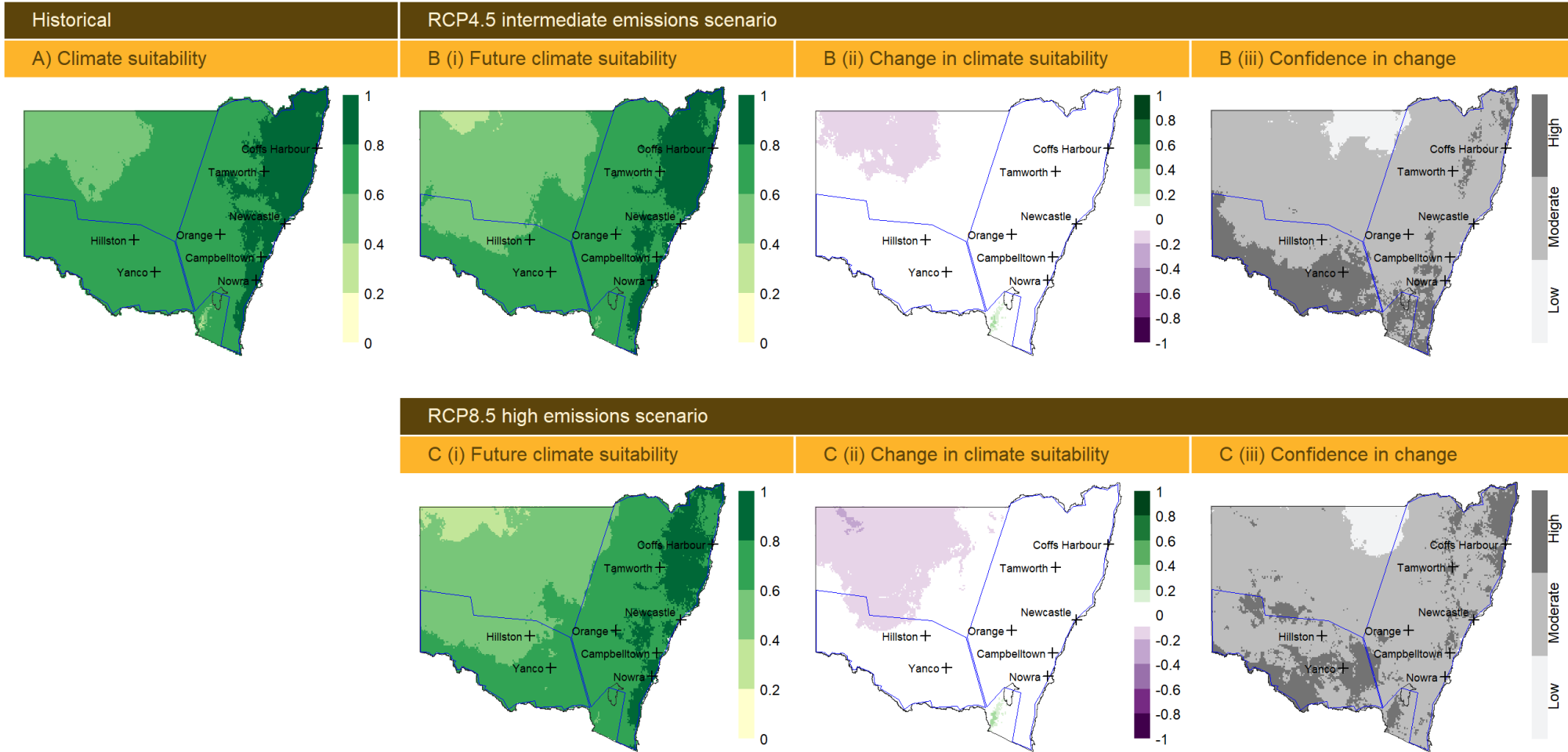


Figure A6. February climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

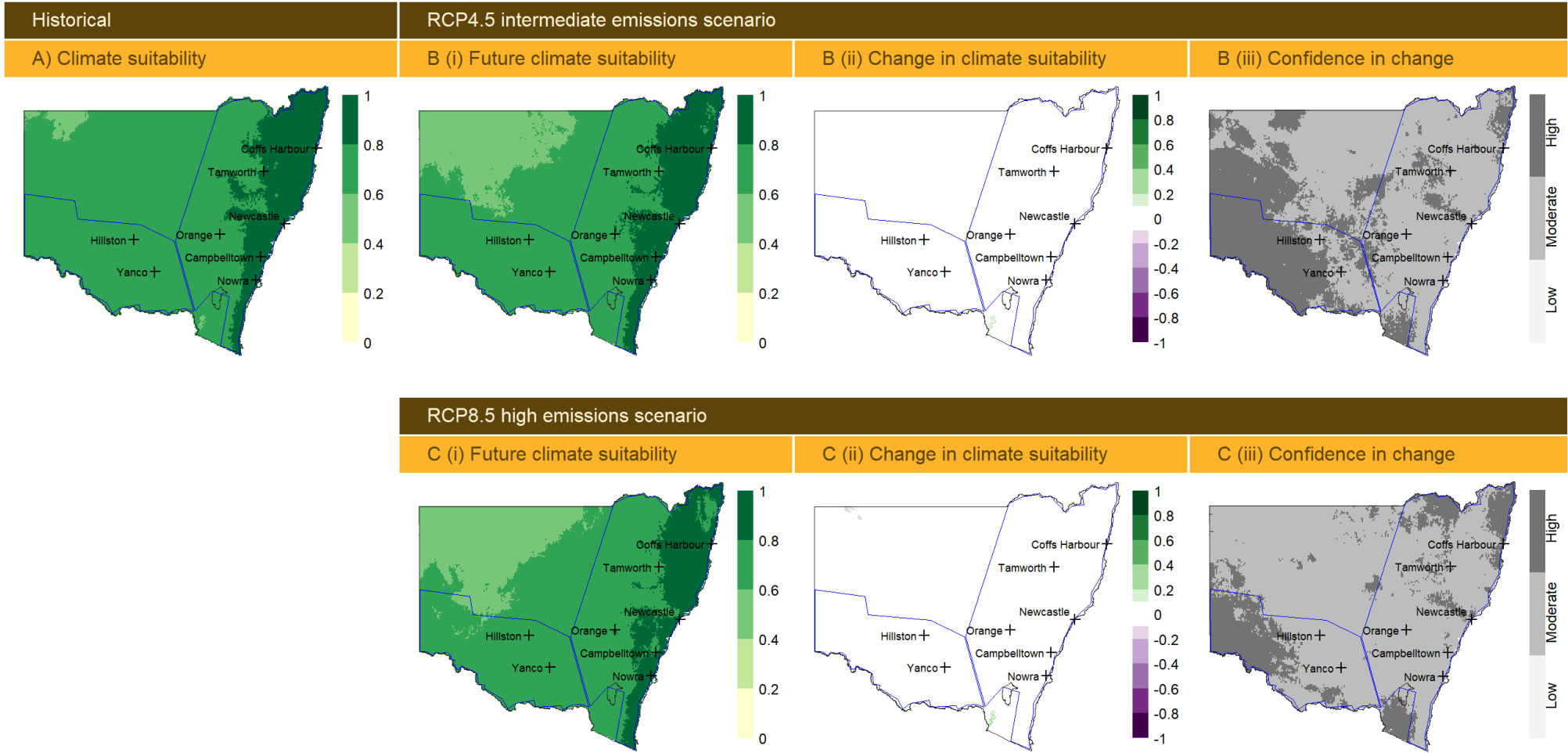


Figure A7. March climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

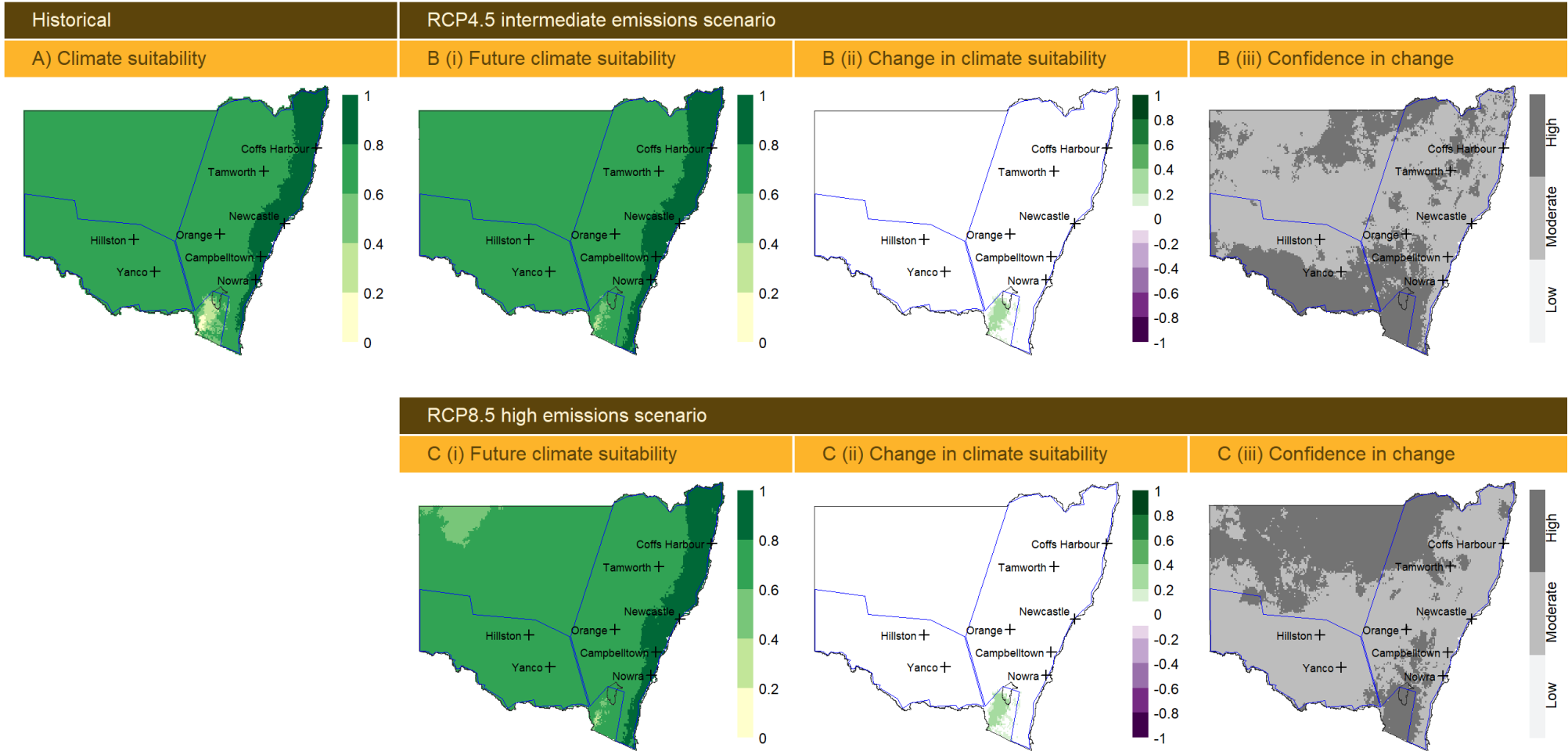


Figure A8. April climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

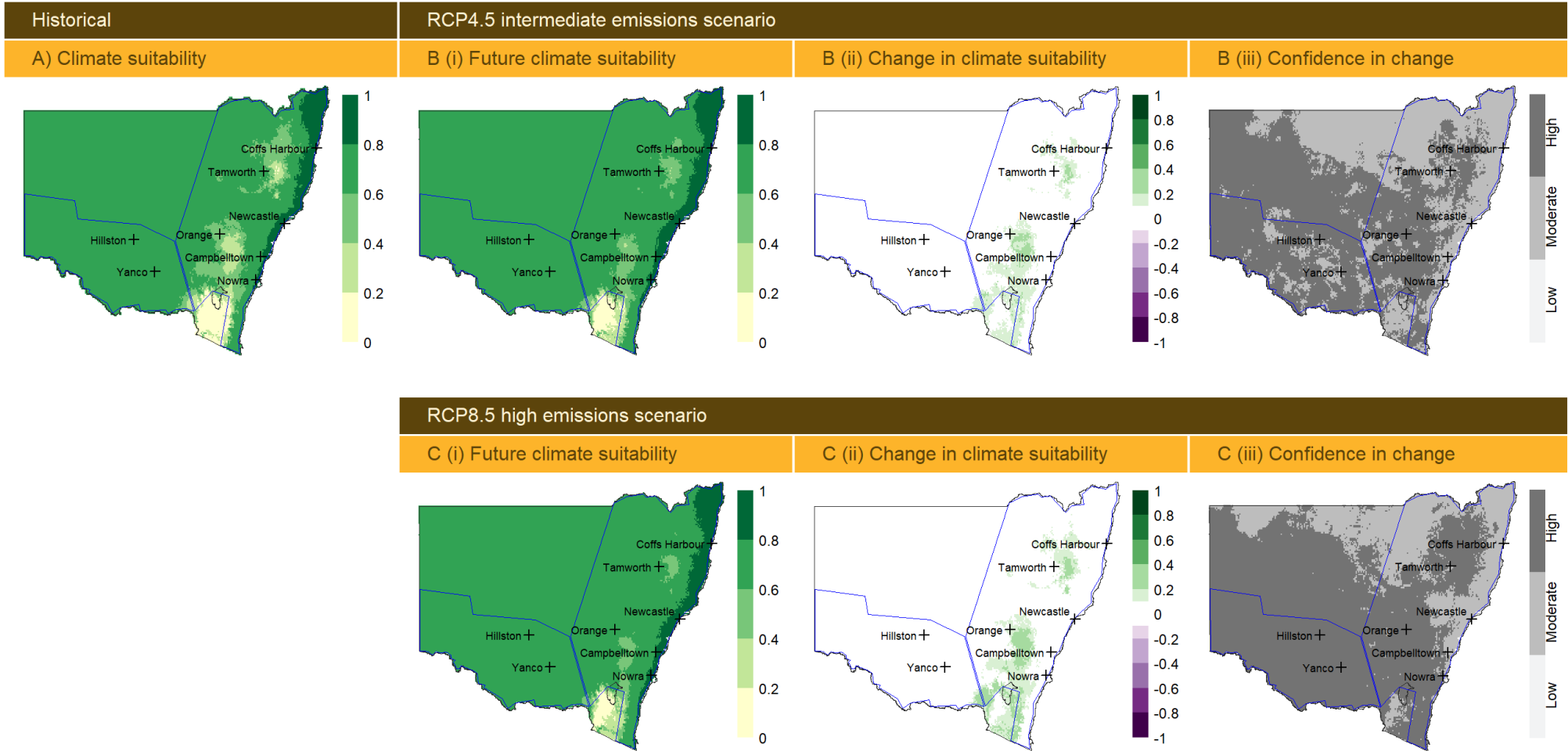


Figure A9. May climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

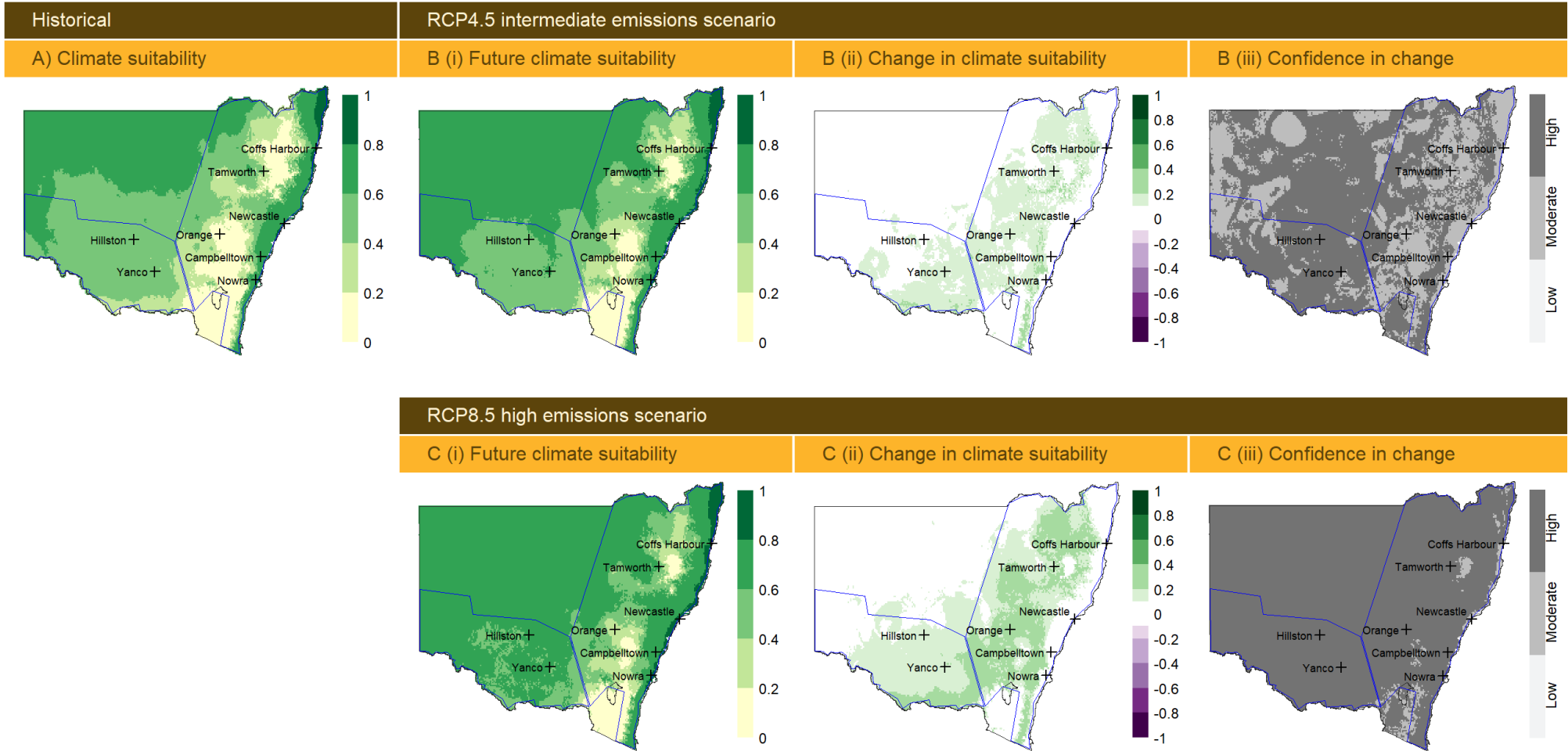


Figure A10. June climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

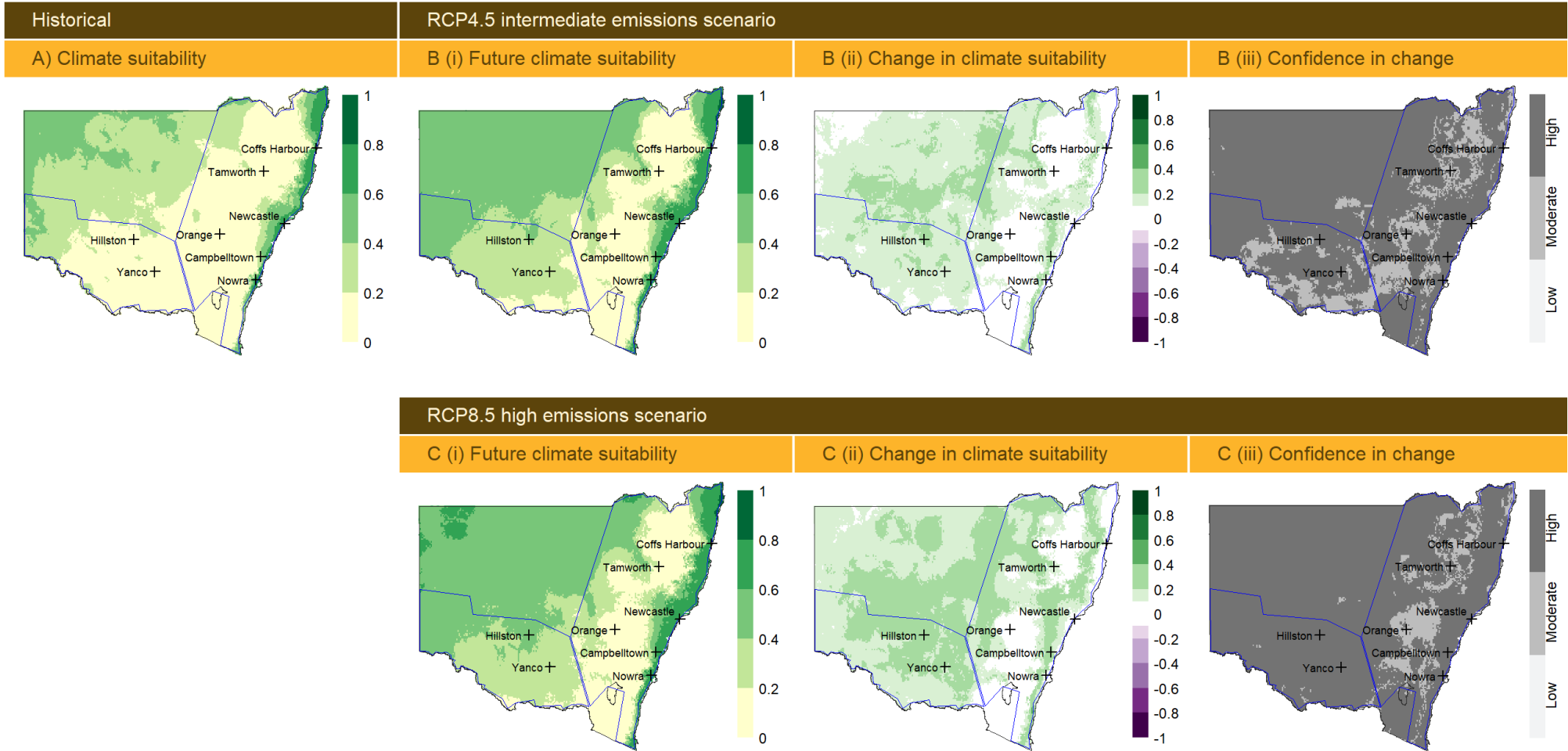


Figure A11. July climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

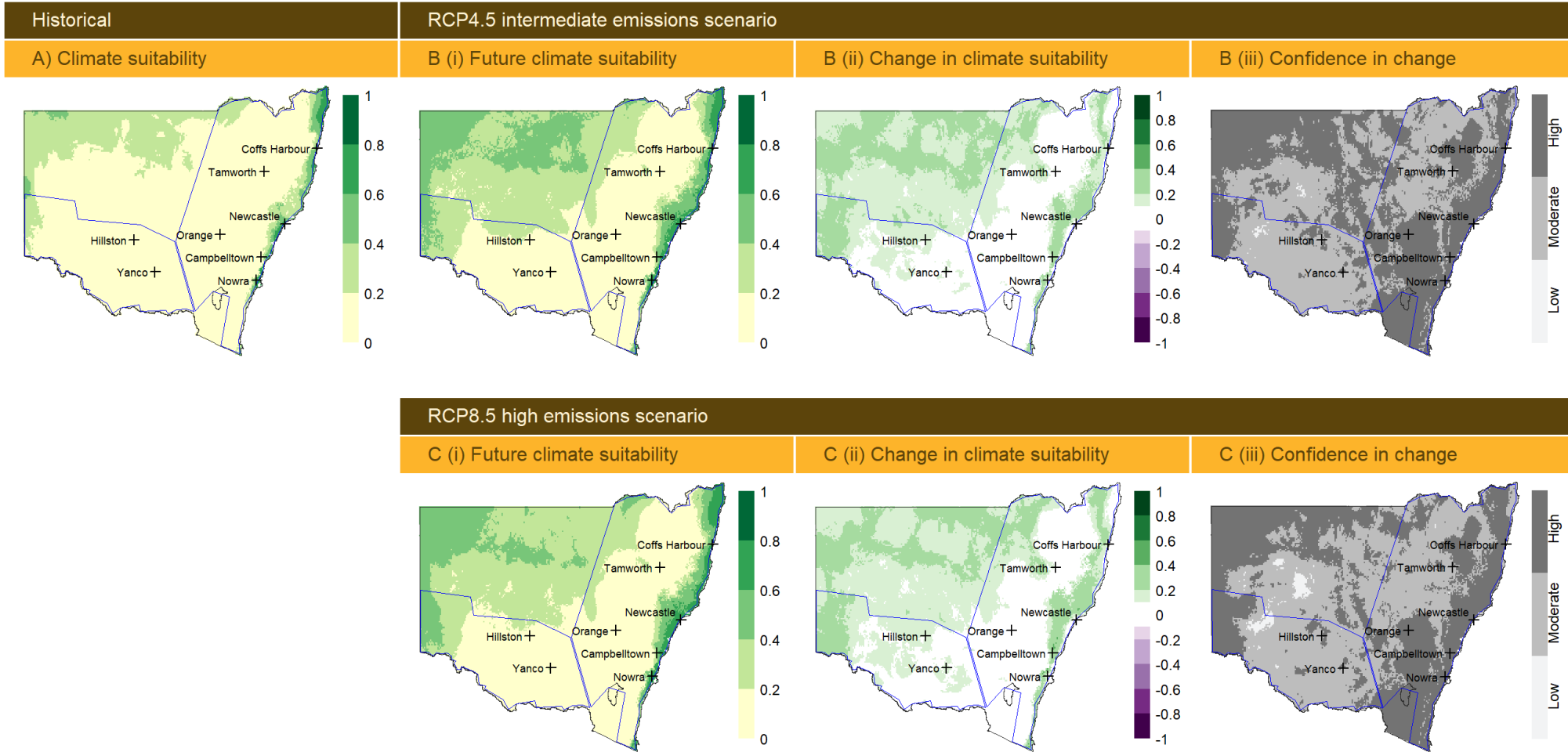


Figure A12. August climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

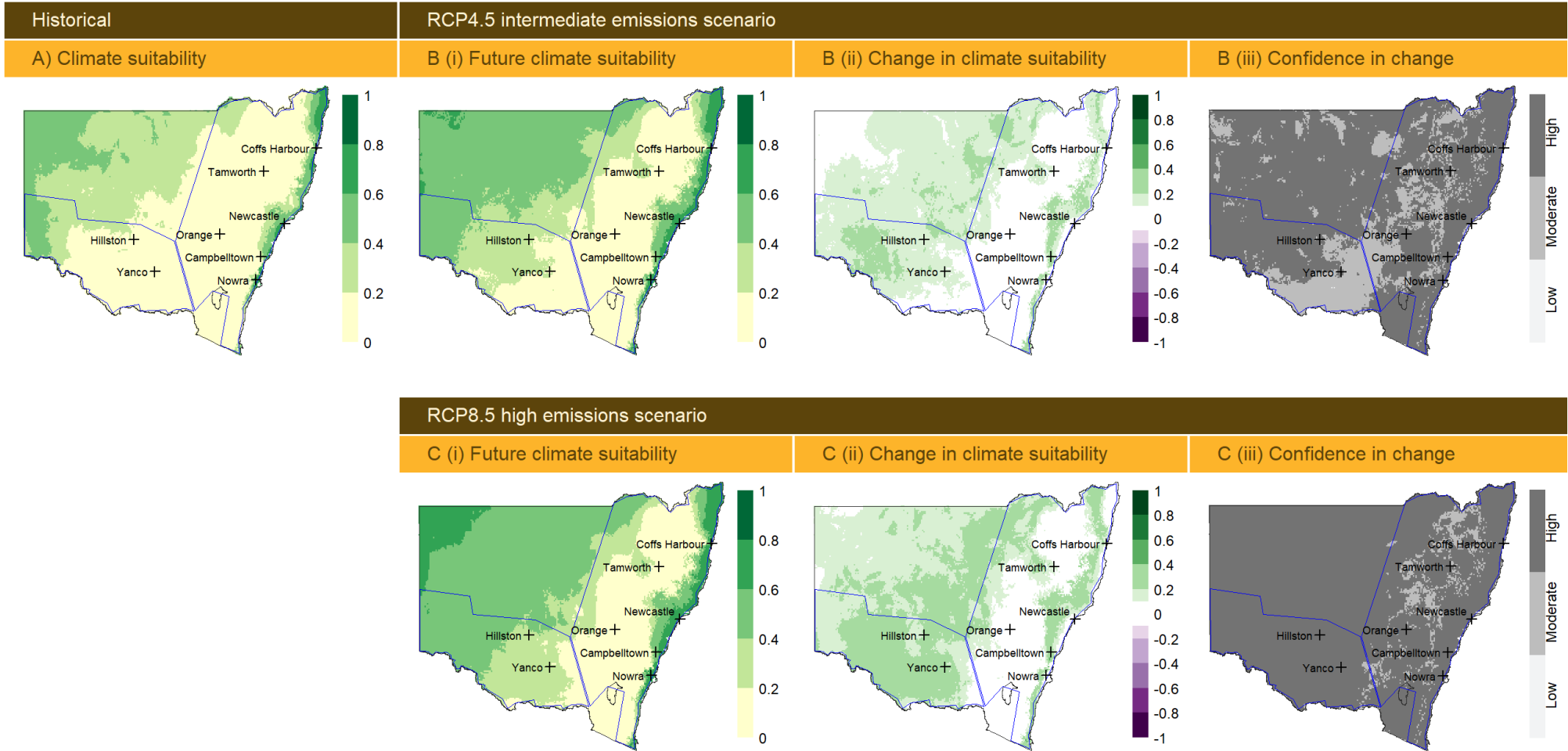


Figure A13. September climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

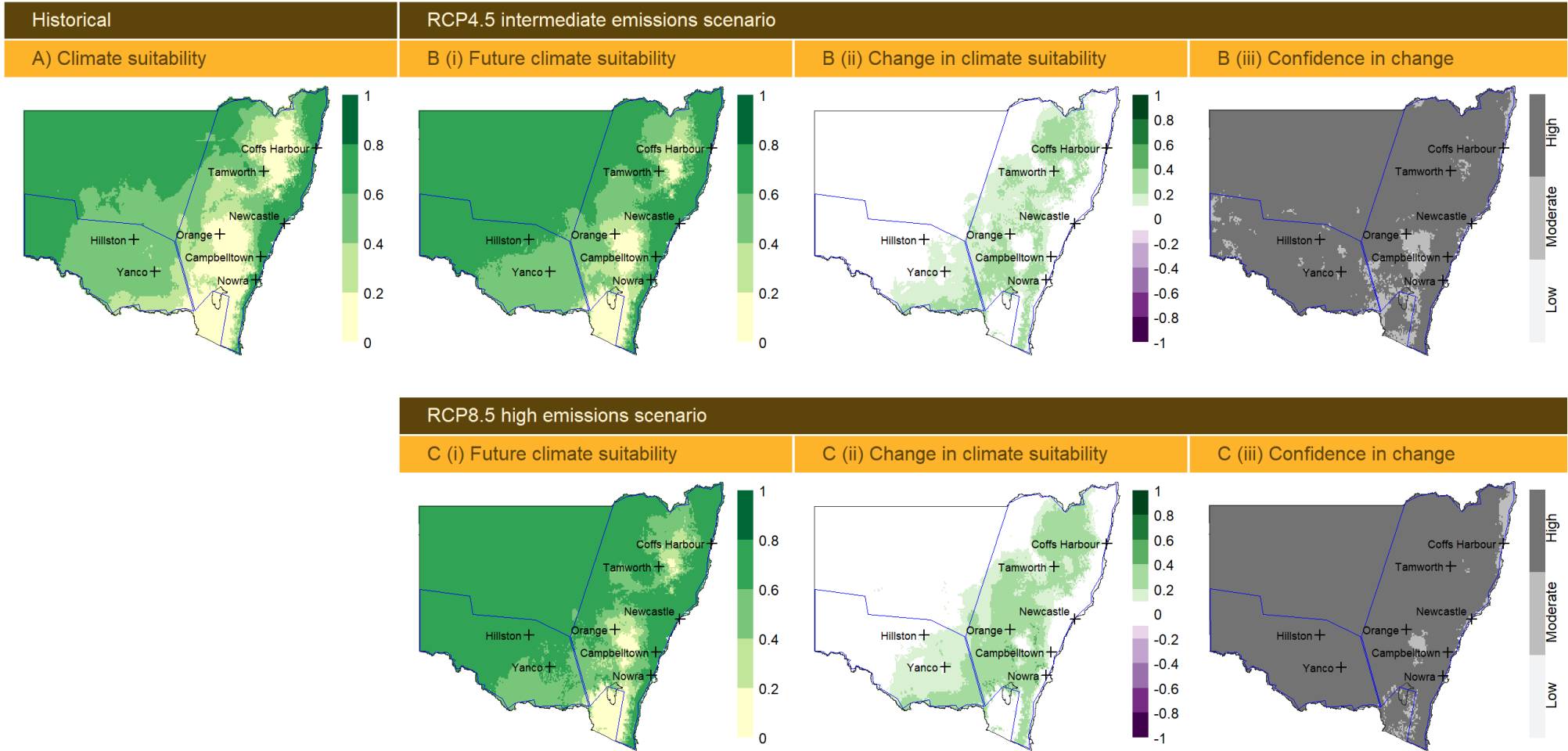


Figure A14. October climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

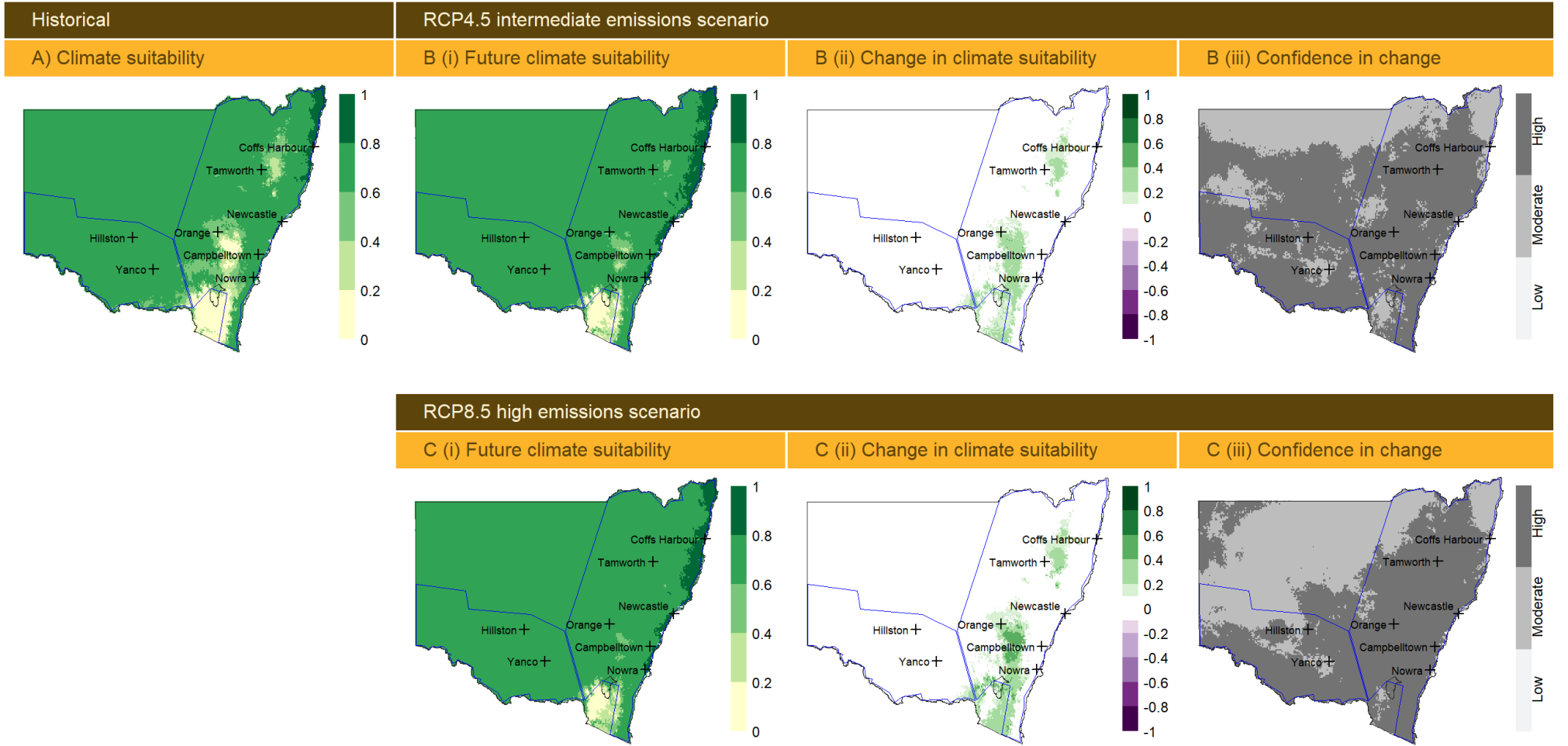


Figure A15. November climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.

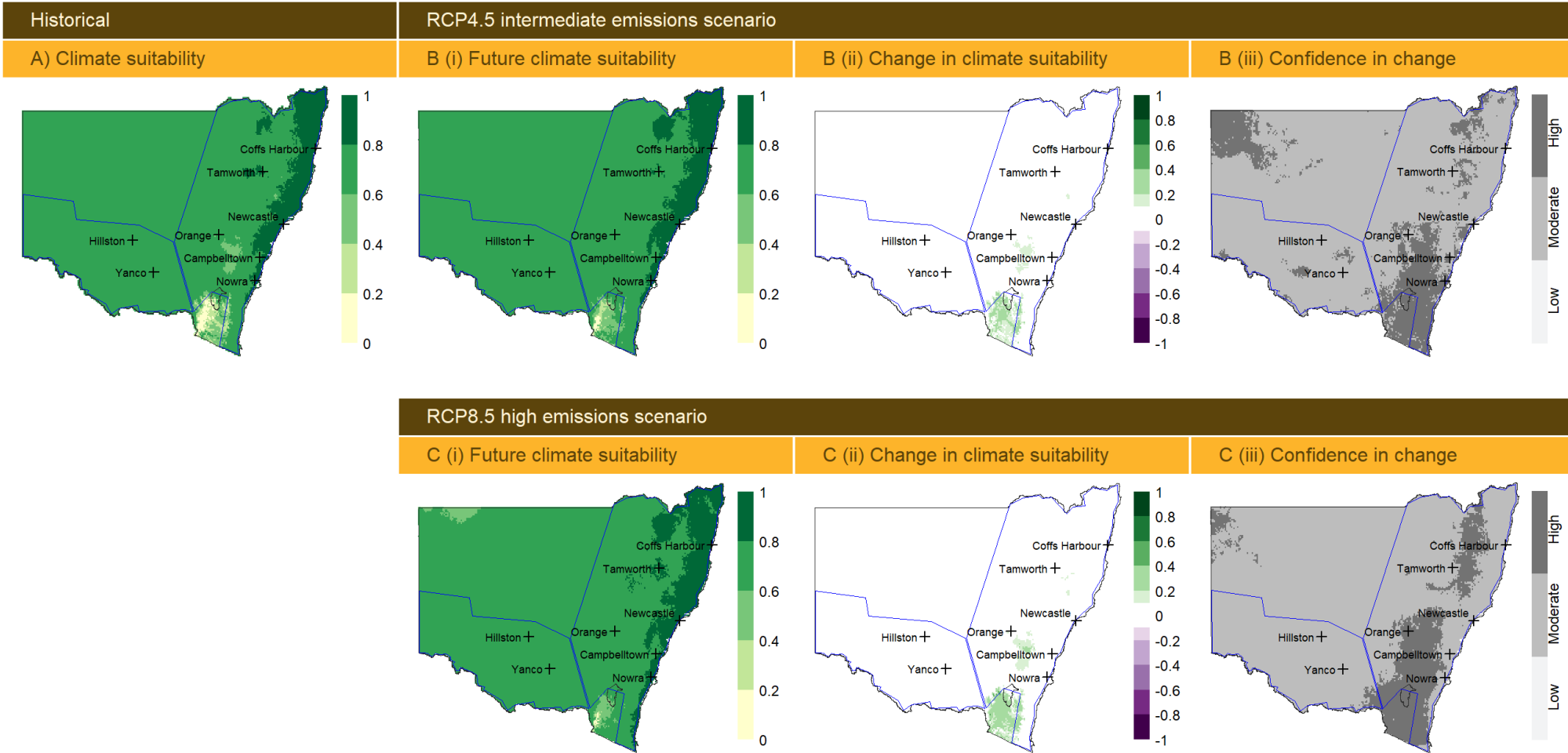
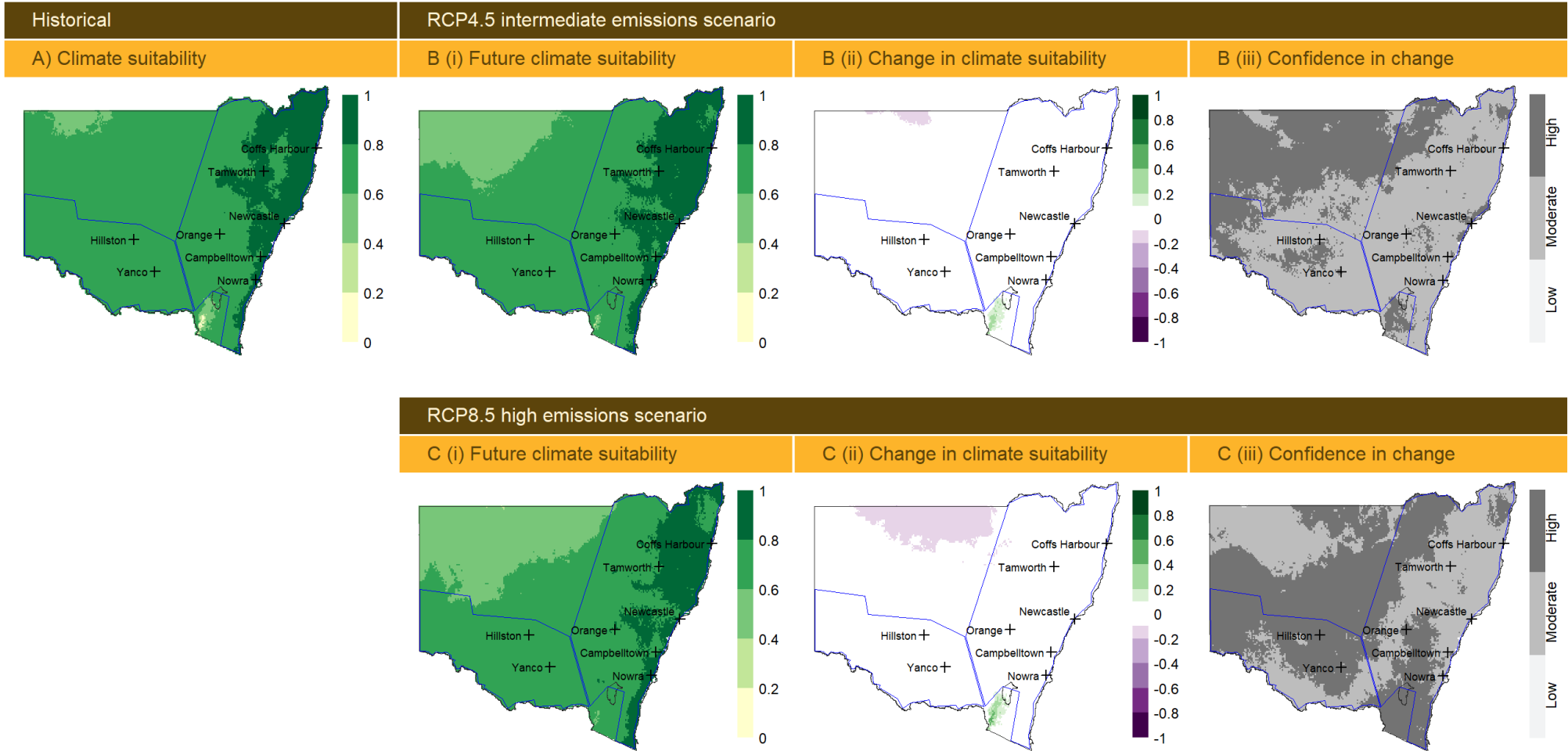


Figure A16. December climate suitability for Queensland fruit fly.

The panel is comprised of 7 maps: A) shows the historic climate suitability; B) and C) shows future climate suitability for the intermediate and high emissions scenarios, respectively; i) shows future climate suitability, ii) shows the projected future change in climate suitability as negligible (white), positive (green) or negative (purple) change, and iii) shows the level of model confidence associated with this change (low, moderate or high). Sites of importance in Queensland fruit fly monitoring are marked by black crosses, and the blue polygons show the eastern and southwestern Queensland fruit fly regions.



Primary Industries Climate Change Research Strategy

Climate Vulnerability Assessment

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