Climate Change Adaptation Research Grants Program
- Freshwater Biodiversity Projects

Project title:
Impacts of elevated temperature and CO_2 on the critical processes underpinning resilience of aquatic ecosystems.

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Objectives:
This project will determine the impacts of changes in climate on the critical processes that underpin aquatic biodiversity and ecosystem function.

A. Using realistic temperature, CO_2 and sunlight treatments we will determine the vulnerability and adaptive capacity of critical aquatic processes to 2050 climate conditions.
B. Using existing field data in combination with the experimental results we will assess the potential for adaptive management of riparian vegetation to mitigate against the effects of changing climate.

Project design and methods
Our approach is to couple detailed laboratory based experiments with field data in order to make realistic predictions about the effects of climate change, and the potential for riparian plantings as an adaptive management tool to mitigate against those effects. We will use highly controlled experimental stream flumes with highly realistic temperature, solar irradiance and CO_2 treatments and assess the impacts on a range of critical aquatic processes. These processes will be algal productivity and biomass, rates of respiration, rates of nutrient cycling, invertebrate productivity, biomass and species composition, and food web structure.

The research consists of three major phases

PHASE ONE:	Generation of realistic climate treatments from existing data
PHASE TWO:	Experimentally manipulating conditions in stream flumes in order to assess effects on critical aquatic processes.
PHASE THREE:	Integration of results from Phase Two with information on thermal mitigation using riparian plantings.
PHASE FOUR:	Interpretation, reporting and outreach. Critically assessing the potential for riparian plantings to mitigate against the effects of warming on critical aquatic processes.

This project will determine the impacts of changes in climate on the critical processes that underpin aquatic biodiversity and ecosystem function.

PHASE ONE:
Objective 1A. Using realistic temperature, CO_2 and sunlight treatments we will determine the vulnerability and adaptive capacity of critical aquatic processes to 2050 climate conditions.

The majority of experimental studies of the effects of climate change have relied on very simple treatments of either warming to a stable temperature (therefore removing natural variability) or warming imposed on ambient conditions (thereby creating a set increase in temperature across all conditions, i.e. minimum temperatures are increased and maximum temperatures are increased. Actual changes in climate are likely to be different to either of these scenarios - climate change models in south-eastern Australia predict increases in maximum temperatures and in the length of hot spells, and much small changes in minimum temperatures. In addition there will be changes in solar irradiance and increases in atmospheric CO_2. The effects of these variables have not been considered in experiments seeking to understand the effects of climate change on freshwater ecosystems. We will utilise previously run simulations undertaken as part of the "climate change demonstrator for the ecoinformatics platform" with the Victorian State Government Department of Primary Industries to generate predicted daily temperatures , patterns of solar irradiance and atmospheric CO_2 for predicted median summer conditions in southern Victoria in 2012 (control) and 2050. That data will be used here to generate an experimental treatment for this study. This data will be of lower

temporal resolution than originally planned, but the data already exists and will allow the experimental portion of the project to begin in mid October. These predictions include air temperature and solar irradiance at hourly intervals and are much more realistic than climate change treatments used in previous studies. The weather predictions will include predicted increases in maximum temperatures as well as increased average temperatures, will have realistic variability, and incorporate real phenomena such as precedence effects (e.g. a >40 degree day is more likely if the previous day was >40 degrees). Predicted atmospheric CO_2 concentrations for the same interval will be converted to dissolved levels and applied with the temperature and light treatments.

PHASE TWO:

Objective 1A. Using realistic temperature, CO_2 and sunlight treatments we will determine the vulnerability and adaptive capacity of critical aquatic processes to 2050 climate conditions.

Our approach is experimental as this is the only tractable way to address these questions. We will use four 5000L climate-controlled recirculating flumes to develop complex and realistic benthic ecosystems mimicking streams. Full-spectrum micro-processor controlled dimmable lighting means that realistic natural solar irradiance patterns can be generated. Microprocessor controlled heating allows realistic temperature treatments to be applied that include temporal variability such as day night cycles. Micro-processor controlled CO_2 injection will be used to mimic the effects of increased atmospheric CO_2. Cobble-filled colonisation trays will be placed in cobble streams in central Victoria for 2mo and then the substrate, biofilms and associated fauna will be moved to the artificial streams. These will be subjected to the 2mo climate change treatment with an appropriate control (a weather scenario representing the median of the last 50 years for Jan/Feb/Mar). The experiment will be repeated 5 times to ensure replicability/experimental power and to assess the impact of temporal differences in the initial colonisation trays. Each flume will include two trays which are isolated from one another by fine mesh, allowing a total of 30 treatment trays and 10 control trays over the length of the experiment.

PHASE THREE:

Objective 1B. Using existing field data in combination with the experimental results we will assess the potential for adaptive management of riparian vegetation to mitigate against the effects of changing climate.

We are currently undertaking work in central Victoria, determining the effects of revegetation on biodiversity, water yields and carbon accrual. One aspect of that work has included determining the effects of riparian vegetation on a range of in-stream variables including temperature.

PHASE FOUR:

Objective 1B. Using existing field data in combination with the experimental results we will assess the potential for adaptive management of riparian vegetation to mitigate against the effects of changing climate.

The research will be summarised and published in the established scientific literature in order to provide the strong peer-reviewed scientific basis for management decisions. The information gained from addressing· the hypotheses will be able to be applied to adaptation and management in the following ways:

1. The resilience of different processes to changes in climate will be assessed and will allow examination of the vulnerability of particular ecosystems. For instance, if systems based on algal productivity are vulnerable to increasing dominance of decomposition processes with flow on effects for biodiversity, open canopy streams such as alpine streams may be particularly vulnerable.
2. The potential for large changes in process rates in response to climate, and the consequences of those changes for biodiversity will be assessed. Information on these effects will form a very important and until now neglected part of risk assessment for aquatic ecosystems in response to changing climates
3. Taxa vulnerable to realistic future weather patterns will be identified and can be assessed for conservation interventions.

In addition, we will prepare a short (5-10 page) document for managers which summarises the vulnerability and adaptive capacity of critical aquatic processes and the potential for riparian plantings to mitigate against those effects. That document will be released and then an online forum will be held targeting managers and allowing them opportunity for a question-and-answer session with the researchers.