

# Reducing risk in reserve design for coastal ecosystem services under sea level rise

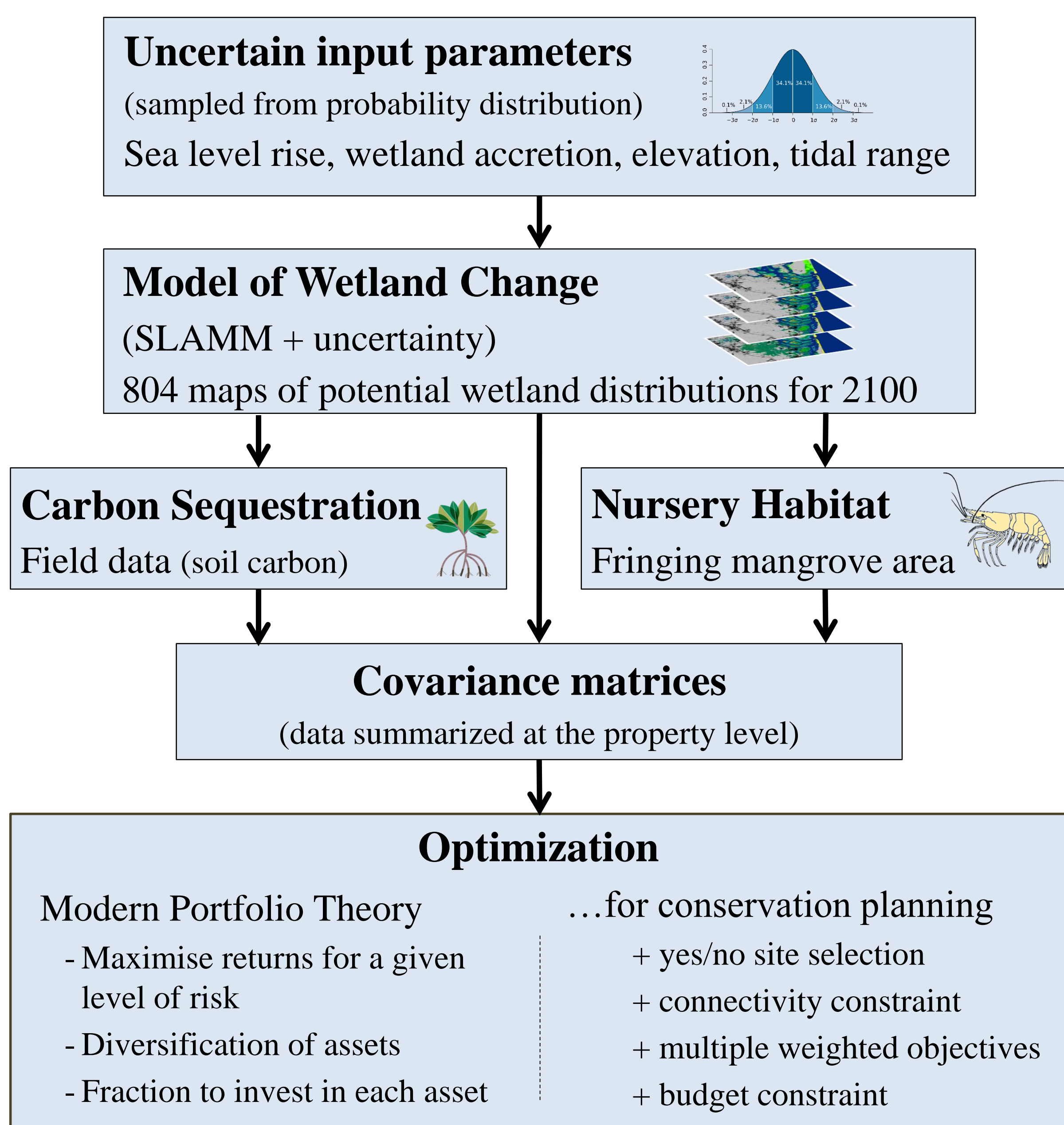
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## The problem

- Climate change impacts ecosystem services, but these changes are uncertain.
- Any long term action, such as designating protected areas, faces substantial risks.
- How can we ensure our plans are robust in the face of uncertainty?
- **Case study:** *Designing a coastal reserve system for wetlands and ecosystem services to reduce the risk posed by sea level rise.*

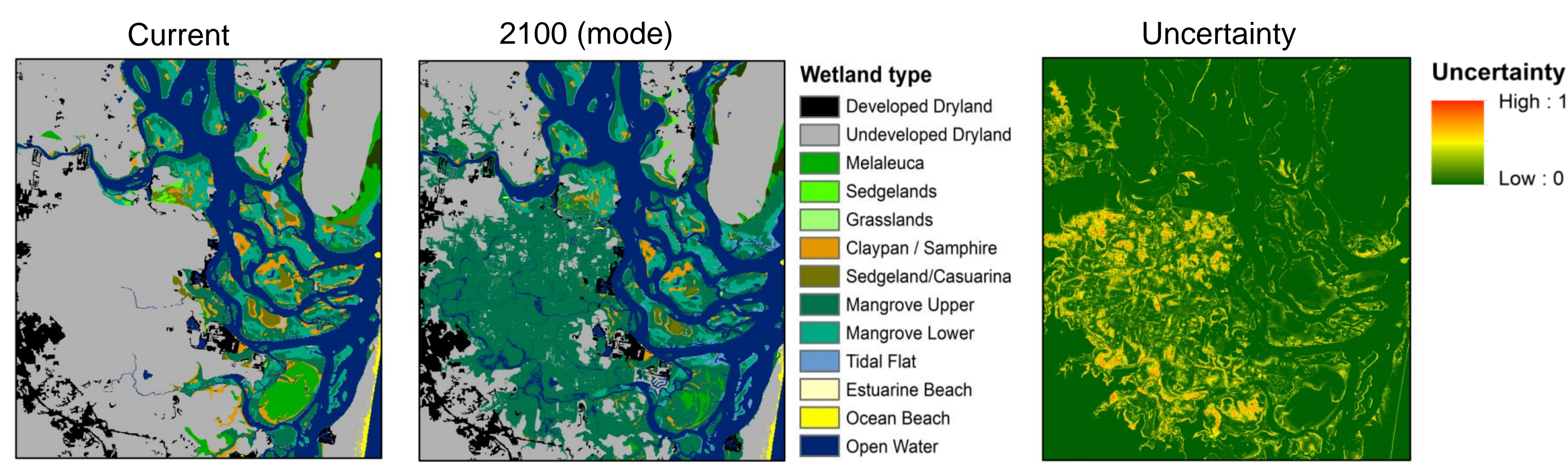
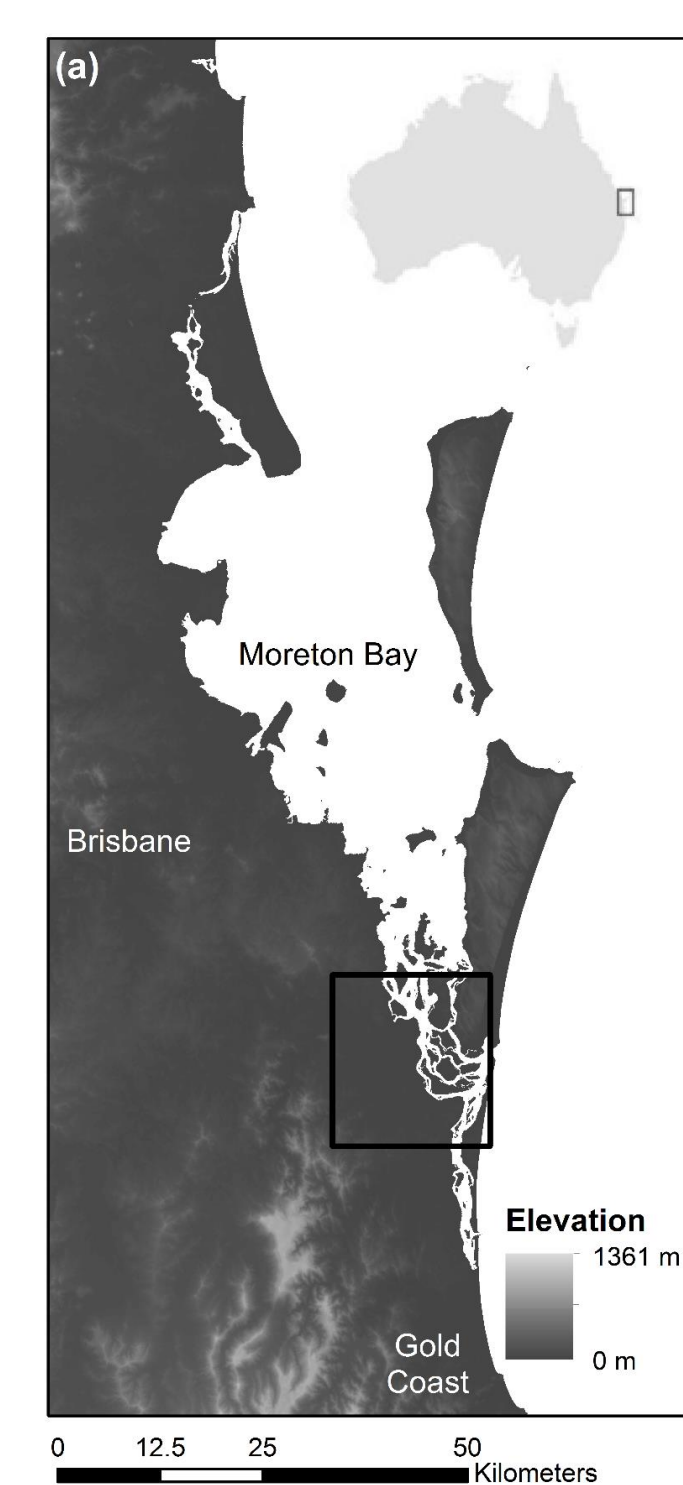


## Methods



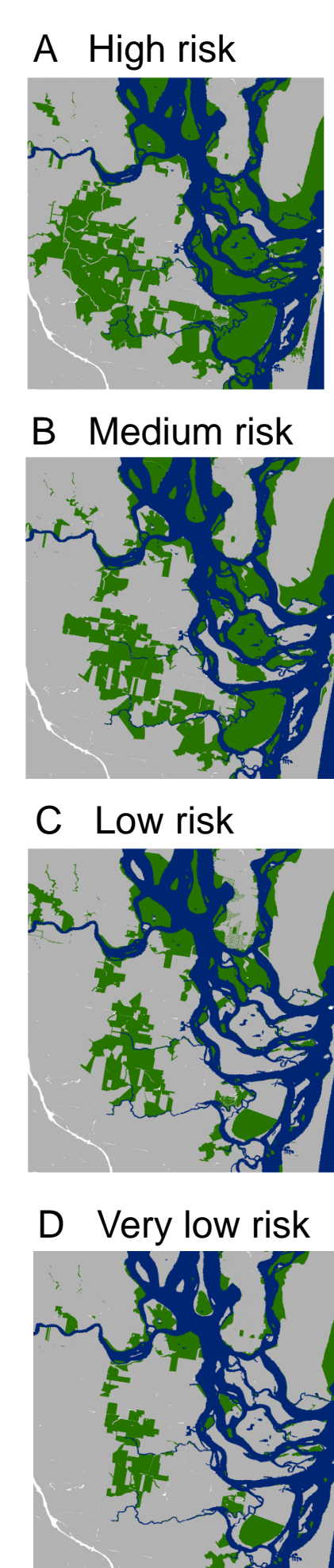
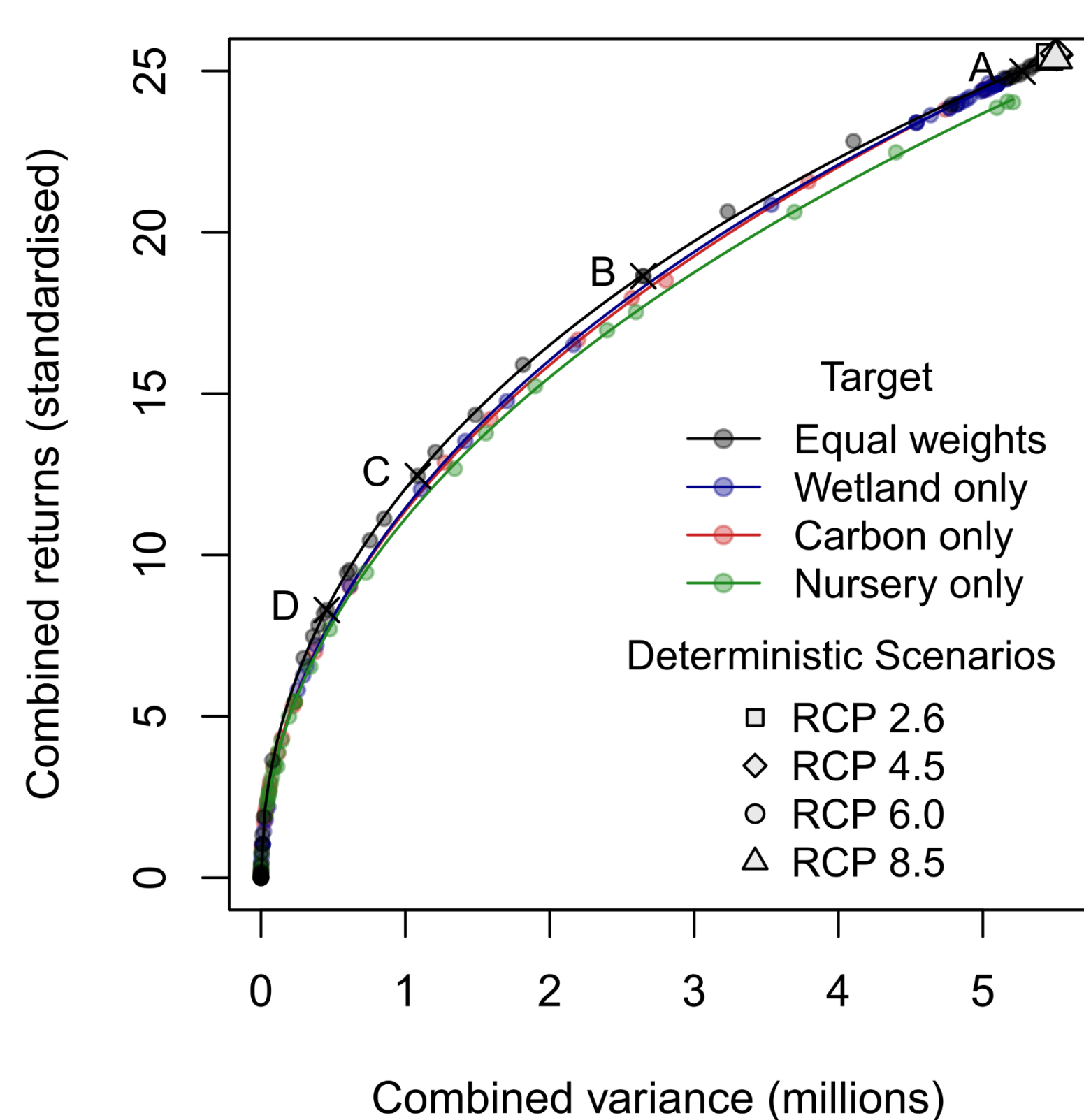
## Coastal wetland change

- Mangroves likely to move landward, encroaching on salt marsh and dryland.
- Some wetlands lost at seaward edge.
- Different parameter combinations resulted in different wetland distributions.
- Substantial uncertainty in:
  - the loss of wetlands (at lower elevations)
  - the expansion of wetlands (at higher elevations)



↑ Coastal wetland change under sea level rise for Moreton Bay, Queensland, Australia. Panel (a) shows the location of the study site. "Current" refers to the current distribution of wetlands. "2100 (mode)" shows the average (mode) wetland type projected to occur in 2100. The uncertainty in projecting each pixel to dryland, wetlands (any type), or water, is also shown.

## Risk vs Returns



- The risk of the reserve network could be reduced, but at the expense of returns (wetlands and ecosystem services protected).
- The reduction in risk is achieved by selecting a complementary set of sites that hedge against different outcomes.
- The desired reserve configuration depends on the risk preference of the decision maker.
- Targeting all objectives together is ideal, but only targeting one objective is a reasonable approach in this case.
- Reserves based on a specific rate of sea level rise were a high risk strategy (even when using the higher rate of sea level rise). These strategies do not hedge against different outcomes.

↑ Risk-return trade-off curves under different conservation targeting strategies. Each point represents a potential reserve network, and moving left along a curve indicated the solution was optimized with increasingly risk aversion. Each line represents a different targeting strategy. The results of the scenario-based approaches are also shown (top right). RCP refers to the Representative Concentration Pathways for carbon emissions from the IPCC.

## Verdict

Modern portfolio theory is a powerful but flexible framework for balancing risk and returns for any objectives characterised by uncertainty.

It can also be used to plan for other conservation actions (not just protected areas).

