Understanding the cumulative impacts of coastal development on marine ecosystems:

Land-use change scenarios and Bayesian networks

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National Environmental Research Program TROPICAL ECOSYSTEMS hub



ARC Centre of Excellence Coral Reef Studies

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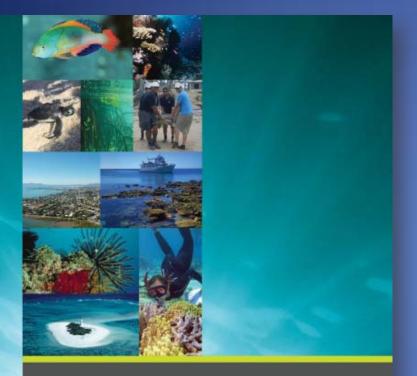
Urban Development

Agriculture

Mining, Ports and Shipping Land reclamation **Recreational boating** Commercial and recreational fishing Agricultural run-off Land clearing Dredging Shipping Anchorage



Introduction Uncertainty Scenario Spatial Bayesian Ways Forward Planning Scenarios Networks





Great Barrier Reef

Marine Park Authority

Strategic Assessment Report



"Quantitative understanding of causeand-effect relationships, both now and under a range of future scenarios, will greatly improve understanding of impacts and their cumulative effects this currently constitutes a major information gap..."

Great Barrier Reef Region Strategic Assessment Report 2014 Great Barrier Reef Marine Park Authority

Uncertainty

Scenario Planning Spatial Scenarios Bayesian Networks

Ways Forward

<u>Aim:</u> To develop a systematic process for assessing the cumulative impacts of coastal development on the marine environment to provide planners and managers with decision support for conservation planning.

Cumulative Impact Assessment

Scenario Planning Spatial Scenarios

Bayesian

Networks

Uncertainty

| Introduction | Uncertainty | Scenario Planning | Spatial Scenarios | Bayesian Networks | Ways Forward |
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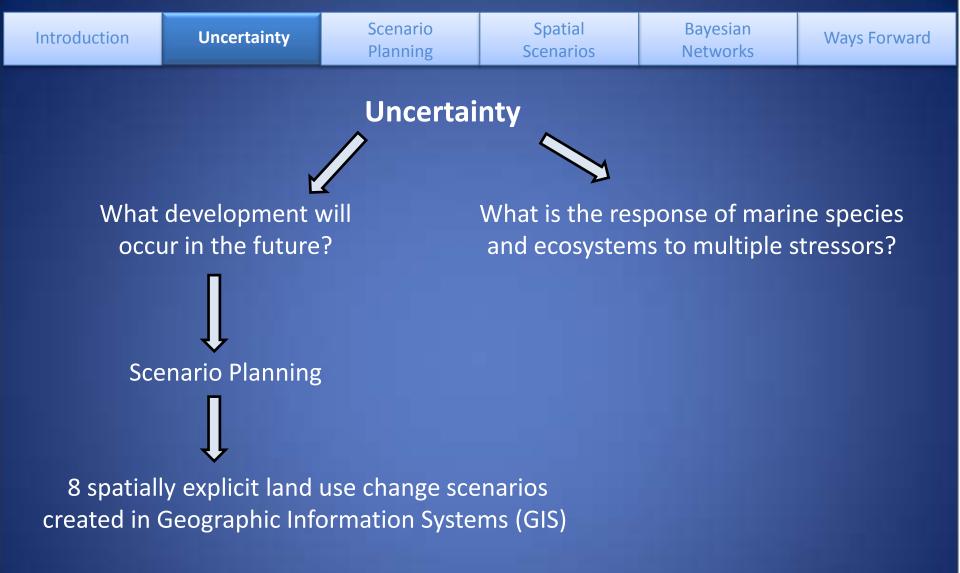


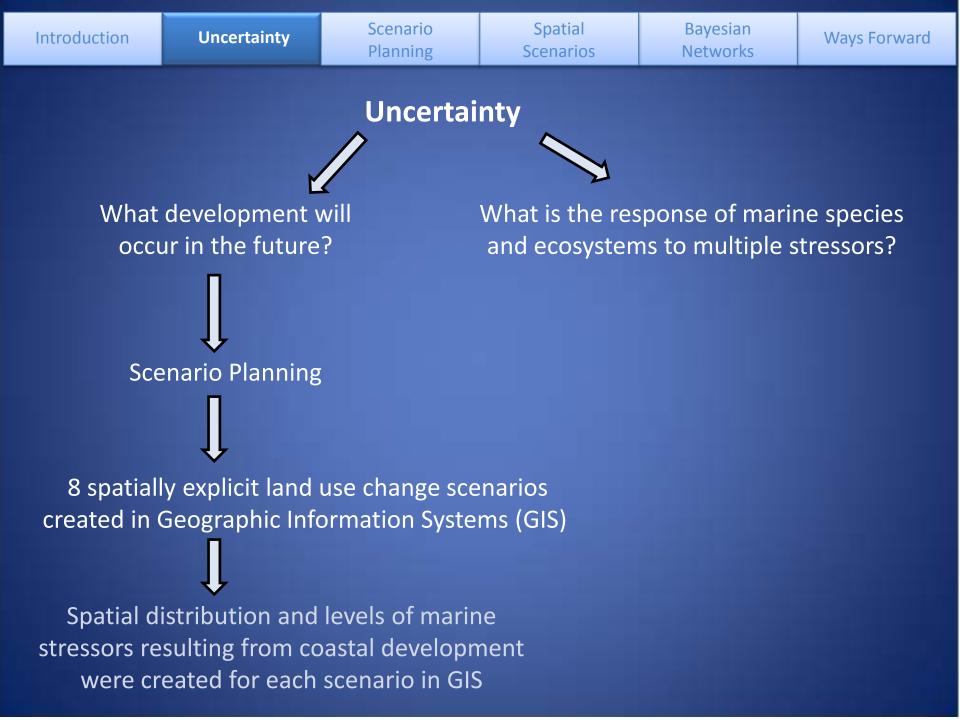
Uncertainty

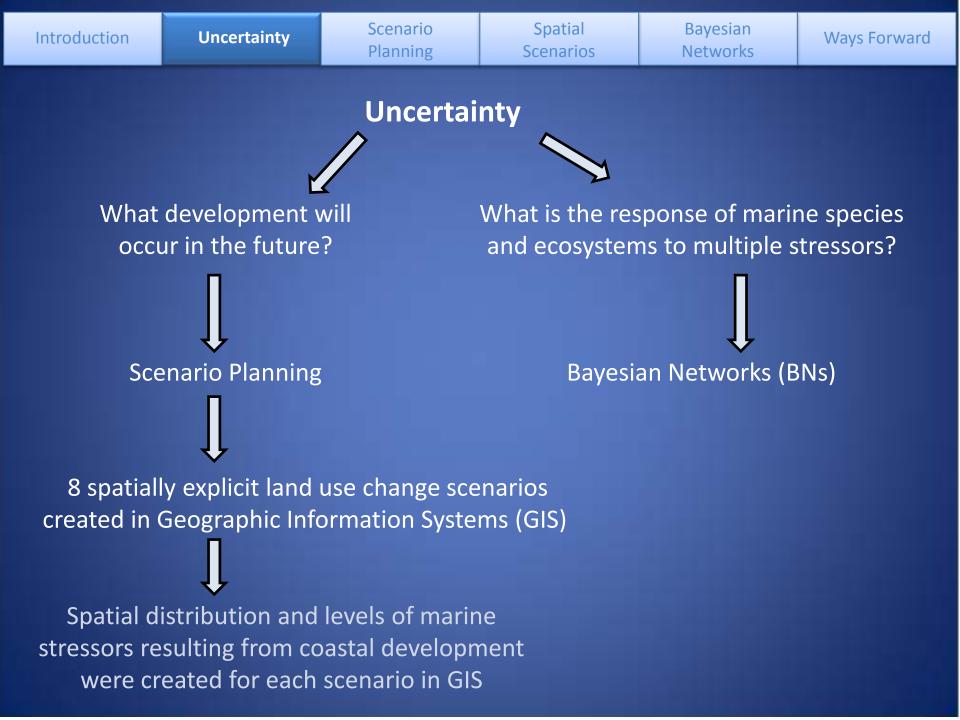
What development will occur in the future?

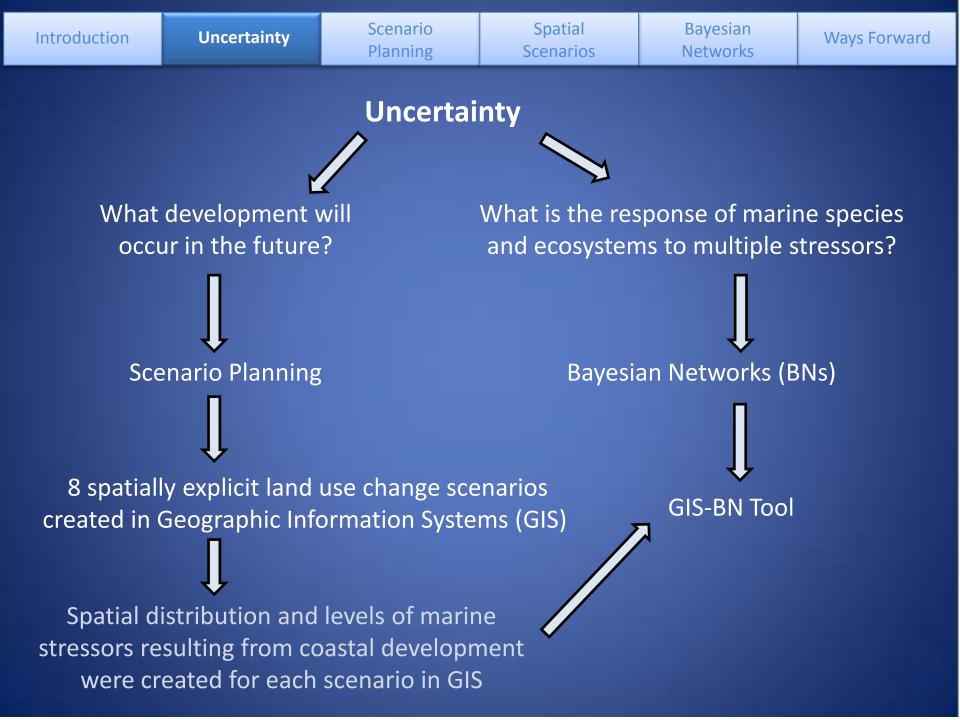
What is the response of marine species and ecosystems to multiple stressors?

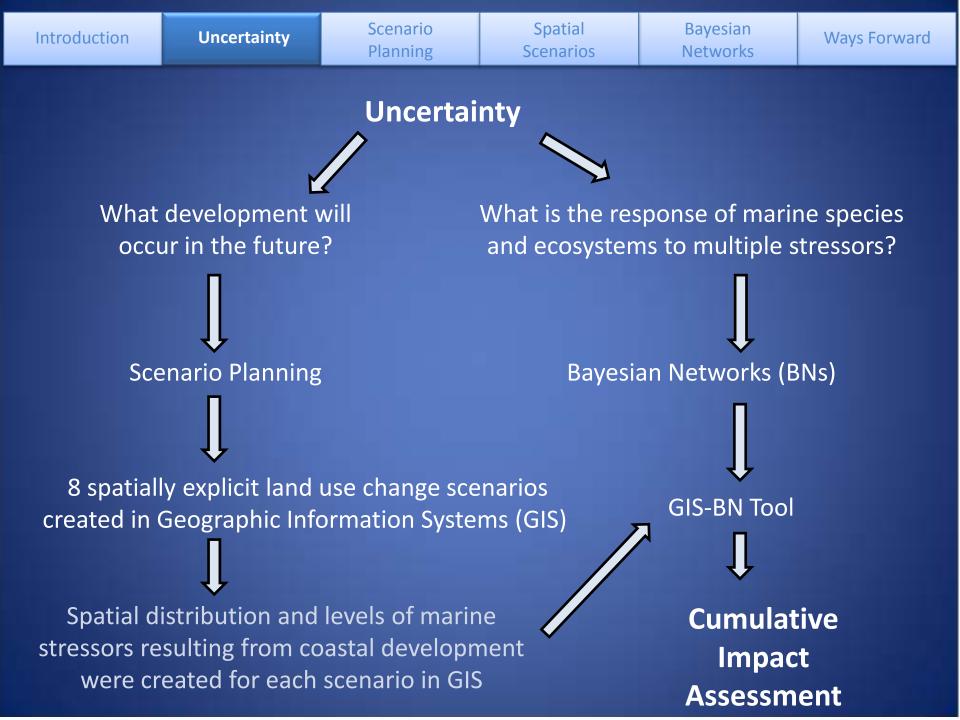














Scenario Planning

Bayesian Networks (BNs)

8 spatially explicit land use change scenarios created in Geographic Information Systems (GIS)

GIS-BN Tool

Spatial distribution and levels of marine stressors resulting from coastal development were created for each scenario in GIS Cumulative Impact Assessment Scenario Planning Spatial Scenarios

Bayesian Networks

4 Scenario Streams

- Food and Minerals
- Tourism
- Green
- Business as Usual

5 Drivers of Change

- Demand for environmental services
- Foreign demand for food and minerals
- Preference for coastal lifestyle
- Innovation and technological advances
- Foreign demand for tourism

<u>2 Types of Governance</u>

- Strong
- Weak

| SCENARIO ST | REA |
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| Legend | _ |
| FOOD AND MINERALS | •] |
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| Demand for environmental services Medium | 1 |
| ↓ Low | i |
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| demand for Foreign | |
| food and demand for minerals | |
| minerals | • 1 |
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| Innovation and | •] |
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| for coastal advances lifestyle | 1 |
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| TOURISM | |
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| demand for Foreign | •] |
| food and demand for | |
| minerals tourism | 1 |
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| minerals tourism | |
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| Preference Innovation and | |
| for coastal technological | |

technological

advances

for coastal

lifestyle

| | GOVERNANCE | SCENARIOS |
|--|------------|-------------------------|
| TREAMS | GOVERNANCE | SCENARIOS |
| Large increase in areas of agriculture (in particular sugar, horticulture), ports and infrastructure, infrastructure corridors and urban (incl. to accommodate fly-in-fly-out mine | | Export anagement |
| and family along the coast) No increase in conservation area and small increase in tourism infrastructure Better agricultural practices and urban run-off management availa | WEAK | Red tape cutting |
| | | |
| Large increase in areas for touris airports, marinas, highways, railways, tourist villages and resorts Trading ports transformed to accommodate <u>cruiseships</u>, with lo | STRONG | Tourist heaven |
| resource exports but high imports • Increase areas for horticulture wi decrease in sugar • Some coastal areas receive protection | | Way for resorts |
| Medium increase of trading ports and infrastructure and agriculture areas but only for clean products (eg organic products, clean minerals, biofuels) Medium increase in eco- tourism | STRONG | Eco- revolution |
| with demand for pristine sites to visit • People highly value coastal lifest • Large increase in protected areas improve status of existing ones | | Green washing |
| | | |
| • Amount of change is extrapolated based on the trends seen between 99-09 | STRONG | A twist on the trend |
| | WEAK | As we go |

| Introduction | Uncertainty | Scenario Planning | | Spatial Scenarios | | Bayesian Networks | | Ways Forward |
|--|-------------------|----------------------|---|--|--|--|--------|--------------------------------------|
| <u>4 Scenario Str</u>Food and M | | | FOOD AND MINE Demand for environmenta Foreign demand for food and | services Low Centre | Large 11 agricult horticul infrastru corridon | G(ncrease in areas of ure (in particular sugar, ture), ports and ucture, infrastructure rs and urban (incl. to nodate fly-in-fly-out miners | OVERNA | CE SCENARIOS Export management |
| TourismGreen | | | roce and minerals Preference for coastal lifestyle | demand for tourism Innovation and technological advances | No increased and sma infrastru Better a | ily along the coast) — ease in conservation areas all increase in tourism acture ggricultural practices and un-off management available | WEAK | Red tape cutting |
| Business as <u>5 Drivers of C</u> | | | TOURISM Demand for environmenta foreign demand for food and | _ | airports railway | ncrease in areas for tourism, , marinas, highways, s, tourist villages and | STRONG | Tourist heaven |
| | environmental sei | | Preference | S SCe | protecti | arios | WEAK | Way for resorts |

for coastal

lifestyle

Foreign

demand for

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for coastal

lifestyle

Foreign demand for

food and

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for coastal

lifestyle

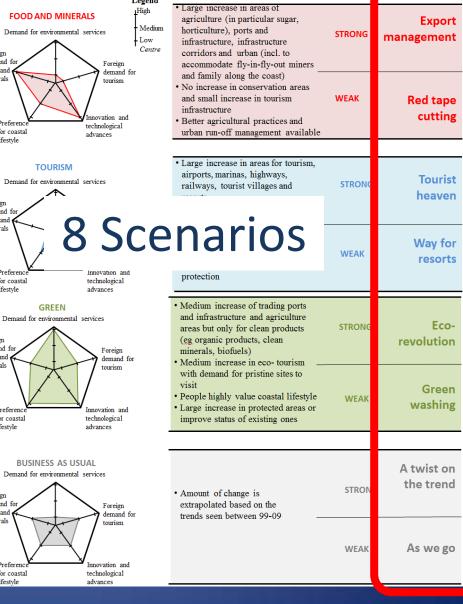
food and

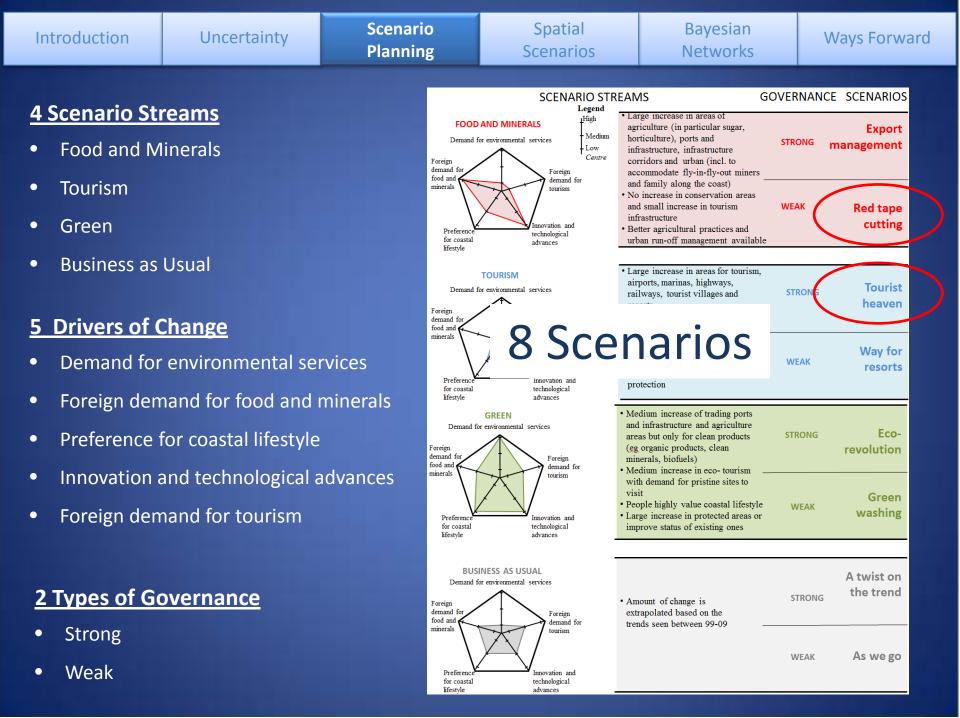
minerals

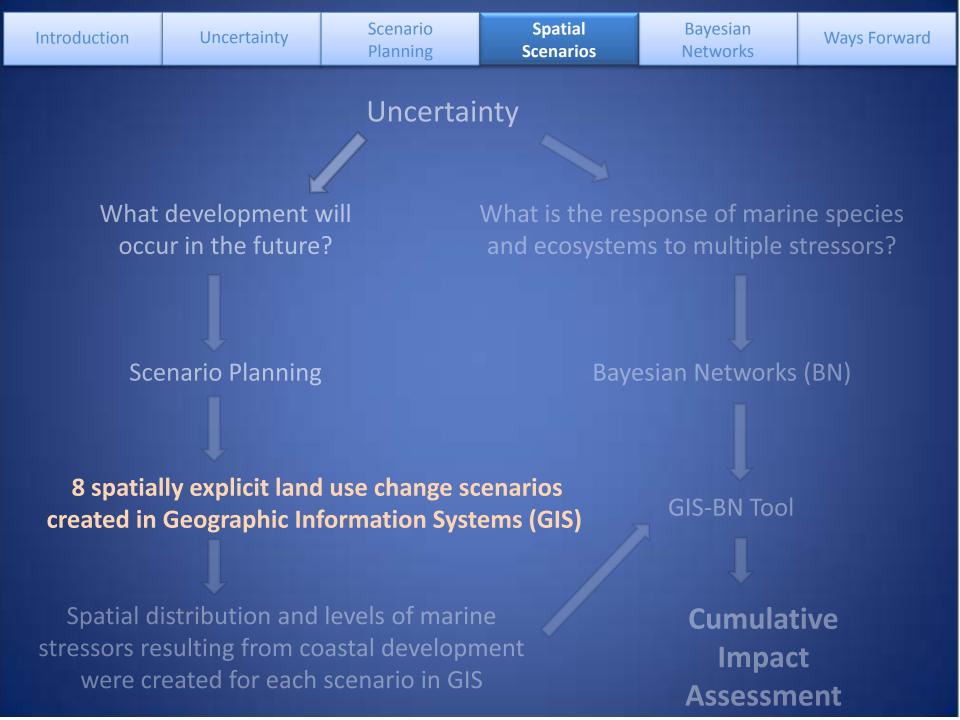
- Foreign demand for food and minerals •
- Preference for coastal lifestyle ullet
- Innovation and technological advances ullet
- Foreign demand for tourism \bullet

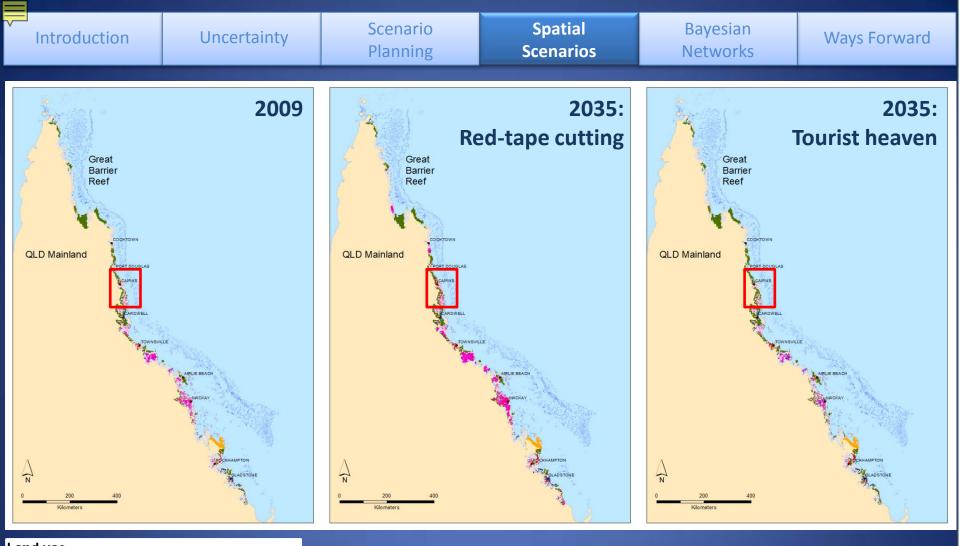
2 Types of Governance

- Strong
- Weak

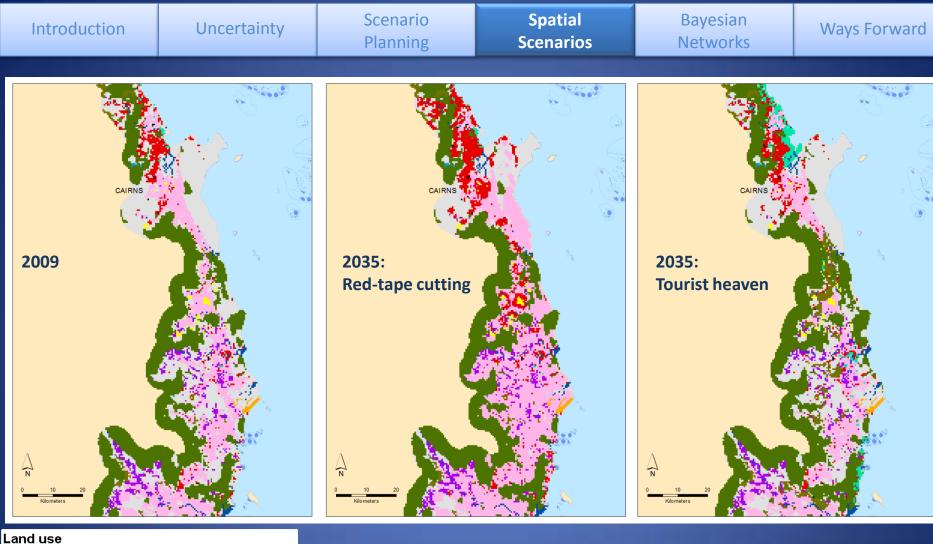




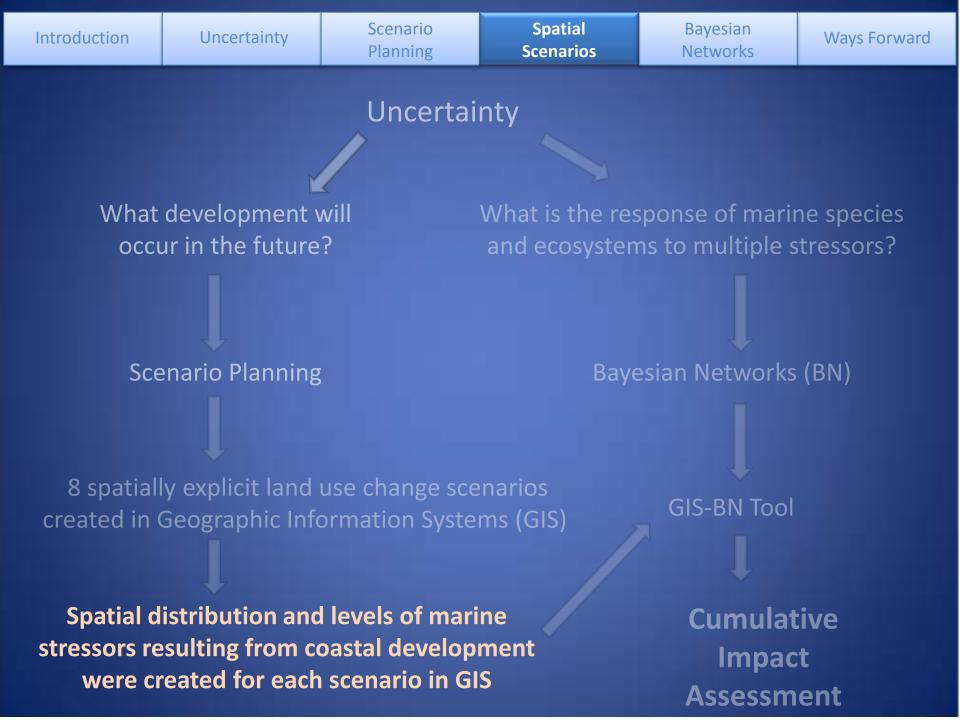




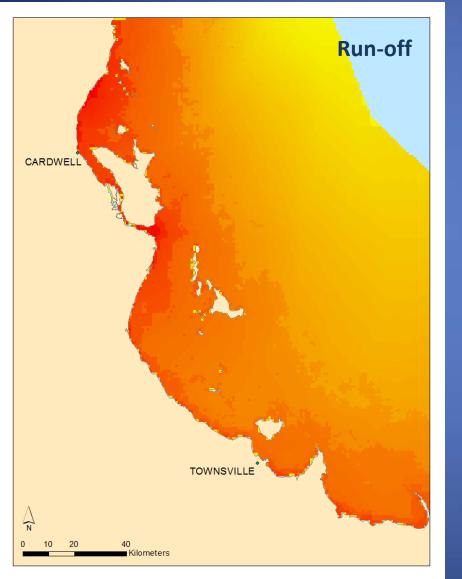




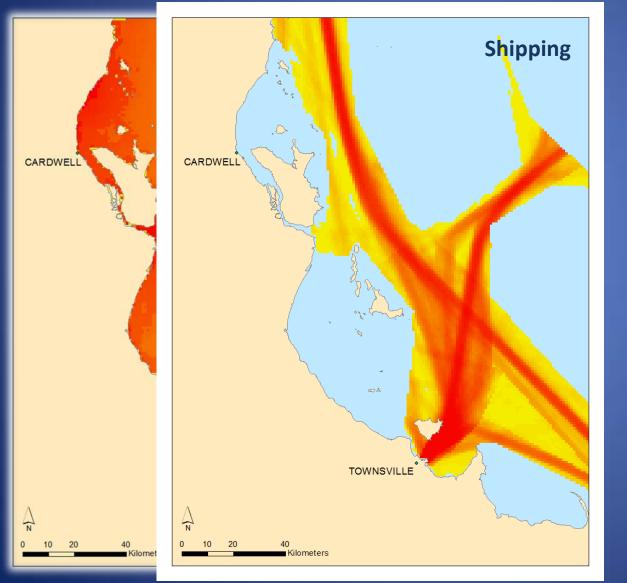




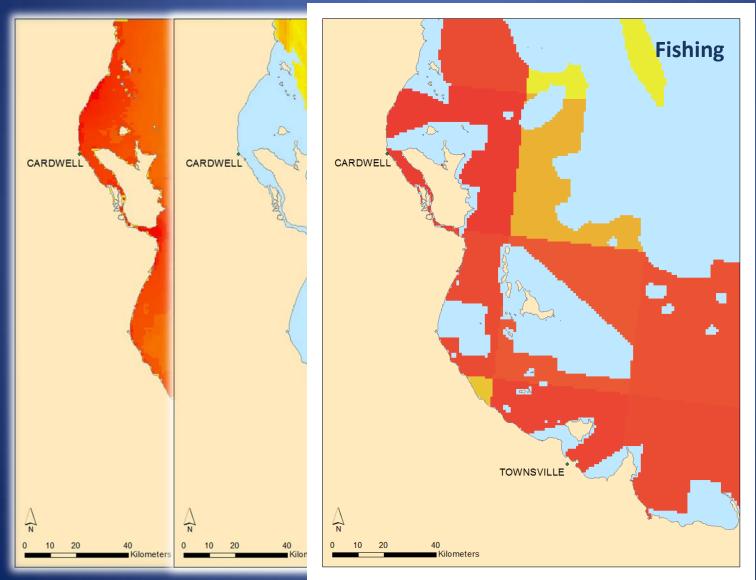
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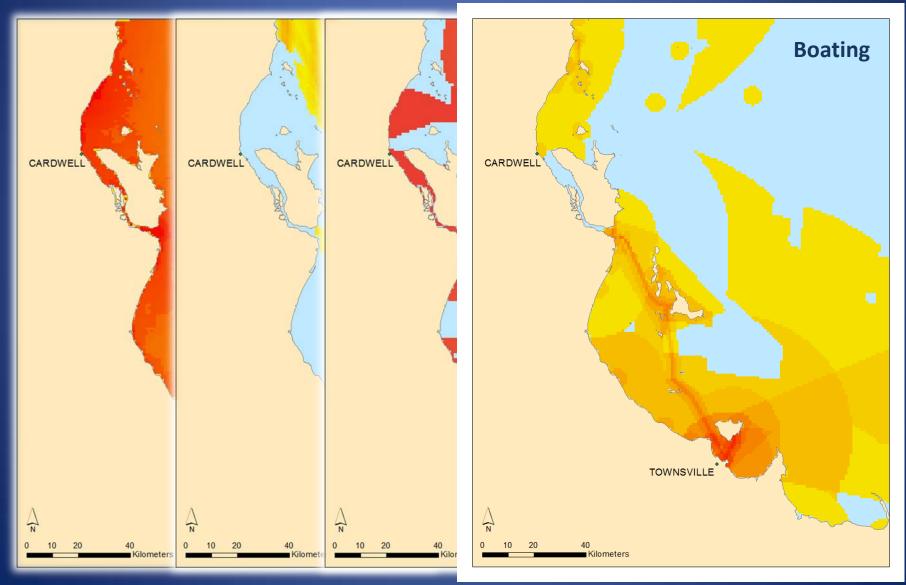
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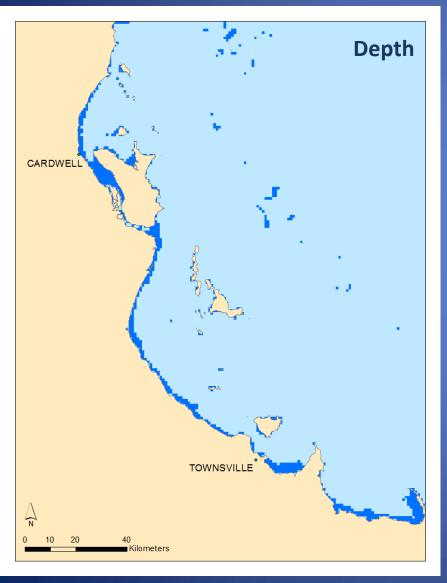


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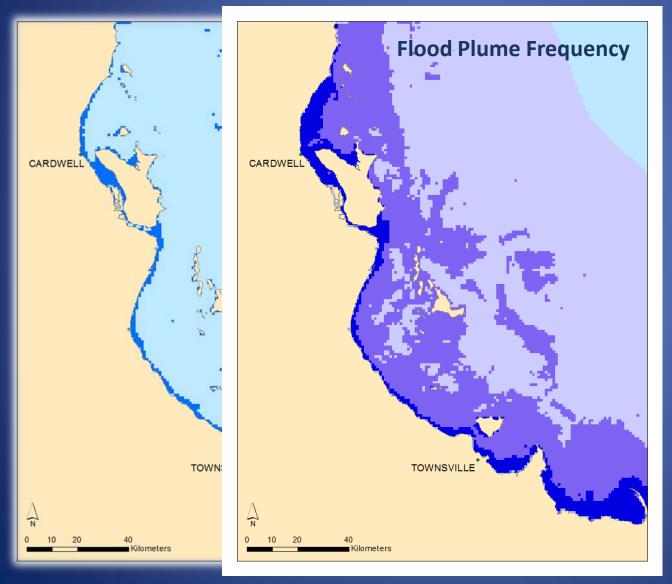
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| | | Planning | Scenarios | Networks | |

Environmental Parameters

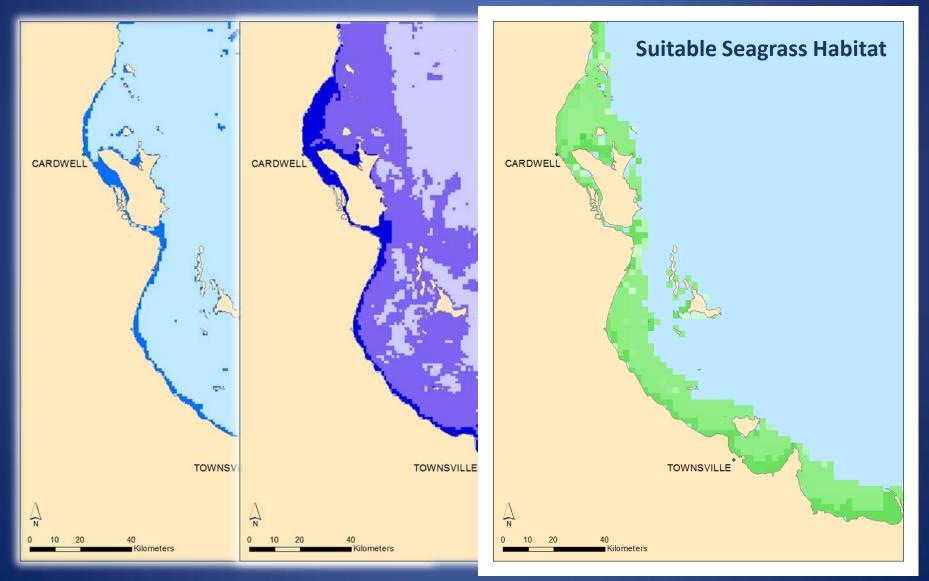


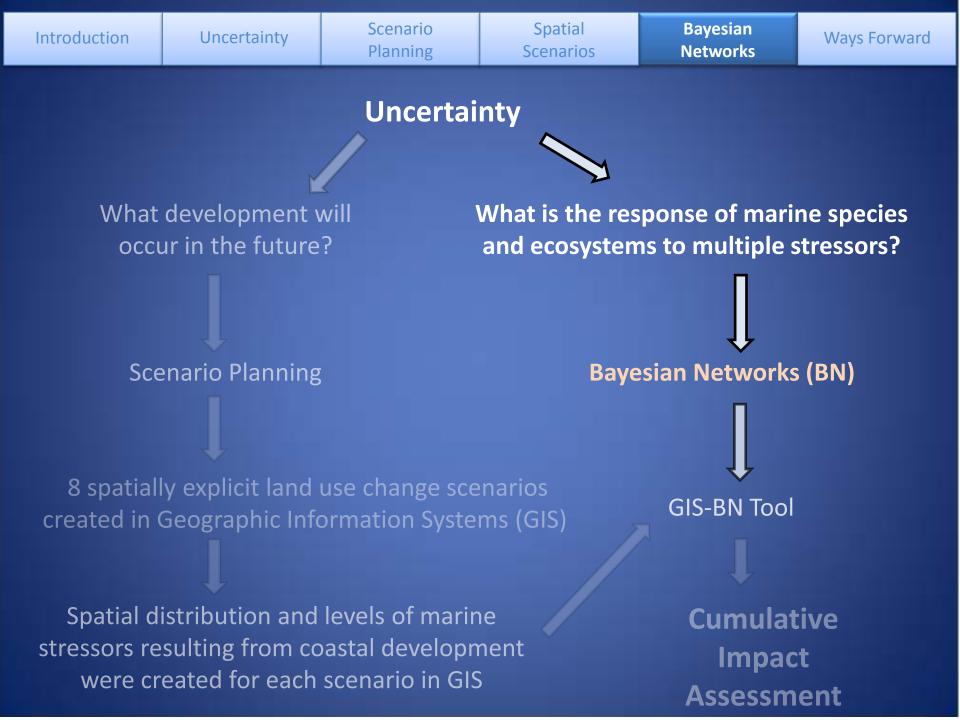
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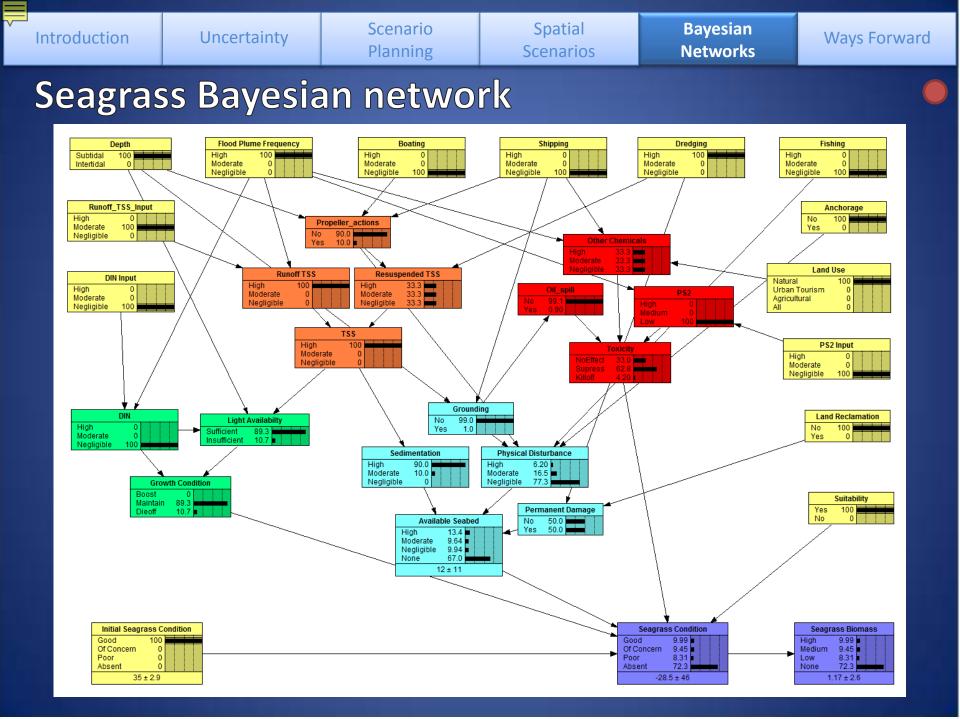
Environmental Parameters



Environmental Parameters

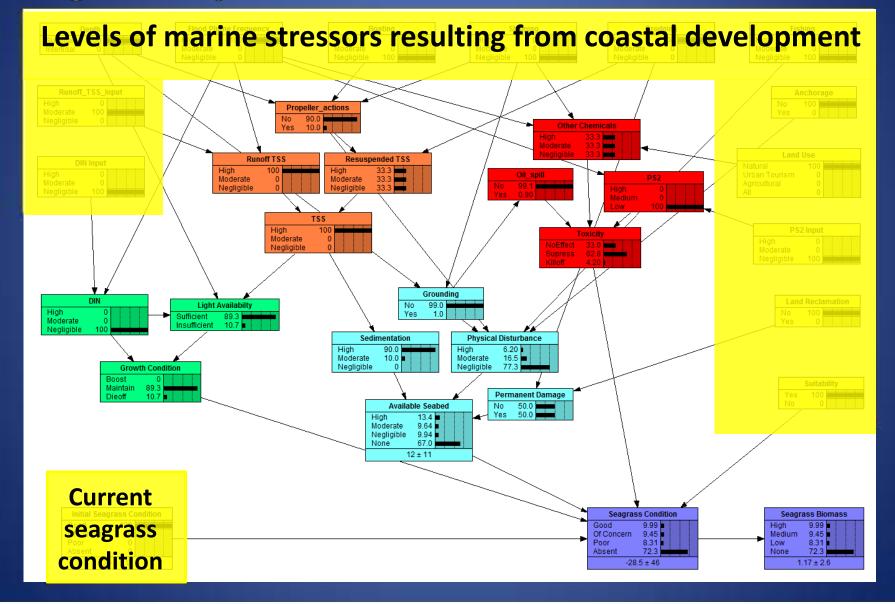






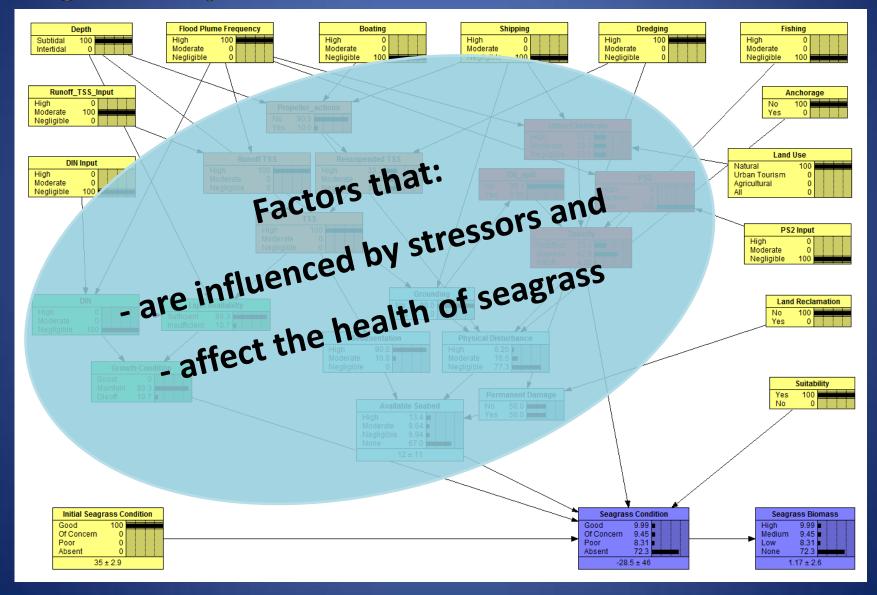


Seagrass Bayesian network



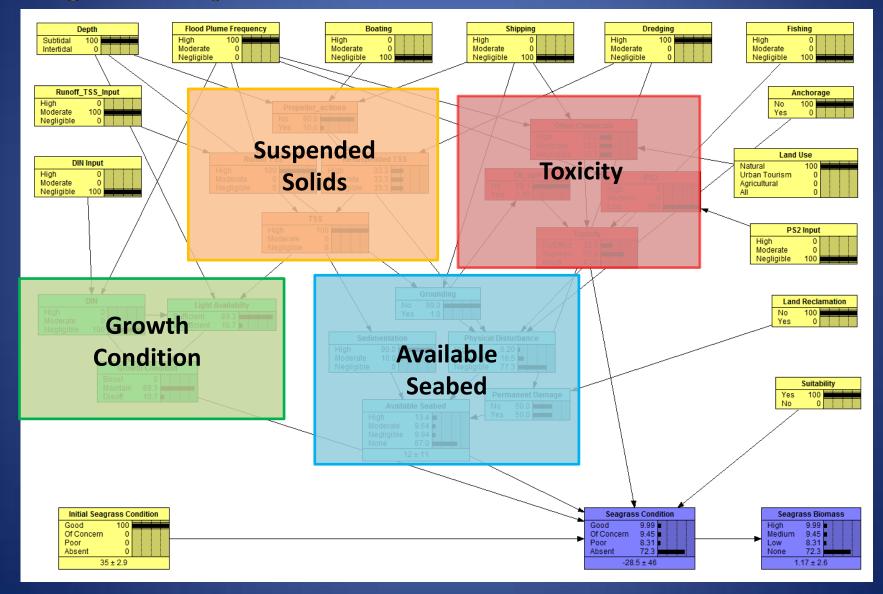
Introduction Uncertainty Scenario Spatial Bayesian Ways Forward Planning Scenarios Networks

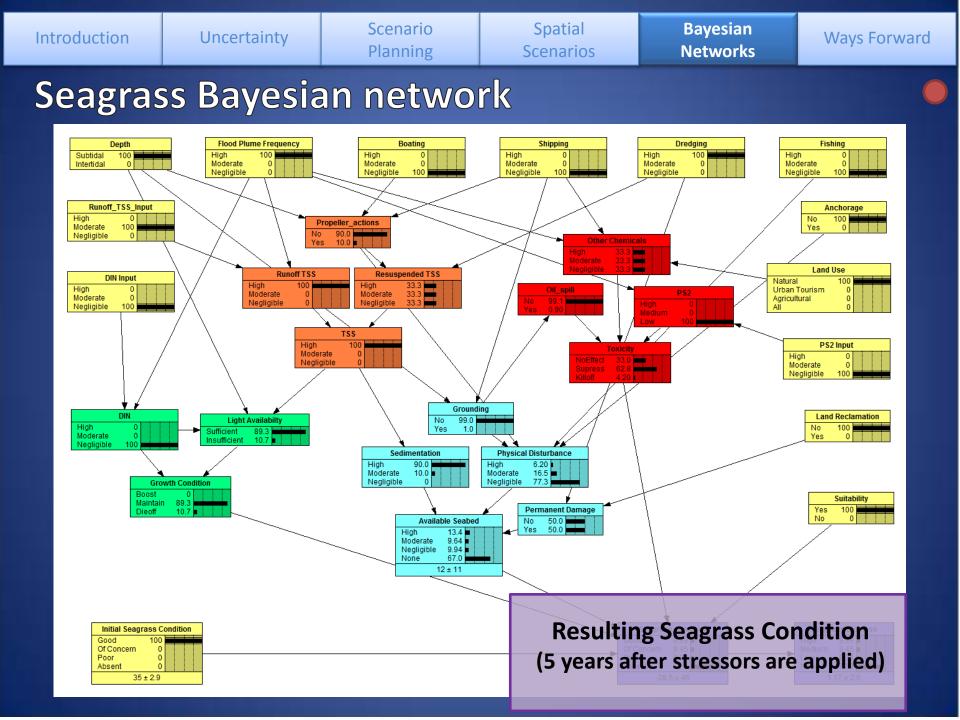
Seagrass Bayesian network

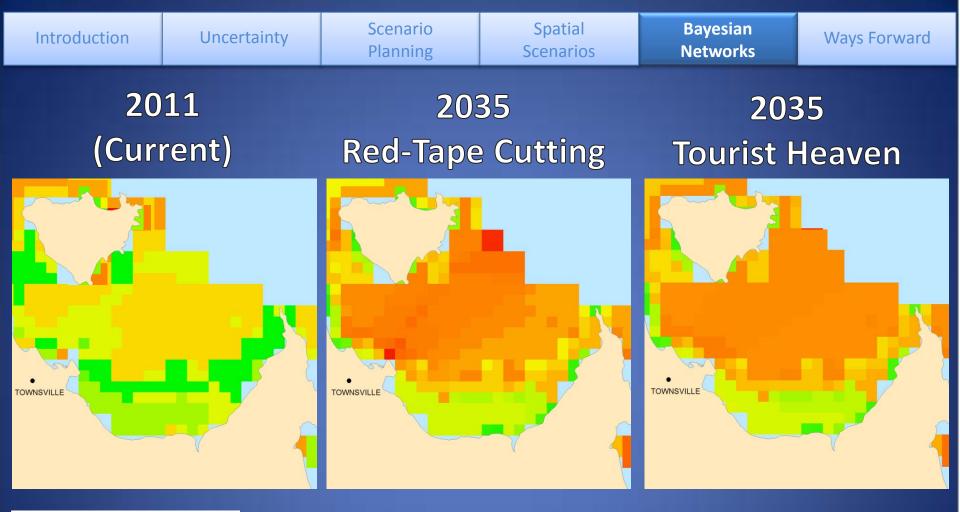


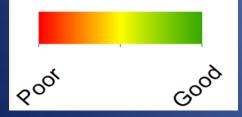


Seagrass Bayesian network









Uncertainty

What development will occur in the future?

What is the response of marine species and ecosystems to multiple stressors?

Scenario Planning

Bayesian Networks (BN)

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GIS-BN Tool

Spatial distribution and levels of marine stressors resulting from coastal development were created for each scenario in GIS Cumulative Impact Assessment

Uncertainty

Scenario Planning Spatial Scenarios Bayesian Networks

Support for Decision Makers

- Understand cumulative impacts arising from a range of scenarios.
- Make decisions to avoid scenarios that have more severe impacts on the GBR.
 - Protect areas threatened by a number of stressors in each scenario.
- Respond to future development with more targeted and finely-tuned management.

Uncertainty

Scenario Planning Spatial Scenarios Bayesian Networks

Ways Forward

Ways Forward

 Potential for Bayesian Networks to be developed for a range of scenarios, species and ecosystems at a variety of spatial scales, from whole-of-GBR to local areas across Australia.

Uncertainty

Scenario Planning Spatial Scenarios Bayesian Networks

Ways Forward

Ways Forward

- Potential for Bayesian Networks to be developed for a range of scenarios, species and ecosystems at a variety of spatial scales, from whole-of-GBR to local areas across Australia.
- By using the best available data, models and expert advice, the task of assessing cumulative impacts of coastal development on marine ecosystems can be streamlined, and made explicit and consistent.

| Introduction Uncertainty | cenario Spatial Planning Scenarios | Bayesian V Networks | Ways Forward |
|--------------------------|---------------------------------------|------------------------|--------------|
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Thank you

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