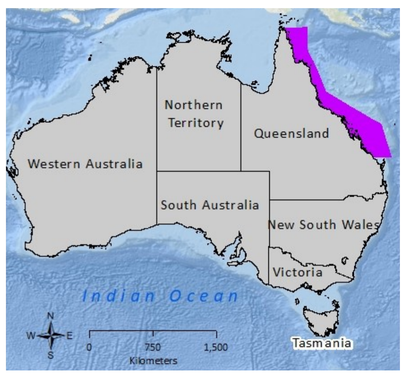
From Lab to Fab:

Suitability Analysis for Introducing Lab Grown Coral into the Great Barrier Reef

Background

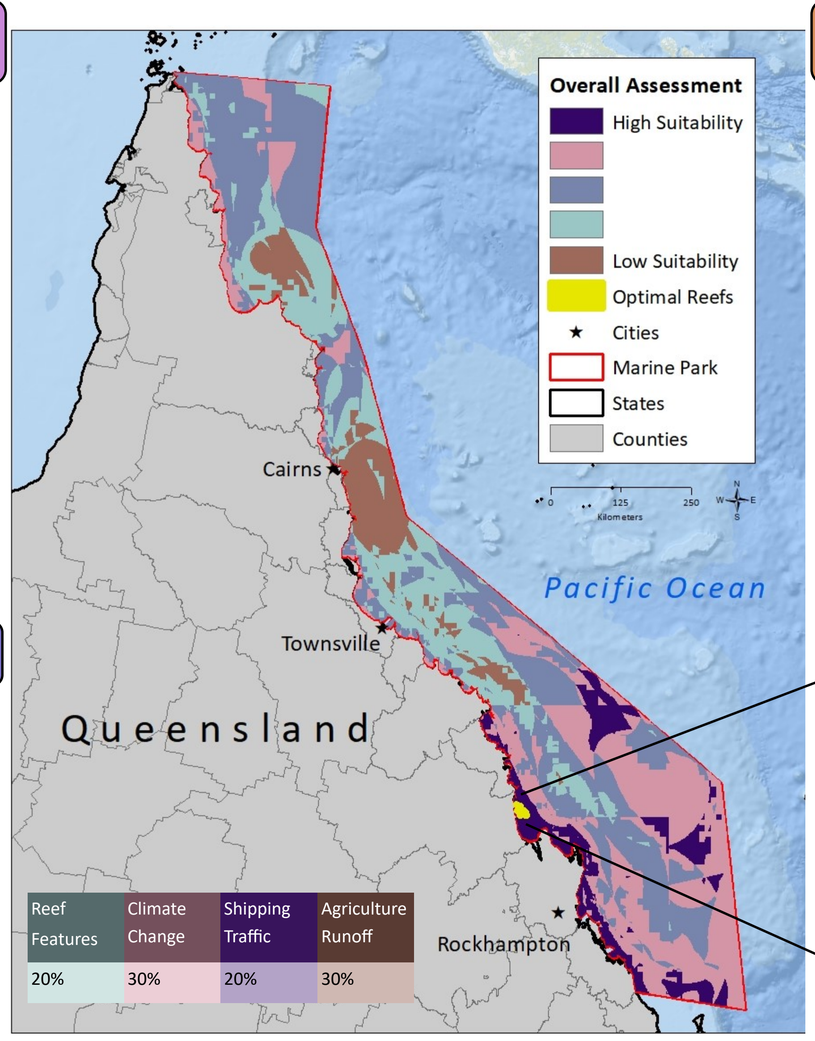
The Great Barrier Reef is fighting for survival and has already suffered about 50% loss. It is expected that the entire reef could disappear by 2050 unless significant changes are made (Vartan 2018). A lot of effort has been focused on finding causes for the massive decline in coral cover. Based on this research, it has been discovered that tropical cyclones, coral predation by crown-of-thorns starfish (COTS), and coral bleaching accounted for 48%, 42%, and 10% of the estimated coral mortality (De'ath, G., et al. 2012). Other anthropogenic activities further deplete coral reefs. Without these threats, there is substantial capacity for reef recovery. Because we have limited control over tropical cyclones, it is more effective to focus on reducing local pressures and to strengthen the reef resilience.

The extent of coral decline is of serious concern because coral grow at such a slow rate. However, if we can manually transport lab grown coral into the wild, this could improve the chance of survival for natural populations. This provides an alternate strategy to save coral reefs that goes beyond fighting the major risks. Previously, Australia has resisted intervention in reef ecology, but the intensity of coral threats requires a more hands-on approach. In the past decade scientists have succeeded in growing corals in the lab, but the next step is to find the best environments to place them in the ocean. The survival of these lab grown coral are still in danger from the same hostile conditions, so a suitability analysis through GIS is used to find optimal locations recommended for introduction.



Methodology

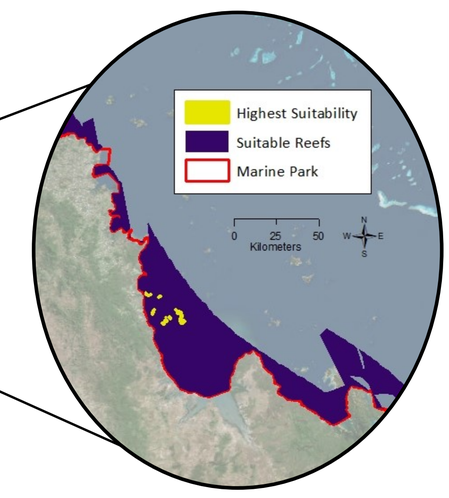
Data was downloaded and imported into ArcMap. Latitude and longitude points were converted to XY coordinates when necessary and clipped to the marine park boundary. The overall suitability assessment for coral introduction included 10 different aspects that either help or harm coral survival. After Euclidean Distance, Interpolation, and Kernel Density tools were run on appropriate layers, they were reclassified into 4 main categories. The suitability analyses consisted of weighted raster calculators for reef features, climate change, shipping traffic, and agriculture runoff, which were then combined to produce the final weighted suitability analysis classified on a scale of 1-5, with 5 as the most suitable. Weights were based on estimated degree of influence.

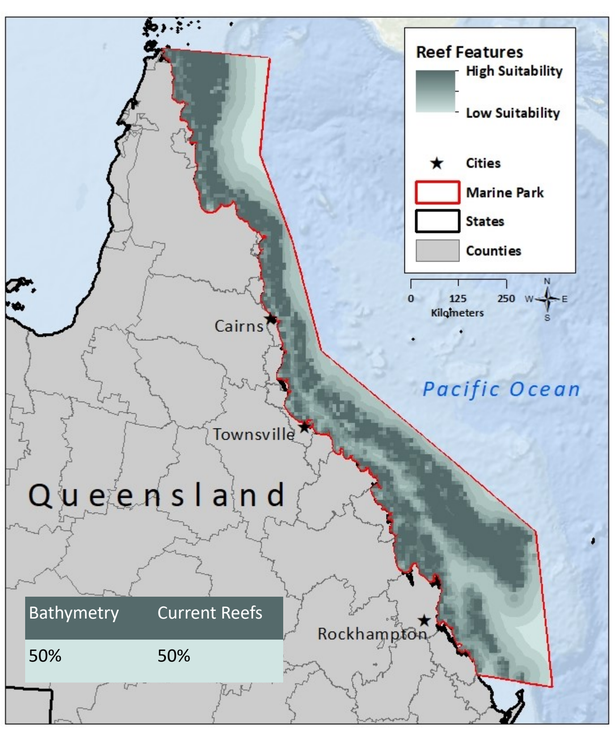


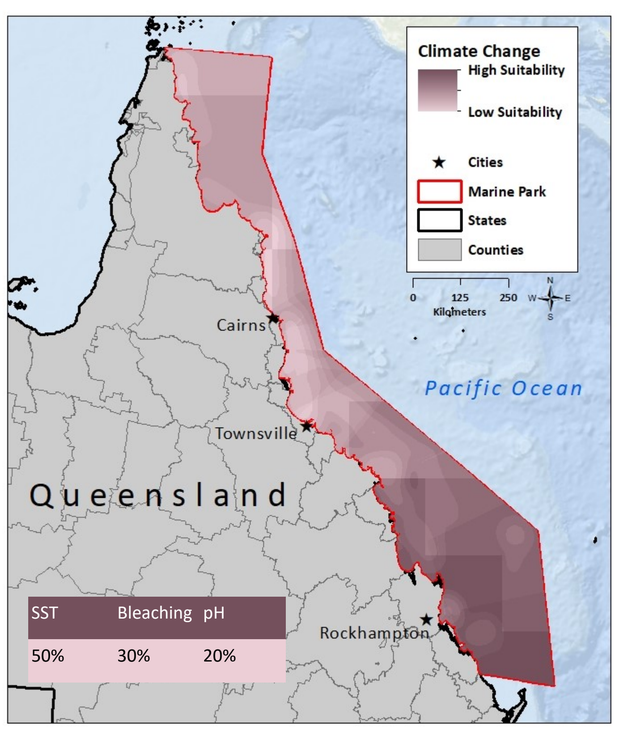
Results

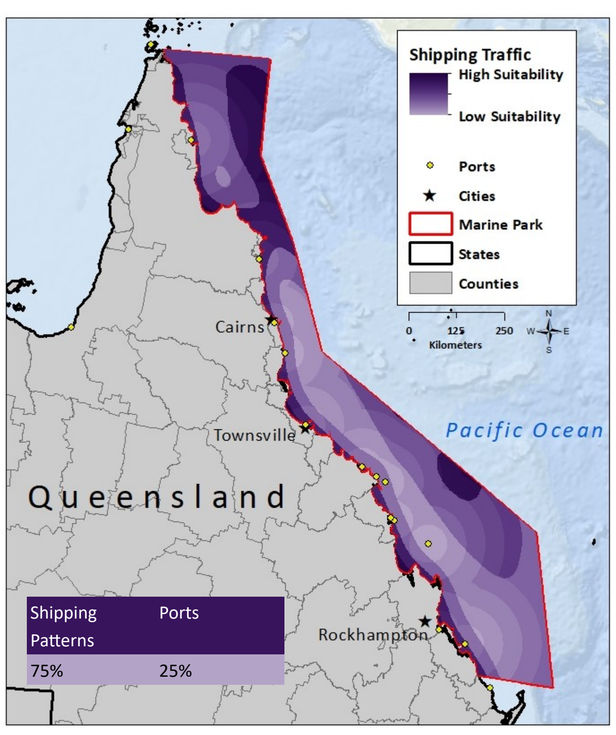
There are a plethora of factors that affect coral health, which makes analysis complicated. Zonal statistics as a Table was performed on the final map and joined to the Reef Features layer in order to evaluate the mean. Out of the 3,000 total coral reefs composing the Great Barrier Reef, just 320 of them were deemed favorable and received a suitability score between 4-5. Out of those 320, only 10 had a perfect suitability score of 5. This healthy section of coral reef represents only 0.33% of the entire Great Barrier Reef. It is advised that lab grown coral be transplanted to the locations specified in the chart and sorted by ascending area.

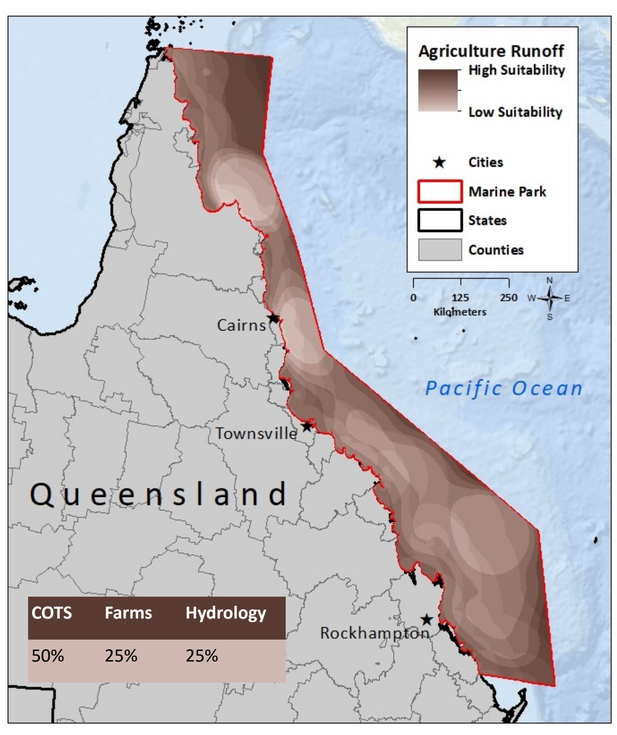
Optimal Reefs
Bald Reef
Drumfish Shoal
Reef Islet Reef
Sandy Shoal
Beware Reef
Fanning Shoal
West Hill Reef
Red Clay Reef
Aquila Reef
Avoid Reef











Reef Features:

Coral polyps live in a symbiotic relationship with photosynthetic algae, called zooxanthellae. The coral provide algae with a safe environment and compounds needed for photosynthesis, while algae reciprocate with food, oxygen, and waste removal (Vartan 2018). If this interaction is destroyed, corals can gradually starve as they turn white, hence the term bleaching. Therefore, bathymetry is a limiting factor when considering coral distribution that ensures access to sunlight. In addition, coral survive better when grouped together in a colony because it allows increased access to shared resources and better recovery from disturbances (Forsman, Zac H., et al. 2015). In order for lab grown coral to reinforce current coral colonies, they need to be located within a close distance

Climate Change:

As the ocean waters become warmer, there are more negative impacts toward coral reefs. Because sea surface temperature has such a strong influence on other harmful factors, it is weighted heavily in the analysis. Not only does it lead to coral bleaching, which contributes to disease susceptibility, but rising sea surface temperatures also increase the likelihood of tropical cyclones that are capable of extreme destruction. Ocean acidification is caused by the uptake of CO_2 from the atmosphere decreasing the pH levels. With global warming and the excess carbon emissions emitted from anthropogenic activities into the atmosphere, the effects of ocean acidification can become more severe preventing corals from calcifying and inhibiting fertilization (Albright and Mason 2013).

Shipping Traffic:

Shipping density of pathways and distance from ports were used to represent both the negative effects of tourism and fishing. With increased tourism, there is inevitably more pollution infiltrating the ocean. Marine debris and other pollutants can smother coral reefs, make them more susceptible to disease, and impede their growth and reproduction (Gabbatiss 2018). Impacts on reproduction limit adaptation potential. Commercial and recreational vessels can threaten reef health by discharging contaminated fuel or sewage and by spreading invasive species ("Pollution"). Furthermore, overfishing physically damages coral through extraction techniques and removes fish that eat algae to keep the ecosystem in balance.

Agriculture Runoff:

Crown of Thorns Starfish (*A. planci*) have become one of the key threats to coral reefs. They prey on nearly all corals and occur naturally in low numbers, but recent outbreaks have devastated coral populations because they consume coral faster than it can grow. These outbreaks are a result of poor water quality. Excess nitrogen from agricultural runoff boosts the phytoplankton that feed COTS larvae (Brodie, Jon, et al. 2005). Therefore, the distance from hydrology and farms was essential for the determination of potential COTS outbreaks along with the density of present COTS infestations. In addition, coral depends on clean and clear water for survival, which is reduced by contaminated runoff flowing out of rivers into the ocean.

Conclusion

Coral reefs are one of the most biodiverse ecosystems on Earth along with tropical rainforests. The Great Barrier Reef provides habitat for an astounding variety of marine plants and animals. The Reef supports the fishing industry, which feeds the human population. People are also attracted to the unique beauty of coral reefs. As the tourism industry grows, the Australian economy profits. Coral reefs also serve as a barrier to protect coastal communities from tropical storms and as an indicator for overall ecosystem health. Additionally, coral may have unique properties that can be adopted in human medicine. Therefore, coral reef conservation through remediation is imperative to human existence.

Future Directions

As seen in the results, there are still limitations associated with lab grown coral supplementing the naturally occurring coral cover. These restoration efforts represent a temporary approach because there are minimal locations that have conditions adequate for coral survival. More recently, scientists are searching for hotspots of resilience where corals have already adapted to the extremes of heat and acidity that are likely to prevail in the future. Genes from these resistant corals could be transferred to more vulnerable reefs, thereby bolstering their possibility of survival through enhanced stress tolerance and ability to recover (Warne 2018). This would require the opposite GIS analysis, where areas of high risk are identified for placement strategy. However, researchers need to first gauge the complications of unanticipated ecological consequences from selective breeding.

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Projection: GDA 1994 Australia Albers

Data Sources: GADM, gbrmpa.gov, Reef Base, NOAA, data.gov.au, ESRI

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