Maximizing urban services in Valdivia, Chile with green infrastructure

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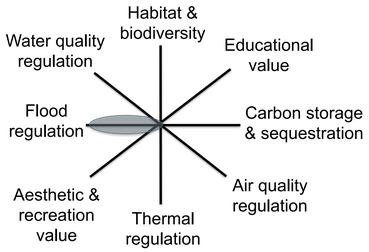
Intentional planning with green infrastructure may mitigate effects of changing climate

Cites are increasingly threatened by climate change. Integrating gray (e.g. built) and green (e.g. wetlands) infrastructure may increase the resilience of cities and urban populations to extreme weather events.

Gray (built) infrastructure

Fail-safe approach minimizing chances of failure

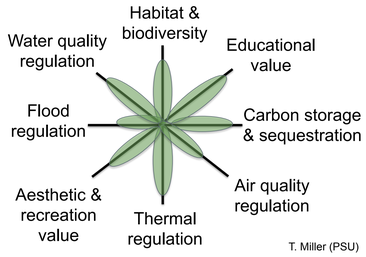
High efficiency solutions with single purpose design



Green infrastructure

Safe-to-fail approach minimizing consequences of failure

Leverages existing natural resources to provide multi-functional services



T. Miller (PSU)

Valdivia: a case study of green infrastructure

Latin American cities are particularly vulnerable to climate change and extreme events due to rapid urban development, dense populations, outdated infrastructure, and limited resources.

We assessed historic and future change in green infrastructure in Valdivia, Chile as a means to mitigate the effects of extreme events through the provision of multiple ecosystem services.

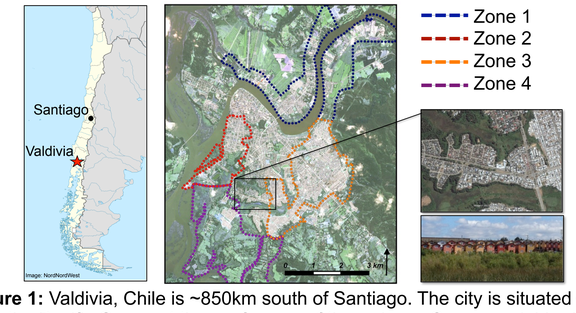


Figure 1: Valdivia, Chile is ~850km south of Santiago. The city is situated ~15km from the Pacific Ocean at the confluence of three rivers. Several neighborhoods (Zones 1 - 4) are at high risk for flooding and loss of natural wetlands due to rapid development. These areas also house citizens of the lowest socio-economic status.

City population: 165,000

City vulnerabilities: Precipitation and tidal flooding, summer drought, lack of planning regulations and resources, earthquakes, and landslides.

Mean annual precipitation: >1870 mm **High/low temperature:** 72/40 ºF

Ecosystem: Biodiversity hotspot in Valdivian temperate rainforest

Natural hazards and humans change green infrastructure in Valdivia

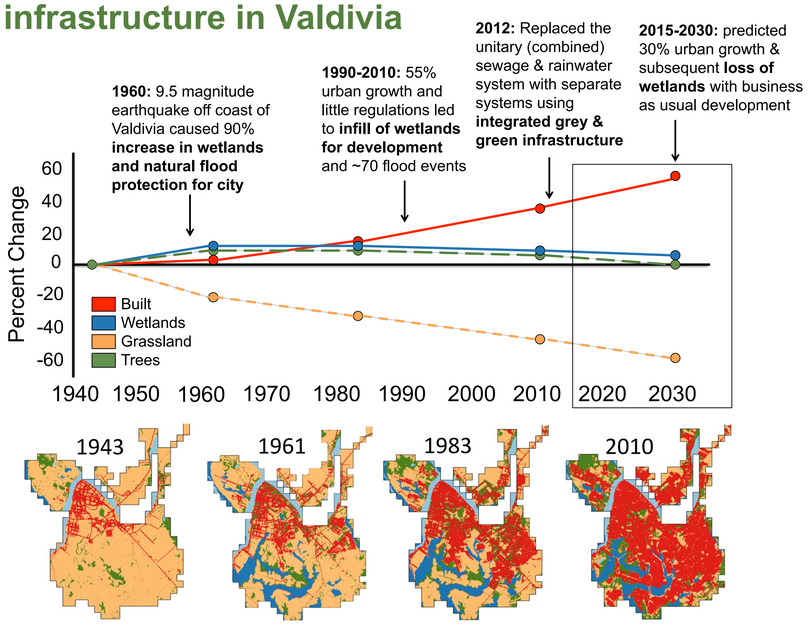


Figure 2: After a significant increase in wetlands following the 1960 9.5 magnitude earthquake, rapid urbanization and lack of development regulations led to the infill and decline of natural wetlands in the city. Historically, wetlands were valued more as cheap land for development and waste disposal than for their ecological value. Recently, however, wetlands have been acknowledged in planning documents as valuable flood protection.

Assessing multiple ecosystem services over time and space

To quantify impacts of urbanization, we modeled indicators of ecosystem services including flood and temperature regulation, habitat area, and carbon storage across years (Fig 3A) and vulnerable neighborhoods (Fig 3B). **These indicators highlight increasing vulnerabilities to climate change and extreme events as green infrastructure and ecosystem services decline over time and in the most vulnerable neighborhoods (e.g. Zone 3)**.

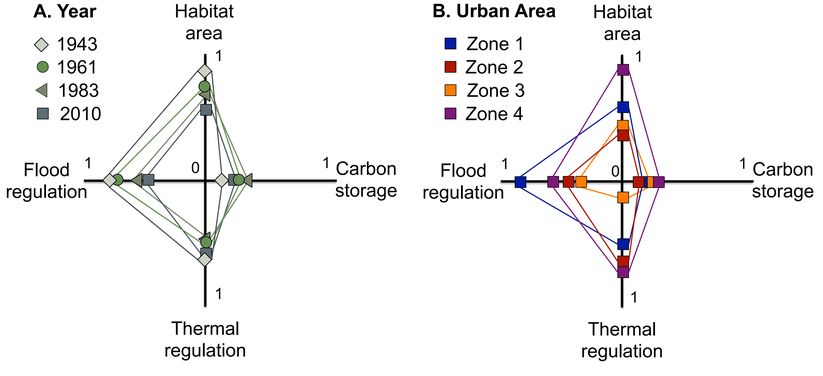


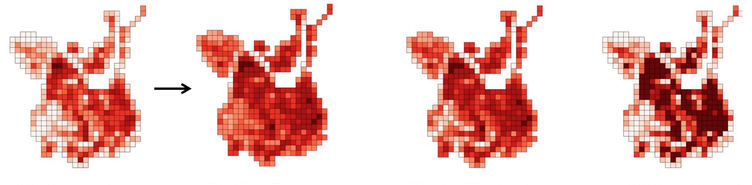
Figure 3: Indicators of ecosystem service provision modeled **(A)** over time and **(B)** in 2010 urban neighborhoods most vulnerable to flooding (see Fig 1). All indicators are standardized on 0 (low provision) - 1 (high) scale for comparability. Median flood regulation (runoff potential based on avg 12mm rain event), thermal regulation (evapotranspiration and emissivity), carbon storage (tree C storage), and habitat area (% green space) estimated in 6.25 ha grid cells across the urban region.

Planning for the future in 2030 to protect green infrastructure and reduce vulnerabilities

Inter-American Development Bank & Initiative for Emerging and Sustainable Cities (ICES) 2015

The recently published Valdivia Sustainability Plan of Action for 2030 highlights normative social, economic and environmental goals for a shared future, including targeted actions to protect natural wetlands.

Based on goals in the Sustainability Plan and predicted 30% population growth by 2030, we developed and assessed 3 future scenarios for Valdivia with different strategies for protecting green space and increasing density.



2010: Existing development

Increasing urban density

2030: "Business as usual" scenario
No restrictions on sprawl or future development, including continued infill of wetlands

2030: "Protecting wetlands" scenario
Moderate regulations implemented to protect wetlands from infilling for development

2030: "Smart growth" scenario
Optimal scenario to increase urban density in strategic urban hubs and protect green space

Multi-criteria assessment of future scenarios as planning and decision support tool

The optimal "smart growth" scenario may provide greater thermal regulation, carbon storage and habitat area than other futures, but have lower flood regulation potential. This highlights the importance of assessing the tradeoffs of multiple services and the need to intentionally integrate both green and gray infrastructure in future planning.

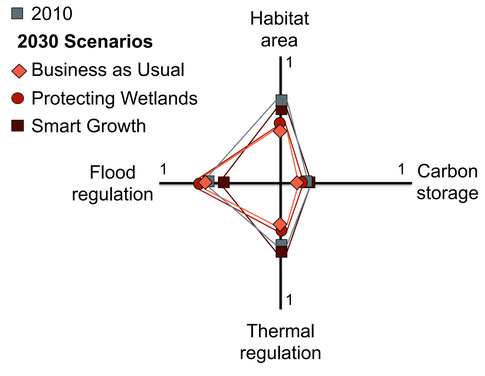


Figure 4: Multi-criteria assessment of indicators of ecosystem service provision of habitat area, carbon storage, and temperature and flood regulation in 2010 and 3 future scenarios for 2030 (Business as usual, Protecting wetlands, and Smart growth scenarios). Ecosystem service indicators same as Fig 3.

Next steps toward co-production of desirable future scenarios and cross city comparisons

We plan to co-produce and assess additional desirable future scenarios with local stakeholders in order to feed into local planning.

We hypothesize that Latin American cities may be more reliant on green infrastructure than North American cities, but incorporate it less formally in municipal planning. Thus green infrastructure will be undervalued in Latin American cities for potential to improve ecosystem services. We plan to compare cities across a diversity of social-biophysical contexts and vulnerabilities to future extreme events (flooding, heat, drought).

Acknowledgements: Many thanks to Javiera Maira (Activa Valdivia), Alexandra Castañeda, Cristóbal García, Karina Godoy, Daniel Harris, Valeria Ochoa (UACh), and David Iwaniec and Nancy Grimm (ASU). This project is based on support by CONICYT-FONDECYT Projects: 3150290 (Postdoctorado),11110183 & FONDAP: 15110020.
References: Hansen & Pauleit 2014, ICES 2015, Rojas 2006, Shaffler & Swilling 2013, UN Habitat 2012