Planning around Air Pollution

Given different natural landscapes, weather patterns, and urban layouts, what infrastructure design most reduces the air pollution exposure of native ecosystems and urban residents while minimizing the impact on climate change?

INTRODUCTION

Urban air pollution affects both current and future health outcomes. It is broadly commensurate with disparities in socioeconomic status and deep inequities in access to green space. As both an indicator of societal inequality and a proximate cause of human suffering, mitigating air pollution is an increasingly pressing issue. More specifically, air pollution is associated with adverse environmental and health impacts, like localized climate change and incidence of respiratory and cardiovascular illnesses. Urban air pollution also contributes to loss of urban biodiversity and degradation of the prevalent ecosystem. These impacts are not distributed equitably throughout cities, with marginalized communities suffering the brunt of the consequences.

The vast majority of urban air pollution is anthropogenic in nature and overwhelmingly comes from cities. Furthermore, we have the tools and strategies to mitigate much of pollution emissions, making this issue a question of access to privilege as much as a question of policy.

Team 4: Urban Air Pollution

Barbara Milewski and Gavin Hashimoto

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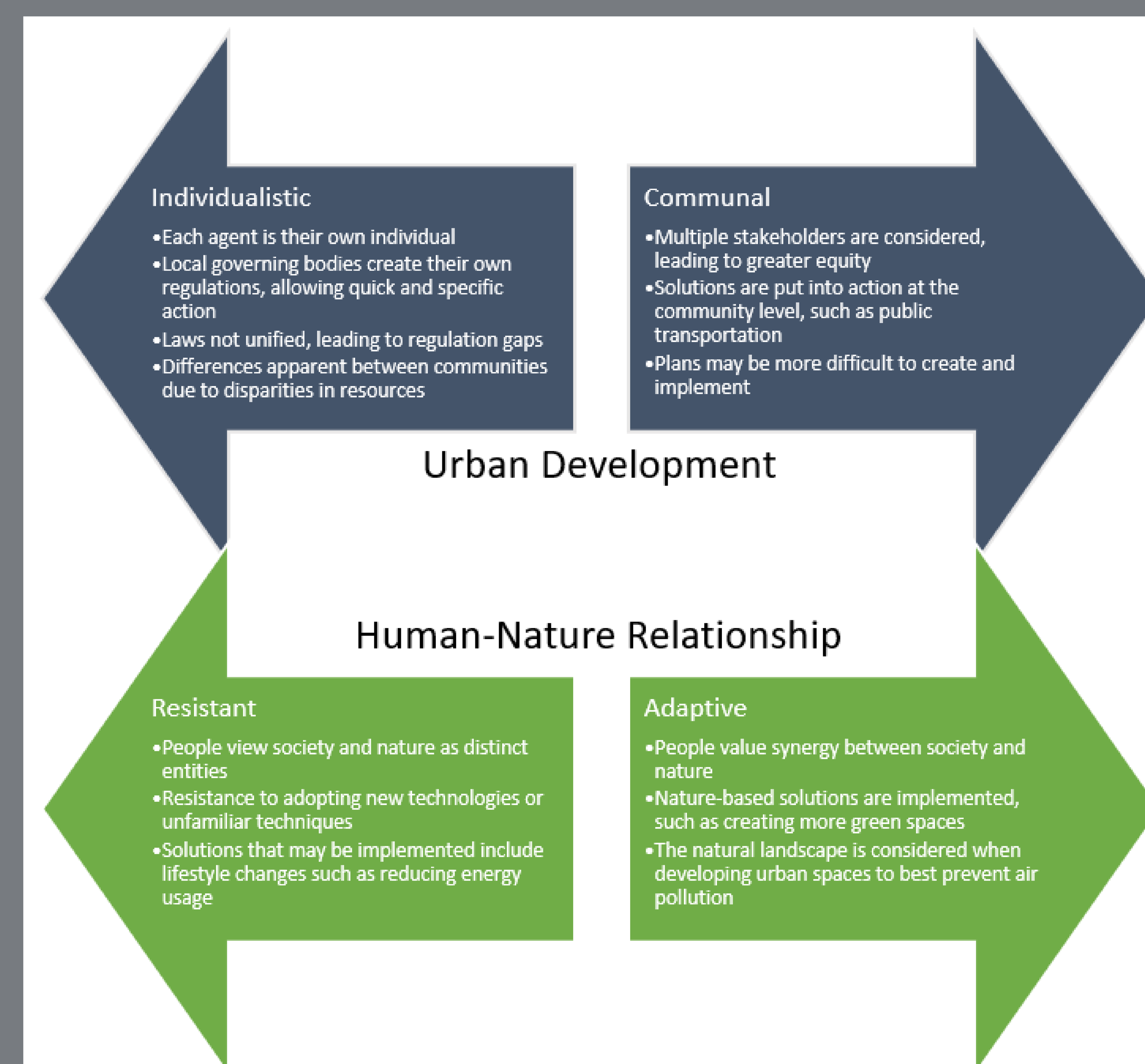
KEY DRIVERS AND DIMENSIONS

Urban development and the human-nature relationship were identified as the two key drivers of urban air pollution. Urban development was chosen because cities account for the majority of urban air pollution production and future urban air quality will depend on the development of urban areas. Harmony with nature was selected because the attitudes people hold towards nature will influence their lifestyles and what solutions they implement to reduce air pollution.

For these drivers, two endpoints each representing a wide range of possible futures were chosen. The endpoints for urban development were an individualistic approach versus a communal approach. Those for the human-nature relationship were a resistant mindset versus an adaptive mindset.



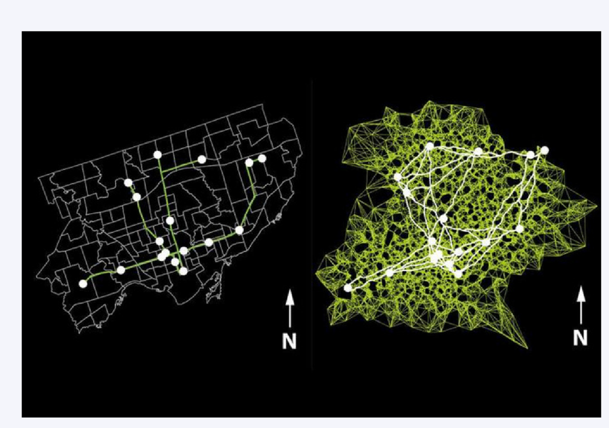
SCENARIO LOGICS

Four divergent futures were identified by crossing the dimensions of the key drivers. These were Isolationist, Individual Stewardship, Human-Focused, and Total Synergy. The indicator metrics for measuring the impact of urban air pollution were:

1. Climate change - Ambient concentrations of air pollutants
2. Biodiversity - Number of urban green spaces with high biodiversity
3. Social equity - Distance of air polluters from communities with respect to socioeconomic status

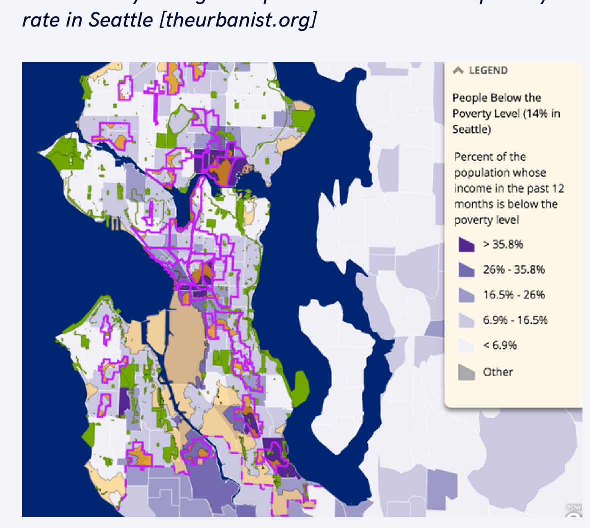
These indicator metrics are effective because they are ways to quantify how urban air pollution affects climate change, biodiversity, and social equity. Air pollution is considered low when there are low ambient concentrations, many biodiverse green spaces, and polluters are far away.

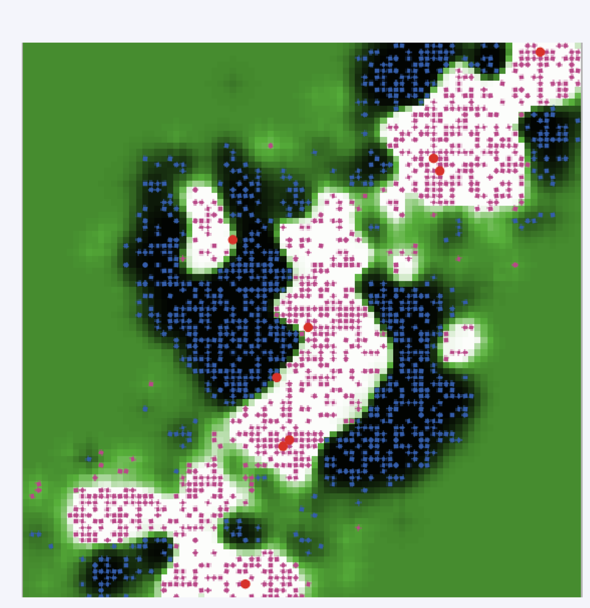
SIMULATION MODELING



Above: Image of virtual slime mold in agar plate modeling Toronto transit system [phys.org]

Below: Analysis of green space access relative to poverty rate in Seattle (theurbanist.org)





There are four kinds of agents in the model:

- Urban residences - They have an associated socioeconomic status value. They both produce air pollution and are affected by it, with exposure to air pollution increasing their pollutant concentrations value.
- Industrial buildings - They create air pollution and can spread it to neighboring patches. They develop mostly around residences with low socioeconomic status.
- Roads - They create air pollution like industrial buildings. They develop between all residences and buildings.
- Urban green spaces - They absorb air pollution, preventing its spread, and start out with a number of species inhabiting them. They can also be affected by it, increasing their air pollutant concentrations value, which will decrease the number of species living in them.

The outputs of this model will be the ambient air pollutant concentrations in each patch, which can be analyzed with respect to socioeconomic status (residences), and the number of species in each urban green space, representing biodiversity.

In the two pictures in the top-left, there is first a crude representation of how circulation networks can be plotted by self organizing systems like slime molds, which we are trying to replicate in our agent-based model. The picture below is an geographic analysis of poverty and access to green space, which is essentially the goal with this model. The picture below this is a screenshot from a modified base simulation in NetLogo, which is intended to show land rents (small red dots are high, blue are low) with respect to green space (larger red dots).

This simulation accurately represents a basic level of understanding about the impact of green space on land values, but our model will also include the road network - as seen in the agar mold - as well as industrial point sources of pollution and a third class of housing quality.

STRATEGIES

Ultimately, this issue is as much of a question of access and political will as much as one of technology. The four futures envisioned here are deeply entwined with ideals of how society centers issues of equity and investments of long-term health. There is no future scenario that can be disentangled from the complex moral questions which these scenarios force us to engage with.

Three possible strategies for dealing with urban air pollution:

1. Adaptation - Implementing solutions that make society more resilient to the impacts of urban air pollution (e.g. better treatments for illnesses linked to air pollution)
2. Mitigation - Reducing the effects of urban air pollution directly (e.g. absorbing air pollution, capturing greenhouse gases)
3. Prevention - Focusing on the source of the problem and preventing air pollution from being emitted in the first place (e.g. clean energy, moving away from polluting lifestyles)

Adaptation is the most convenient solution because it means current technologies and lifestyles do not have to change much, but will likely not be effective in the long-term.

Mitigation is the best strategy overall because it deals with the air pollution already emitted, which is essential for greenhouse gases such as carbon dioxide.

Prevention is the second-best strategy and would work well in places not yet heavily affected by urban air pollution.