InVEST Virtual Workshop

Urban InVEST: Modeling ecosystem services in cities

August 18, 2020
A recording of this webinar and the slides we present today will be available on our Virtual Workshops webpage following the event

naturalcapitalproject.stanford.edu/impact/invest-virtual-workshops
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Jade Delevaux, Life Science Researcher at the Natural Capital Project, Stanford University

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Question and Answer box:
NatCap, ecosystem services, InVEST, or other CONTENT

Chat box:
WEBINAR logistics or technical assistance
Schedule

0:00 - 0:05 - Welcome: Jesse
0:05 - 0:45 - Introduction to Urban InVEST: Roy*
0:45 - 0:55 - BREAK
0:55 - 1:45 - Urban Cooling model: Chris*
1:45 - 1:55 - New developments for urban planning: Chris
1:55 - 2:00 - Wrap up: Jesse

Post-Event Survey

*including questions & answers
Please take our SURVEY
Poll Question

Which of our prior InVEST Virtual Workshops have you attended?

- Intro
- Freshwater
- Both
- Neither
naturalcapitalproject.stanford.edu/impact/invest-virtual-workshops
Menti.com Question

In which decision-contexts or research do you want to apply the Urban InVEST models?

Please go to menti.com and enter code to participate:

28 25 38 8
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InVEST Virtual Workshops

August 18, 2020

natural capital
PROJECT

Stanford University
Natural Capital Project

PARTNERSHIP

MISSION

Pioneering science, technology, and partnerships that enable people and nature to thrive.

SOFTWARE

InVEST: integrated valuation of ecosystem services and tradeoffs
ROOT
RIOS
OPAL
MESH
PyGeoProcessing
VISION: TO MAINSTREAM THE VALUES OF ECOSYSTEM SERVICES AND BIODIVERSITY IN CITY PLANNING, CONSERVATION, AND DEVELOPMENT TO IMPROVE OUTCOMES FOR BOTH PEOPLE AND THE PLANET

QUESTIONS WE ADDRESS:

When does Nature provide services? 

Who benefits from Nature’s services? 

What does it mean for decisions in practice?
NatCap’s Livable Cities program

STARTED ~3 YEARS AGO

- **Science:**
  - New science on urban ES, biodiversity, health & environmental justice

- **Technology:**
  - InVEST models, and additional urban tools

- **Partnerships:**
  - TNC, WWF, NTU Singapore, SRC, World Bank, CIRED, ICLEI, C40
The science that started our work

Social-ecological and technological factors moderate the value of urban nature

Bonnie L. Keeler, Perrine Hamel, Timon McPhearson, Malke H. Hamann, Marie L. Donahue, Kelly A. Meza Prado, Katie K. Arkema, Gregory N. Bratman, Kate A. Brauman, Jacques C. Finlay, Anne D. Guerry, Sarah E. Hobbie, Justin A. Johnson, Graham K. MacDonald, Robert I. McDonald, Nick Neverisky, and Spencer A. Wood

Urban nature has the potential to improve air and water quality, mitigate flooding, enhance physical and mental health, and promote social and cultural well-being. However, the value of urban ecosystem services remains highly uncertain, especially across the diverse social, ecological and technological contexts represented in cities around the world. We review and synthesize research on the contextual factors that moderate the value and equitable distribution of ten of the most commonly cited urban ecosystem services. Our work helps to identify strategies to more efficiently, effectively and equitably implement nature-based solutions.
Greening the City: When and How

**DECISION CONTEXTS:**

1. Global policy on urban growth and biodiversity protection
2. National policy on green space within cities
3. Green infrastructure planning for multiple benefits within a city
4. Decision-making for individual green spaces in a city
Local to city scale

MINNEAPOLIS & ST. PAUL
Green infrastructure and land use change

Effects of potential land use change on ecosystem services in 135 Twin Cities golf courses

Automated land use change scenarios approach generalizable to any land use “typology”

Urban heat island, nutrient run off, biodiversity and more
Land-use change comparison
Metropolitan scale

Paris Metro Region

Slides from Anne Guerry, Perrine Hamel, and CIRED
PARIS: Goals of the IDEFESE project

Institutional analysis
- Understand where information on ES can be the most effective

Spatial analyses of ES, now and under future climate
- Assess climate change and future urban plans scenarios

Analysis of inequalities
- Assess access to services by different population groups
Regional masterplan for Ile de France (revised every ~8yr)
Pollination service

Change in pollination service within agricultural regions under future climate and land use change
Multicity scale

CHINESE AND US PILOT CITIES
Urban ES assessment in China

**Partnership cities in China**
- Dalian
- Beijing
- Shanghai
- Guangzhou
- Shenzhen

**9 ecosystem services**
- Air Purification
- Heat-island Regulation
- Carbon Sequestration
- Water Purification
- Biodiversity Conservation
- Noise Abatement
- Runoff Regulation
- Non-point Resource Pollution Regulation
- Daily leisure service

**Demand for the development of Urban InVEST**
- Inform urban planning decisions
- Increase residents’ wellbeing in city.
**Soil conservation**

*Keep 2.82 million t soil*

**Heat mitigation**

*Average cooling 1.99 °C*

**Carbon sequestration**

*Seque. 300 thousand t CO₂*

*Relea. 220 thousand t O₂*

**Estate landscape premium**

*16 billion RMB 销售溢价*

**Releas. 220 thousand t O₂**
US cities - Urban Heat Island

Atlanta
GA

Dallas
TX

Philadelphia
PA

Phoenix
AZ

San Francisco
CA

Minneapolis-St Paul
MN
Nature in the Urban Century

A global assessment of where and how to conserve nature for biodiversity and human wellbeing
Report Findings Dashboard

Urban Growth:
- By 2050, there will be 2.4 billion more people in cities.
- This rate of urban growth is the equivalent of building a city with the population of London every 7 weeks.
- Humanity will urbanize an area of 1.2 million km², larger than the country of Colombia.

Coastal Resilience:
- Coastal habitats reduce the risk of coastal hazards, such as coastal flooding and erosion during storms.
- By 2030, urban area is forecast to more than double, to 23,000 km² in low-lying coastal zones where natural habitat plays a critical role in reducing coastal hazards.

Natural Habitat:
- 1992 - 2000
  - Urban growth was responsible for 190,000 km² of natural habitat lost.
  - 29% of strictly protected areas were less than 50 km from urban areas.
- 2000 - 2030
  - Urban growth could threaten 290,000 km² of natural habitat.
  - 40% of strictly protected areas are projected to be within 50 km of an urban area.

Carbon Storage:
- In business as usual scenario, urban growth would destroy natural habitat that stores an estimated 4.35 billion metric tons of CO₂.
- This is the equivalent of carbon dioxide emissions from 931 million cars on the road for one year.
- Globally avoiding the release of carbon from habitat loss due to urban growth has a social cost of 182.8 billion USD.

*as defined by IUCN's Protected Area Categories

This increases the number of urban dwellers dependent on natural ecosystems in coastal areas.
InVEST, integrated valuation of ecosystem services and tradeoffs, provides maps of benefits such as heat mitigation, carbon sequestration, mortality reduction, energy savings, etc. Input data reflect scenarios, with models supplying ecosystem service outputs and valuations.
URBAN COOLING
URBAN FLOOD RISK MITIGATION
STORMWATER RUNOFF RETENTION
URBAN RECREATION
MENTAL HEALTH
URBAN BIODIVERSITY
PHYSICAL ACTIVITY
AIR FILTRATION
MORE TO COME…

Developed on external platform with CAS
Twin Cities, MN

InVEST Results

Sensor/Satellite Reference Data

Paris, France

$r^2 = 0.74$, mean error $0.14 \degree C$

$Hamel$ et al. (in prep)

$r^2 = 0.86$

$r^2 = 0.74$

$r^2 = 0.53$, mean error $0.14 \degree C$
Urban Flood Risk Mitigation
Urban Flood Risk Mitigation Model overview

**Supply:** Water Retention During Large Storm(s)

**Service:** Reduction of Floodwater Volume in Flood-Prone Areas

**Value:** Avoided Flood Damage ($ / ¥ / €)

For a large storm event:
- Volume of rainfall-runoff retained by the landscape
- Volume of surface runoff
- How much flood damage is potentially avoided due to retention? And where?

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Urban Flood Risk Mitigation Model overview

**Storm event (rainfall) volume, \( P \)**

**Peak flow volume, \( Q_{peak} \)**

**Watershed peak flow, \( \sum Q_{peak,i} \)**

**Retention volume, \( R \)**

**Retention Volume (\( R_i \)):** \( R_i = P - Q_{peak,i} \)

**Retention Index (RI):** \( RI = \frac{R_i}{P} \)

Stanford University
Model Inputs

**Climate**
Storm Depth (mm)

**Soils**
Hydrologic Soil Group (HSG)

**Land Use/ Land Cover (LULC)**
Curve Number

**Sub-Watersheds**
Areas of interest

**Bio-Physical Table**
Assigns Curve Numbers to Pixels by HSG and LULC

**Flood-prone areas (Optional)**
for Valuation

**Buildings (Optional)**
Damage cost
Model Outputs

Runoff Retention Map
- MM, m³, and Index (R/P)

Shapefile (Summary per Sub-Watershed):
- Runoff retention index (average)
- Runoff retention in m³ (Sum)
- Potential damage cost ($)
- Potential service ($/m³)

Peak Flow Retention (m³)

- 22  Low
- 23.8
- 25.6
- 27.5
- 29.3
- 31.1
- 32.9
- 34.6
- 36  High

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Urban Stormwater Retention Model overview

Supply:
Stormwater retention
*(long-term – annual)*

Service:
Reduction of stormwater volume and associated pollutants

Value:
Economic (replacement cost), Other Valuation TBD

- Pixel-based (raster) application, no cell-to-cell routing currently
- Runoff volume and pollutant runoff export are functions of retention coefficient and pollutant concentrations
- *Retention coefficient* is function of soil type and land cover
- Pollutant concentration (nitrogen, phosphorus) is function of land cover
InVEST Urban Stormwater Retention Model

**Land Cover** (aggregated from NLCD): n=9

1. Open Space, Developed  
   < 20% Impervious
2. Low-Intensity Developed  
   20 – 50% Impervious
3. Medium-Intensity Developed  
   50 – 80% Impervious
4. High-Intensity Developed  
   80%+ Impervious
5. Bare Soil  
   Vacant / Un-vegetated
6. Grass/Shrubs, Undeveloped
7. Forest, Undeveloped
8. Water
9. Agriculture  
   Cropland

**Optional: Street Centerlines**  
(surrogate for storm sewers; adjustment to retention)

**Soil Type** (Hydrologic Soil Group) n=4

A. High Infiltration (Sandy)
B.
C.
D. Low Infiltration (Clayey)

**OUTPUTS** (aggregated pixels over area of interest)

- Runoff Volume (Annual)
- Runoff Nutrient Export  
  \( \text{volume} \times \text{concentration} \)
- Potential Groundwater Recharge

**Biophysical Property Table**

<table>
<thead>
<tr>
<th>LC</th>
<th>HS G</th>
<th>Reten. Coeff.</th>
<th>TP Conc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>0.92</td>
<td>0.30</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>0.68</td>
<td>0.52</td>
</tr>
</tbody>
</table>
Example: Urban Stormwater Retention*

Dallas, Texas, USA

**Land Use/Land Cover**

- Soil Hydrologic Group
- Road centerlines (surrogate for storm sewers)
- Mean annual rainfall

**OutputS**

- Volume Retention (Annual Retained Rainfall)
  - Also Volume Export (Annual Runoff Volume)
- TP Retention (Annual Retained TP / Total TP Runoff Generated)
  - Also TP Export (Annual TP Export)
- TN Retention (Annual Retained TP / Total TP Runoff Generated)
  - Also TN Export (Annual TP Export)

*Retention = Infiltration + Evaporation*
Example: Urban Stormwater Retention

Dallas, Texas, USA

**Volume Retention Ratio**
Annual Retention / Rainfall
(1 = All Rainfall Retained, 0 = All Rainfall Becomes Runoff)

**Total Phosphorus Retention Ratio**
Annual Retained TP / Total Runoff TP
(1 = All Runoff TP is Retained, 0 = All Runoff TP is Exported)
Recreational access
Recreation model overview – demand/supply approach

Balance = \( m^2 \) green space/capita - \( m^2 \) green space/capita

Multi-level

- Individual level: Capita green space budget
- Collective level: Total green space budget at multiple levels

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Supply of urban green space (UGS)

Two step floating catchment area method

\[ r_j = \frac{s_j}{pop\_total} \quad ai = \sum_{j \in \{d_{ij} \leq d_0\}} r_j \]

Demand for urban green space

Policy targets or preferences

E.g.:
- 10 m² green space/capita
- Within 500m from residence

\[ S_j: \text{the area of UGS } j; \]
\[ pop\_total: \text{the population within the search radius of UGS } j \]
\[ ai: \text{UGS provided to i population point (m²/cap)} \]
Recreational Access - Paris

Land cover

Population

Liu et al. (in prep)
Wallpapering tool
Wallpapering: A parcel-based approach to simulate land use change
Example of Wallpapering Scenarios (we chose five)
Wallpaper in scenario analysis: Urban cooling

Change in Land Use

Golf Course  Natural  City Park  Low-Density Resi  High-Density Resi  Industrial

Change in Air Temperature

Air Temperature

Scenario

Wallpaper in scenario analysis: Urban cooling
RESEARCH: URBAN NATURE AND HEALTH
Mental health
Review – working group – conceptual model – (model)

SOCIAL SCIENCES

Nature and mental health: An ecosystem service perspective

Gregory N. Bratman\textsuperscript{1,2,3,4,*}, Christopher B. Anderson\textsuperscript{3,5}, Marc G. Berman\textsuperscript{6,7}, Bobby Cochrane\textsuperscript{8}, Sjoerd de Vries\textsuperscript{9}, Jon Flanders\textsuperscript{10,11}, Carl Folke\textsuperscript{12,13,14}, Howard Frumkin\textsuperscript{15,16}, James J. Gross\textsuperscript{17}, Terry Hartig\textsuperscript{18,19}, Peter H. Kahn Jr.\textsuperscript{1,20}, Ming Kuo\textsuperscript{21}, Joshua J. Lawler\textsuperscript{1,2}, Phillip S. Levin\textsuperscript{1,2}, Therese Lindahl\textsuperscript{14}, Andreas Meyer-Lindenberg\textsuperscript{23}, Richard Mitchell\textsuperscript{24}, Zhiyun Ouyang\textsuperscript{25}, Jenny Roe\textsuperscript{26}, Lynn Scarlett\textsuperscript{27}, Jeffrey R. Smith\textsuperscript{3,5}, Matilda van den Bosch\textsuperscript{28,29}, Benedict W. Wheeler\textsuperscript{30}, Mathew P. White\textsuperscript{30}, Hua Zheng\textsuperscript{25}, Gretchen C. Daily\textsuperscript{2,4,5,31,*}

A growing body of empirical evidence is revealing the value of nature experience for mental health. Urbanization and declines in human contact with nature globally, crucial decisions must be made to preserve and enhance opportunities for nature experience. Here, we first provide points of consensus across natural, social, and health sciences on the impacts of nature experience on cognitive functioning, well-being, and other dimensions of mental health. We then show how ecosystem service assessment can be expanded to include mental health, and provide a heuristic, conceptual model for doing so.

Fig. 1. A conceptual model for mental health as an ecosystem service.
Nature and physical activity in cities

• International working group
  • Literature review and synthesis
  • Conceptual model
  • Research and modelling frontiers
Poll Question

Which urban models would you want to use or see developed by NatCap?

- Urban cooling
- Urban water models
- Health models
- Biodiversity
- Other

InVEST
integrated valuation of ecosystem services and tradeoffs
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1:55 - 2:00 - Wrap up: Jesse

Post-Event Survey

*including questions & answers
10 Minute Break

Sign Up for the NatCap Newsletter
to get the latest news on our tools, projects, and research
naturalcapitalproject.stanford.edu/sign-our-newsletter

Enroll in NatCap’s MOOC
Introduction to the Natural Capital Project Approach
edx.org/course/introduction-to-the-natural-capital-project-approach

investsummer2020@gmail.com
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naturalcapitalproject.stanford.edu/impact/invest-virtual-workshops
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DEEP DIVE

URBAN COOLING MODEL
Urban Cooling Model

Motivating Questions:

- Can we accurately predict air temperature and the urban heat island impact in cities based on biophysical relationships?
- Can we analyze changes in these metrics given scenarios of change (e.g. land use, climatic)
Model overview

**Supply:**
Reduction of air temperature

**Service:**
Reduction of heat stress

**Value:**
Avoided energy use (A/C), improved work productivity

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Supply | Model Inputs

**Climate**
- Background temperature
- Reference evapotranspiration
- Maximal UHI effect

**Land Use/ Land Cover (LULC)**
- Raster data
- Associated biophysical parameters

**Area of interest**
- Neighborhood or city

**Buildings (optional)**
- Footprints and energy use
For each Land Use category:

- **Albedo**: proportion of solar radiation reflected
- **Kc**: crop evapotranspiration coefficient
- **Shade**: proportion of tree cover or other substantial sources of shade
- **Green Area**: binary indicator of ‘green area’ potential, with larger (>2ha) green areas providing additional cooling
- **Building Intensity**: ratio of building floor area to land area
Cooling Capacity Index ($CC_i$)

**DAYTIME METHOD**

$$CC_i = 0.6 \times \text{shade} + 0.2 \times \text{albedo} + 0.2 \times \text{evapotranspiration}$$

**NIGHTTIME METHOD**

$$CC_i = 1 - \text{building intensity}$$

Zardo, et al. 2017
Supply | Biophysical Model

- Calculate **cooling capacity** from input data
- **Nighttime** or **daytime** methods

**Heat mitigation**

- Evaluate spatial interactions
- **Air blending**
- Proximity to large contiguous ‘**green areas**’

**Temperature**

- Scale heat mitigation index based on urban heat island **magnitude** to get urban heat island **impact**
- Apply urban heat island impact to baseline temperate to get **overall air temperature**
Air Temperature (Modelled)

Productivity
- Convert temp and humidity to wet bulb globe temp
- Use international standards to calculate reductions in work capacity (or work time) based on WBGT, for different sectors
- Convert lost work capacity to economic loss

Energy cost
- Local estimates of energy consumption increase per degree of temp, for different building categories
- Calculate the difference in energy consumption between maximum temp (including UHI) and modelled temp (likely reduced due to green infrastructure)
Based on estimates of loss of work capacity (e.g. Kjellstrom et al. 2009):
Valuation | Energy Cost

Based on relationship between energy consumption and temperature
• see e.g. Santamouris et al. 2015

\[
\text{Energy savings}(b) = \text{consumption.increase}(b) \times (\overline{T_{\text{air,MAX}}} - T_{\text{air,i}})
\]

Where consumption.increase(b) (kW/degree) is the local estimate of the energy consumption increase per each degree of temperature, for building category b; \( T_{\text{air,MAX}} \) (degC) is the maximum temperature over the landscape (\( T_{\text{air,ref}} + UHI_{\text{max}} \)); \( \overline{T_{\text{air,MAX}}} - T_{\text{air,i}} \) (degC) is the average difference in air temperature for building b), with \( T_{\text{air,i}} \) modeled in the previous steps.
Valuation | Morality + Morbidity — NOT IN THE MODEL

- Average % change in mortality due to 1 degree C increase in temp
  - see example tables in *Bunker et al. 2016* for the elderly; or *Bobb et al. 2014* for US only

- **World Health Organization** method
  - Chapter 2.3 of 2014 report on “Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s”
Data Sources | UHI Magnitude

SUPPLY:

1. Cooling capacity index ~ shade + evapotranspiration + albedo
2. Spatial interactions (cooling next to parks + dispersion)
3. Scaling of the index based on estimated UHI

https://yceo.users.earthengine.app/view/uhimap

Chakraborty and Lee 2019
Model outputs

Rasters:
- Cooling capacity and heat Mitigation
- **Air temperature (degree C)**

Shapefiles (Aoi and Buildings):
- Average CC value (-)
- Average temperature value (degC)
- Average temperature anomaly (degC)
- (Optional) Avoided energy consumption ($)
- (Optional) Average WBGT (degC)
- (Optional) Loss.light.work (%)
- (Optional) Loss.heavy.work (%)

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Running the model | Example Data

Inputs

Results

Alternative Scenario

Temperature Difference
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Post-Event Survey

*including questions & answers
Equity + Urban InVEST

A PRELIMINARY METHODOLOGY
Defining ‘equity’ for Urban InVEST

**DISTRIBUTIONAL EQUITY**
- How are resources distributed?
- Who benefits from natural capital?
- Who is harmed by their environment?

**PROCEDURAL EQUITY**
- Who gets to decide how resources are distributed?
- Who is ‘at the table’ in a meaningful way?
- Who is the decision-maker? Who started the process? Why?
The Disparities Metric

- Who benefits (or is harmed) and where?
- Based on **covariance**:
  - Spatially-decomposable deviation from the mean

![Graph showing Δ UHI vs Δ % Socio-Economic Metric](image)

**Δ % Socio-Economic Metric**
(e.g. Impoverished Population)

**Δ UHI**
Positive

Negative
The Disparities Metric: In Practice

Model some ecosystem service
- Urban Cooling Model -> Air Temperature

Overlay results with socio-economic data
- poverty, race, education, etc

Compare socio-economic metrics with ecosystem services

Minneapolis, MN
The Disparities Metric: In Practice
The Disparities Metric: In Practice
The Disparities Metric: Scenarios

Current

Poverty Disparity metric: 0.05

Scenario

Poverty Disparity metric: 0.04
Green Gentrification

In Atlanta’s Old Fourth Ward neighborhood (the historic Black community where Martin Luther King Jr grew up), housing prices skyrocketed and white residents now outnumber Black residents after green infrastructure investments like stormwater systems and a bike greenway.
Displacement typology

Base year (ex. 2010)
- Vulnerable
- Neither
- Exclusive

Current Year
- ‘At risk’
- Gentrifying
- Neither
- Remaining Exclusive
Displacement typology

Vulnerable

- Housing value or rent < 80% regional
- At least 2:
  - % poverty > regional
  - % college educated < regional
  - % BIPOC > regional
  - % renters > regional
Displacement typology

- Housing value or rent < 80% regional
- At least 2:
  - % poverty > regional
  - % college educated < regional
  - % renters > regional

Deconstructing Gentrification Risk Vulnerability (2014)

Rent
- House Value
- Poverty
- College
- % BIPOC
- Renters
Displacement Typology

- Raises **warnings** (‘flags’) about the potential impacts of investment in green infrastructure.
- Works as a check against the simple Disparities Metric:
  - Investing heavily in areas with **high disparity** (low income, high UHI) might increase **displacement risk**.
This scenario funnels funding into areas [at high risk of] / [experiencing] gentrification from these interventions.

We recommend these resources on anti-displacement strategies.
This intervention spreads funding and benefits across communities. Based on current spatial demographics, it could lead to a [significant, negligible] decrease in racial and economic disparities.

We recommend these resources on anti-displacement strategies.

Equity is about power and inclusion.
Given the socio-demographics of intervention areas, we recommend reaching out to the following communities, ensuring they are equitably at the table:

- [Latinx community]
- [Hmong community]
- [Lower-middle class renters]
- [People at risk of homelessness]

This intervention spreads funding and benefits across communities. Based on current spatial demographics, it could lead to a [significant, negligible] decrease in racial and economic disparities.

Equity is about power and inclusion. We recommend these resources on anti-displacement strategies.
Thank You!
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Post-Event Survey

*including questions & answers
Please take our SURVEY
Menti.com Question

Where do you see your work intersecting with Urban InVEST?

Please go to menti.com and enter code to participate:

28 25 38 8
Appendix 1: Data Sources

This is a rough compilation of data sources and suggestions about finding, compiling, and formatting data, providing links to global datasets that can get you started. It is highly recommended to look for more local and accurate data (from national, state, university, literature, NRO and other sources) and only use global data for final analyses if nothing more local is available.

Digital Elevation Model (DEM)

DEM data is available for any area of the world, although at varying resolutions.

User Guide
releases.naturalcapitalproject.org/invest-userguide/latest

Community Forum
community.naturalcapitalproject.org
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Introduction to the Natural Capital Project Approach
naturalcapitalproject.stanford.edu/impact/invest-virtual-workshops
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- Continue to learn about how the Natural Capital Project’s approach is used in diverse applications around the world
Natural Capital Visualization Gallery

- [viz.naturalcapitalproject.stanford.edu](viz.naturalcapitalproject.stanford.edu)
- Navigate through examples of interactive viewers and dashboards
- Resources to facilitate synthesizing, visualizing, and communicating ecosystem services data
Social Media

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0:00 - 0:05 - Welcome: Jesse
0:05 - 0:45 - Introduction to Urban InVEST: Roy*
0:45 - 0:55 - BREAK
0:55 - 1:45 - Urban Cooling model: Chris*
1:45 - 1:55 - New developments for urban planning: Chris
1:55 - 2:00 - Wrap up: Jesse

Post-Event Survey

*including questions & answers
Please take our SURVEY