Preservation within a Full Spectrum of Reuse

Scenario Planning Technologies to Plan Circular Futures

Introductory Handbook to Principles, Tools, and Practices

December 2025

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Table of Contents

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This project was divided into two phases. The first phase focused on the development of an Agent-Based Model (ABM) to explore developer decision-making along a spectrum of reuse in the built environment. The second phase was devoted to 3D Modeling, LCA analysis, and the development of an ESRI StoryMap web platform.

We wish to acknowledge the entire project team, including: Farzin Lotfi-Jam, Realtime Urbanism Lab (PI, Co-PI); Jennifer Minner (PI, Co-PI), Just Places Lab; Courtney Bower (Co-PI), Just Places Lab; Xinyu Tang, Realtime Urbanism Lab; Jebreel Bessiso, Realtime Urbanism Lab; Jessica Kaiman, Realtime Urbanism Lab; Hung Ming Tseng, Realtime Urbanism Lab; Sun Ho Synn, Realtime Urbanism Lab; DongHak Lee, Just Places Lab; Vanessa Yang, Realtime Urbanism Lab; Nisarg Shah, Just Places Lab; and Ash Kopetzky, Just Places Lab.

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How to Use this Handbook

This handbook is designed for historic preservation professionals, planners, architects, researchers, and others interested in using emerging concepts, methods, and technologies to shape more sustainable and circular urban futures. The handbook introduces key ideas, including circularity, embodied carbon, and a spectrum of reuse in the built environment. It explores how these concepts intersect with historic preservation and climate action.

Readers will find practical guidance on how tools such as scenario planning, agent-based modeling, life-cycle analysis, and 3D visualization can be utilized to inform decision-making at multiple scales, ranging from individual sites and historic districts to community-wide planning efforts. Real-world applications of these technologies are then discussed for readers to consider and adapt to their own context. This handbook provides examples of how these technologies can be used in preservation, architecture, planning, and other allied professions.

The examples in the handbook were developed in research within the city of Ithaca, New York. This is a link to the GitHub site with the agent-based model: https://github.com/RealtimeUrbanismLab/ithacaDeveloperABM.

The Appendix includes an example survey of developers that laid the foundation of an agent-based model.

The following are links to ArcGIS StoryMaps with detailed examples of 3D models and life cycle analysis with case study scenarios at the site scale.

Main StoryMap:

- Preservation within a Spectrum of Reuse

Individual Case Study StoryMaps:

- Site 1: Adapting a New Government Space
- Site 2: Student Housing
- Site 3: Collegetown Mixed-Use
- Site 4: Collegetown Historic Fire Station and Mixed-Use
- Site 5: Whole Block Redevelopment
- Site 6: Landmark Train Station Revitalization
- Site 7: Vintage Gas Station to Welcome Center

Figure 1 shows a matrix of scenarios that were created in this project. Given the complexity of BIM models, the underlying Revit models are available by contacting the authors.

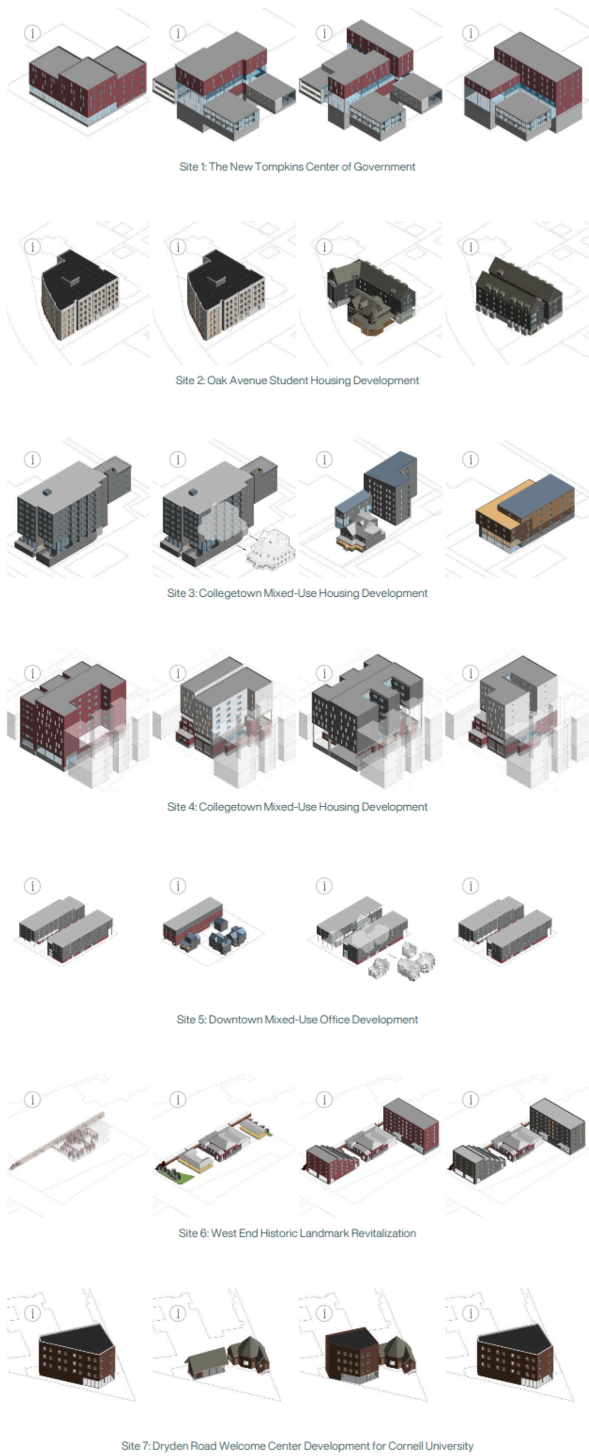

Figure 1. Twenty-eight scenarios were created in this project and presented in ESRI StoryMaps.

I. A Full Spectrum of Reuse in Planning Circular Futures

As cities face cascading challenges, from climate change to rapid redevelopment to vacant buildings and escalating technological and societal changes, the need for thoughtful, adaptable city strategies becomes more urgent. Among the allied fields addressing these challenges, historic preservation has a critical role to play. At its core, preservation is about managing change by shaping approaches to maintenance and care of the built environment. It provides an important framework for working with the existing built environment in ways that honor past histories and respond to present needs.

Although preservation is sometimes perceived as a static endeavor aimed at freezing architecture and places in time, many professionals understand the field as dynamic and forward-looking. Preservation has long embraced a range of pragmatic and creative solutions for reusing, adapting, and interpreting the built environment. These practices are not just about protecting heritage but also about helping communities navigate complex urban futures.[1]

In this handbook, we approach preservation as part of a broader continuum of circularity and reuse strategies. Preservation's reach extends into the stewardship of both non-historic and historic resources, re-conceptualizing the entire urban fabric with a full spectrum of reuse options. This spectrum includes preservation treatments, adaptive reuse options, moving buildings, and the deconstruction of buildings and reuse of reclaimed materials to preserve built historic and non-historic resources, all of which help to move toward building a local circular economy.

This spectrum of reuse encompasses the treatments outlined in the Secretary of the Interior's Standards for the Treatment of Historic Properties, but it also extends beyond them.[2] It includes methods such as adaptive reuse, deconstruction, and building material reuse, relocation of structures, designing new buildings for longevity and disassembly, and reuse of buildings regardless of historic designation or significance.

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[1] Jennifer Minner, Felix Heisel, Joshua Lee, and Joseph Murray, "Preservation and Circular Construction: A Dialogue with Jenni Minner and Felix Heisel on Cultural Memory, Public Policy, and Inclusion," in Sustainable Design for Uncertain Futures: Dialogues on Time-based Architecture (London: Wiley, 2025), 76–93.

[2] U.S. National Park Service, "Secretary of the Interior's Standards for the Treatment of Historic Properties," last updated August 24, 2023, National Park Service, https://www.nps.gov/orgs/1739/secretary-standards-treatment-historic-properties.htm.

Circularity and a Spectrum of Reuse in Preservation

Preservation has long challenged the way the built environment is torn down prematurely, pointing to the retention of significant histories associated with buildings and other sites and structures. Circularity in the built environment, also described as a shift from a linear to a circular economy, offers a powerful framework to work toward sustainability.

The Ellen MacArthur Foundation defines the circular economy as:

> *a system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting. The circular economy tackles climate change and other global challenges, like biodiversity loss, waste, and pollution, by decoupling economic activity from the consumption of finite resources*.[3]

The environmental benefits of reusing existing buildings as an alternative to demolition have become increasingly clear.[4] Buildings are a significant source of *embodied carbon*, the greenhouse gas emissions produced through the extraction, manufacturing, and construction, maintenance, and end-of-life and storage of waste from demolition.[5] Keeping buildings in use, repurposing them, and reusing their materials when it is not possible to preserve them can contribute significantly to climate mitigation and adaptation strategies through the conservation and reduction of embodied carbon. These approaches are transformative, as they involve moving from a linear system of designing and maintaining the built environment to a circular one.

Scholarship and policy guidance have called for local governments to integrate preservation and broader building reuse into climate action.[6] In situations where buildings must be

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[3] Ellen MacArthur Foundation. "What Is the Circular Economy?" Ellen MacArthur Foundation. Accessed September 1, 2025. https://www.ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview. See also Felix Heisel, Dirk E. Hebel, and Ken Webster, *Building Better-Less-Different: Circular Construction and Circular Economy: Fundamentals, Case Studies, Strategies*, 1st ed. (Boston: Birkhäuser, 2022).

[4] Liam James Heaphy, and Philip Crowe, eds. "Aligning Heritage Conservation and Climate Mitigation Through Adaptive Reuse." *Urban Planning* 10 (2025). www.cogitatiopress.com/urbanplanning. Huuhka, Satu. "Understanding Demolition." *Buildings and Cities* 4, no. 1 (2023): 927–37. https://doi.org/10.5334/bc.398. Huuhka, Satu. "Circularity in the Built Environment: Proceedings of the 2025 Conference Held in Tampere, Finland, September 16–18 2025." Preprint, Tampere University, September 15, 2025. https://doi.org/10.5281/ZENODO.17092525.

[5] Carbon Neutral Cities Alliance and One Click LCA. *City Policy Framework for Dramatically Reducing Embodied Carbon*. 2020. https://www.embodiedcarbonpolicies.com/.

[6] See for example: Just Places Lab and CR0WD, Toward Building Sustainable Communities and Circular Economies: A Local Government Policy Guide to Alternatives to Demolition through Deconstruction and Building Reuse (Ithaca, NY: Just Places Lab and CR0WD, 2023), https://.aap.cornell.edu/just-places-lab/publications. Jennifer Minner,

dismantled, deconstruction policies can encourage material recovery, job creation, and the reduction of landfill waste (PlaceEconomics, 2021; CR0WD and Just Places Lab, 2022). These approaches offer pathways to apply circular principles in city planning and historic preservation.

Figure 2 is a Building ***Reuse to Waste Hierarchy*** that illustrates the most preferred to least preferred strategies for the treatment of buildings. At the top of this is *Building Maintenance, Preservation, and Refurbishment.* These actions preserve embodied carbon in place, reducing the need to expend greenhouse gases by retaining buildings. The next preferred set of methods extends the life of buildings through adaptive reuse, the expansion of buildings, or the relocation of buildings. These may involve the expenditure of more greenhouse gases, but still conserve embodied carbon in existing structures.

If the life of buildings cannot be extended, the deconstruction of buildings is the next preferred strategy. Deconstruction is the systematic dismantling of buildings. After this, demolition with the recycling of building materials is preferred over demolition. This strategy typically requires more intensive expenditure of carbon for the processing of materials, but reduces landfill waste and contributes to the economy through the production of new materials.

Jocelyn Poe, Felix Heisel, Ash Kopetzky, Maya Porath, and Gretchen Worth, *Embodying Justice in the Built Environment: Circularity in Practice* (Ithaca, NY: Cornell University, April 15, 2024).

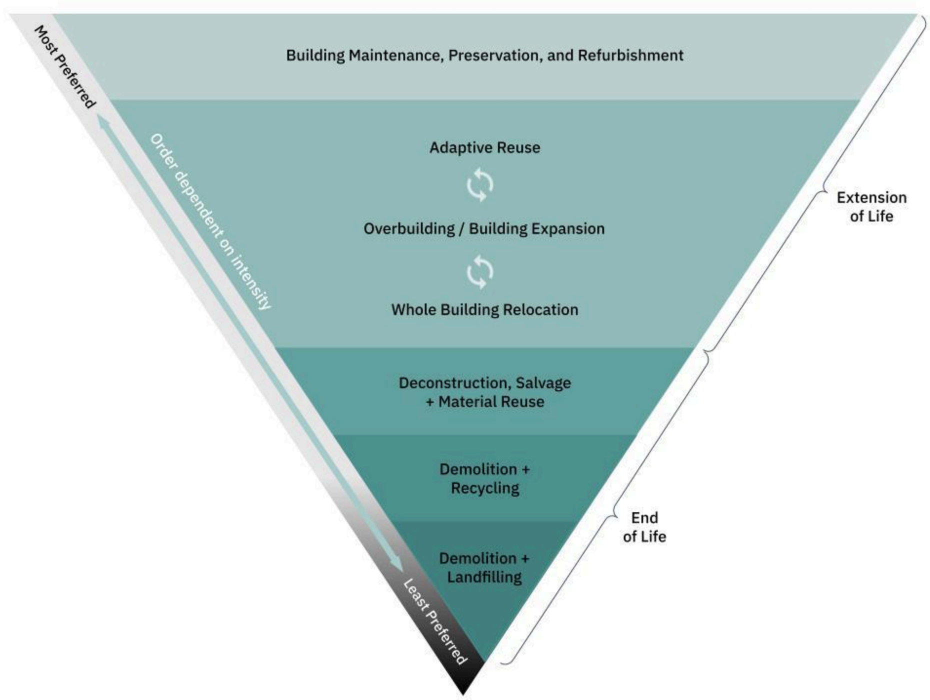

Figure 2. Building Reuse to Waste Hierarchy. Developed by Wyeth Augustine-Marceil and additional researchers in the Just Places Lab.

Preservation professionals are typically concerned with the very top of this hierarchy, as they strive to retain historic resources over time. However, not every building can be preserved as a landmark and even some valuable historic resources are eventually lost. Preservation as a field can broaden its impact and advocate for circularity and sustainability in the built environment by considering the whole of building stock within cities and preservation within a full spectrum of reuse.[7]

Visualizing Urban Change and Expanding the Preservation Toolkit

Alongside policy developments, there is a growing suite of tools available to preservationists and planners to visualize, model, and assess urban change. These include 3D modeling, geospatial analysis, and life-cycle assessment (LCA). Such tools can help communities understand the environmental and cultural implications of development decisions, particularly as they pertain to building reuse.

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[7] See for example Susan M. Ross, "Re-Evaluating Heritage Waste: Sustaining Material Values through Deconstruction and Reuse," *The Historic Environment: Policy & Practice* 11, nos. 2–3 (July 2020): 382–408, https://doi.org/10.1080/17567505.2020.1723259.

This handbook is designed to aid preservation professionals, planners, researchers, educators, and other design professionals in using these tools within the context of exploratory scenario planning. By integrating scenario thinking into preservation practice, we can better explore a range of possible futures and develop strategies that are resilient, inclusive, and aligned with sustainability goals.

Scenario Planning to Explore Urban Futures

There are significant opportunities to advance preservation practice through the use of scenario planning and digital modeling techniques that support decision-making. Scenario planning is a participatory method that engages stakeholders in exploring multiple plausible futures to inform strategic and comprehensive planning.[8] Although widely used in fields like transportation and regional planning, this approach has rarely been applied to historic preservation—an omission that this handbook seeks to address.

Our approach draws from a growing body of literature on scenario planning, 3D visualization, and agent-based modeling. These methods can help preservationists and planners visualize alternative futures, understand stakeholder perspectives, and evaluate the environmental and social impacts of various reuse strategies. In particular, 3D modeling has become an increasingly important tool in architectural practice for both historic documentation and proactive planning.[9] By integrating these methods, preservationists can more effectively contribute to shaping cities that are culturally rich, socially just, and environmentally resilient.

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[8] Robert Goodspeed. *Scenario Planning for Cities and Regions: Managing and Envisioning Uncertain Futures*. Lincoln Institute of Land Policy, 2020. Stapleton, Jeremy. How to Use Exploratory Scenario Planning (XSP): Navigating an Uncertain Future (Cambridge, MA: Lincoln Institute of Land Policy, 2020).

[9] Dingkun Hu, and Jennifer Minner. 2023. "UAVs and 3D City Modeling to Aid Urban Planning and Historic Preservation: A Systematic Review" *Remote Sensing* 15, no. 23: 5507. https://doi.org/10.3390/rs15235507. Minner, Jennifer S. and Jeffrey Chusid, “Time, Architecture, and Geography: Modeling the Past and Future of Cultural Landscapes,” APT Bulletin: Journal of the Association for Preservation Technology 47, no. 2–3 (2016): 49–58. Petra Hurtado and Gomez, Alexsandra. (2021, April 1). Smart City Digital Twins Are a New Tool for Scenario Planning. Planning Magazine.
https://www.planning.org/planning/2021/spring/smart-city-digital-twins-are-a-new-tool-for-scenario-planning/

II. Scenario Planning with Agent-Based Modeling

Agent-based modeling (ABM) is a simulation method used across many disciplines to explore how individual decisions and interactions generate larger patterns, such as urban forms or market dynamics. An agent-based model is a computerized environment that represents real-world actors—such as developers, property owners, city agencies, or preservation advocates—and encodes how their choices respond to policies, market conditions, and spatial constraints over time.

For preservation and circularity planning, ABM functions as a scenario planning tool: it can enable practitioners to define alternative policy or regulatory futures, simulate how different actors might respond under each one, and examine how those responses accumulate across a city. This makes it possible to compare scenarios in terms of demolition, deconstruction, reuse, and embodied carbon.

Although rarely used in preservation practice, ABM aligns well with the field's needs. This methodology can be used to test how specific interventions—such as reuse incentives, deconstruction requirements, or preservation subsidies—shape behavior at the parcel and neighborhood scales, and how these choices intersect with climate and equity goals.

This research project used ABM to simulate the interactions between actors who influence building and building material reuse in Ithaca, New York. The model integrated qualitative insights, a developer survey, and parcel-level spatial data to generate scenario-based futures along a spectrum of reuse. A version of the model is available on GitHub for practitioners who wish to adapt or extend it for their own communities (See Figure 3 below).[10]

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[10] See https://github.com/RealtimeUrbanismLab/ithacaDeveloperABM.

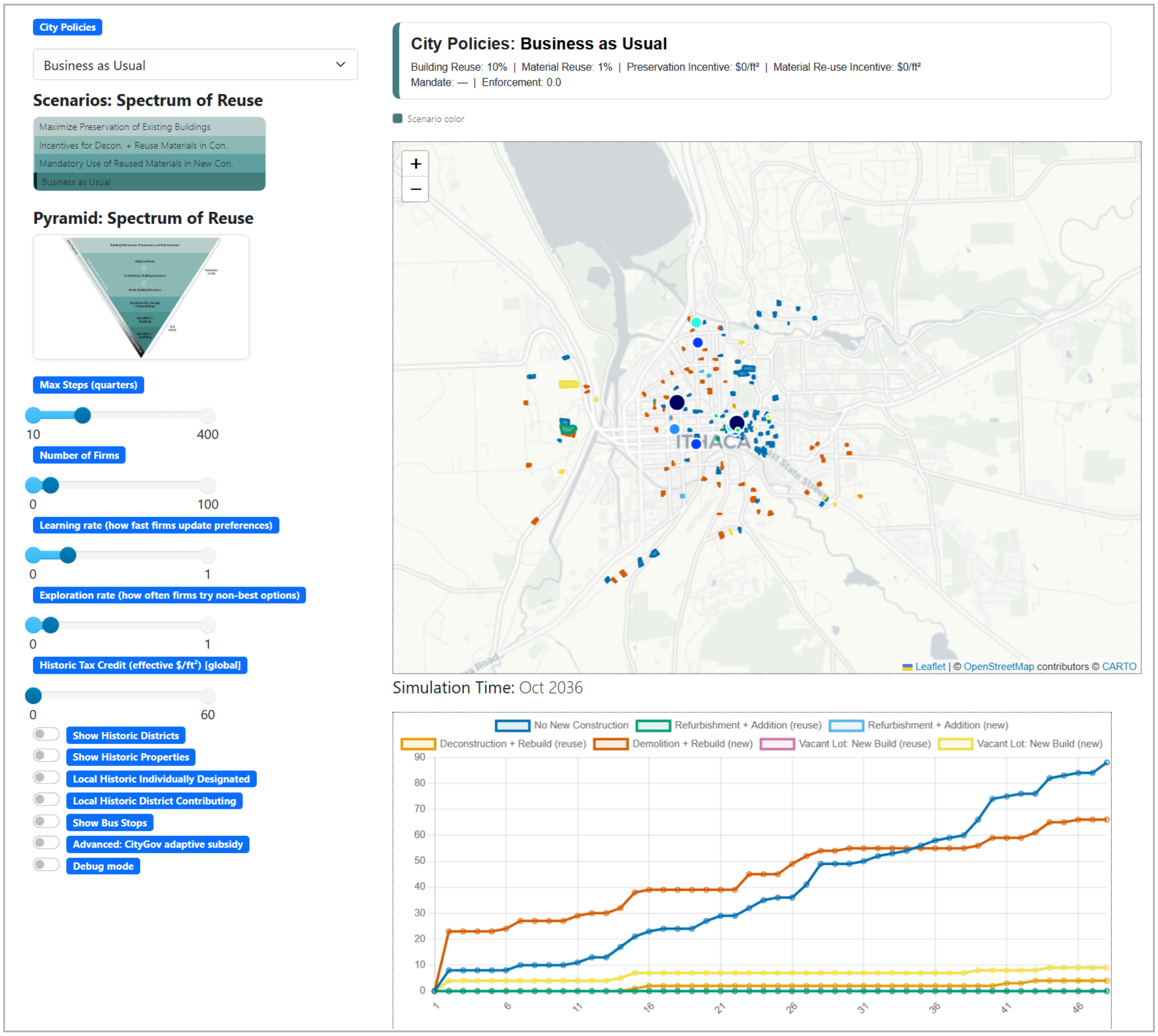


Figure 3. ABM dashboard. Realtime Urbanism Lab and Just Places Lab.

Why Consider Using An Agent-Based Model

Represent Diverse Decision-makers

Preservation and reuse outcomes emerge from many actors, each operating with different capacities, constraints, and knowledge. ABM offers a structured way to reflect this diversity. Agents can vary in capital resources, timelines, risk tolerance, and familiarity with reuse practices. This matters when evaluating scenarios where only some actors are likely or able to pursue deconstruction or deep reuse.

Connect Parcel-scale Conditions to Citywide Outcomes

Most preservation decisions are made one parcel at a time. ABM can be used to model these decisions and visualize them in relation to zoning, land values, historic overlays, building conditions, and infrastructure. The model developed here uses parcel-specific data to shape agent decisions, making it possible to trace how policy shifts or incentives would reshape patterns across neighborhoods and districts.

Evaluate Policy Scenarios Before Implementation

Scenario planning benefits from tools that clarify tradeoffs. ABM can test incentives for deconstruction, minimum reuse requirements, preservation subsidies, streamlined permitting, or hybrid approaches. By simulating thousands of decisions under different conditions, the model surfaces differences in embodied carbon, demolition frequency, reuse uptake, and spatial distribution of change.

Support Engagement and Shared Understanding

Because ABM outputs can be visualized, they help facilitate discussions among preservationists, planners, developers, neighborhood groups, and environmental advocates. Scenarios become something stakeholders can explore, question, and adjust. This strengthens transparency and builds a shared basis for decision-making.

What Tools Are Available

NetLogo

Useful for conceptual or instructional models, but it lacks native support for spatial data, limiting parcel-level urban modeling and integration with complex geospatial datasets.

Mesa and Mesa-Geo (Python)

Open-source, flexible, and well-suited to planning applications. Mesa-Geo reads GIS data directly, supports spatial querying, and integrates easily with data-science workflows. Browser-based interfaces make results legible to non-technical users.

GAMA, Repast, AnyLogic

Feature-rich environments for large or complex systems. These provide advanced modeling capabilities but require specialized expertise and often less transparent workflows.

GIS-based Scripting

Some teams encode simple agent logic within ArcGIS or QGIS. These approaches are easy to maintain but limited in representing adaptive behavior or multi-scenario decision-making.

For preservation and circularity planning, the most relevant criteria include:

- parcel-level spatial integration;
- ability to encode reuse pathways;
- transparent and adaptable rule sets;
- long-term maintainability without proprietary dependencies.

Tools Used in Our Study

Mesa-Geo (Python)

The ABM for this project was developed in Mesa-Geo to support parcel-level modeling, flexible decision rules, and a browser-based user interface.

Key components:

- **Agents** representing developer types identified through interviews and a survey;
- **Parcel environments** built from zoning, historic overlays, ILR ratios, infrastructure access, and building condition data;
- **Decision rules** shaped by qualitative findings, policy constraints, and cost/time assumptions for reuse, deconstruction, and new construction;
- **Reuse pathways** reflecting a spectrum from maintenance to full deconstruction;
- **Scenario toggles** comparing baseline, incentive-based, and requirement-based futures;
- **Outputs** measuring embodied carbon, demolition counts, levels of reuse, and spatial distribution of activity.

GIS Integration

Parcel and zoning data were prepared in QGIS and ArcGIS and linked directly to the model. This ensured that agent decisions reflected real environmental constraints.

Optional Visualization Links

Prototype work explored connecting ABM outputs to 3D viewers. While the handbook discusses 3D modeling separately, this integration points toward workflows where modeled scenarios generate visual massing or carbon impact views.

Figure 4 illustrates the model architecture that we created.

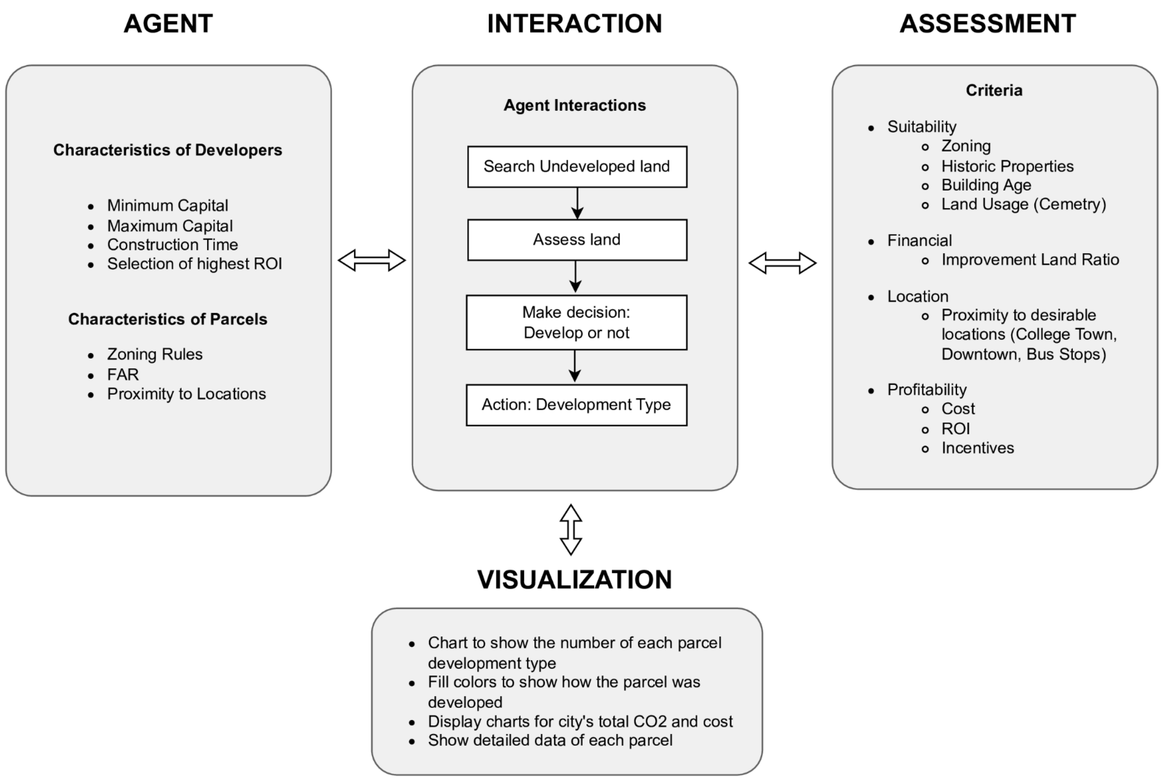


Figure 4. ABM Model architecture. Realtime Urbanism Lab and Just Places Lab.

Figure 5 Illustrates the way the model simulation works. Developers in the model assess parcels and then make assessments about how to develop properties along a spectrum of reuse, based on available land and profitability assessments. The parameters change in different community-wide scenarios. The carbon outputs are then estimated and compared.

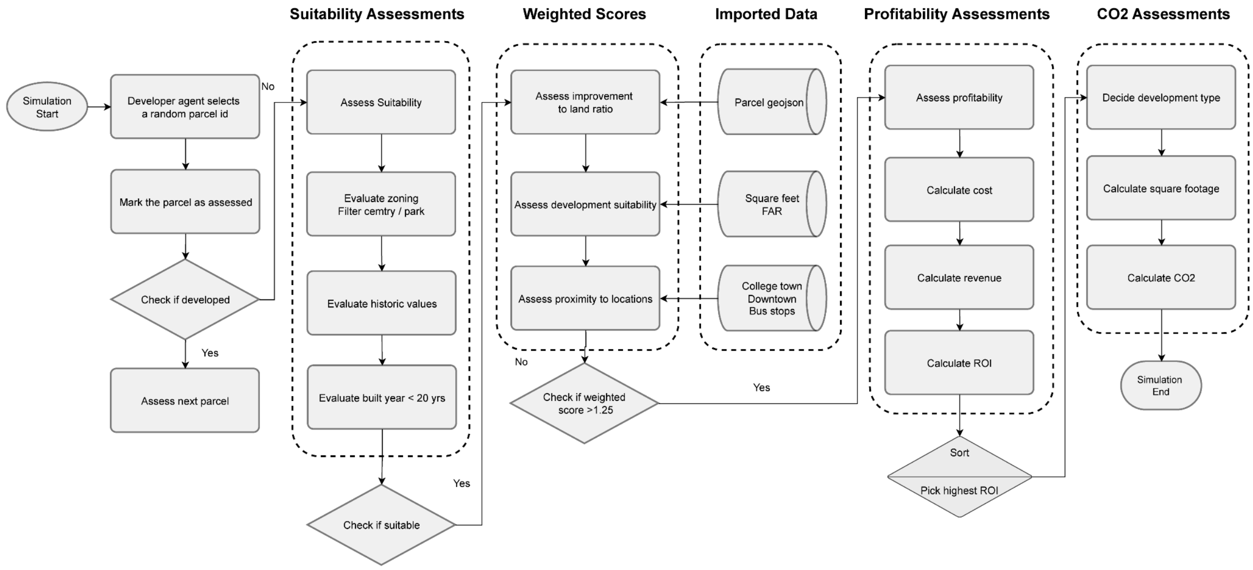


Figure 5. Model simulation flow chart. Realtime Urbanism Lab and Just Places Lab.

New Tools and Considerations

Embodied Carbon Integration

The ABM can incorporate simplified embodied-carbon factors to help compare scenarios in terms of demolition, deconstruction, and reuse. These factors are not calculated inside the model; instead, representative carbon values developed through external tools are linked to the ABM's inputs and outputs. A full explanation of embodied-carbon methods, tools, and workflows appears in Section IV.

Expanded Representation of Reuse Behaviors

As circular economy practices mature, models can include more granular actions—partial deconstruction, salvage-market participation, design-for-disassembly—that improve scenario granularity and allow practitioners to test a wider spectrum of reuse pathways.

Improved Data on Decision-making

Developer and owner behavior varies widely. Interviews, surveys, permit histories, and market data strengthen decision rules within the model. Preservation offices also hold inventories, condition assessments, and code violation records that can help refine agent attributes and environmental constraints.

Participatory Model Development

ABM benefits from early stakeholder engagement. When practitioners and community groups see their priorities reflected in agent definitions and scenario options, the model becomes a tool for shared problem solving.

Governance and Maintenance

Model assumptions, data sources, and rule definitions must be transparent. Long-term stewardship requires documentation, version control, and ongoing data updates.

Visualizing and Publishing Model Outputs

ABM outputs can be linked to platforms that animate spatial change and support interactive exploration. Game engines such as Unity and Unreal Engine can import geospatial data, represent parcel-level change, and animate development sequences or host the ABM itself. They provide high-fidelity visualizations suited to presentations, design charrettes, and public meetings that benefit from clear and cinematic communication.

Browser-based 3D frameworks, including Three.js and Babylon.js, allow similar scenario outputs to be presented directly in a web environment. These lightweight tools can be embedded in dashboards, planning websites, or interactive story maps, offering stakeholders an accessible way to engage scenarios without specialized software.

AI-assisted Development and Expanding Toolchains

AI programming assistants (e.g., ChatGPT, Claude, GitHub Copilot) now support coding across major ecosystems used for ABM and visualization, including Python, JavaScript, TypeScript, and C#. Their ability to generate code templates, translate logic between languages, automate data-handling routines, and assist with debugging has begun to change how simulation and visualization tools are developed.

In this project, most of the ABM and associated workflows were initially developed through manual coding, with AI-assisted programming tools becoming available only later in the research process. As a result, AI was used selectively rather than as a primary development method. Current-generation AI agents could substantially assist similar projects by accelerating iteration, supporting refactoring, and helping new teams understand and extend existing codebases.

At the same time, AI-assisted development does not remove the technical demands of this work. Building and maintaining an ABM remains data-intensive and resource-intensive, requiring careful preparation of spatial data, clear definition of behavioral rules, validation of assumptions, and ongoing model calibration. Architectural, planning, and computational expertise are still necessary to ensure that scenarios are technically sound and analytically meaningful.

As toolchains evolve, selecting languages and frameworks that align with robust AI support—such as Python-based ABM frameworks or C#-based environments like Unity—can improve long-term maintainability and collaboration. AI assistance should be understood as a complement to, rather than a replacement for, domain expertise and technical rigor.

III. Scenario Planning with 3D Visualization and Analysis

Why Consider 3D Visualization

3D modeling provides a spatial framework for evaluating preservation and building reuse, deconstruction, and new construction scenarios. 3D modeling methods allow practitioners to visualize massing, volumes, and adjacencies; assess alternatives at the parcel, block, or district scale; and integrate performance metrics such as embodied carbon, cost, or zoning capacity. As a scenario-planning tool, 3D visualization supports clearer communication with stakeholders and helps translate abstract strategies into spatially grounded options.

Scenario planning in 3D involves constructing alternative development futures for each parcel based on policy constraints, economic conditions, construction pathways, and reuse potential. These scenarios vary in functional use, floor area, construction systems, and deconstruction and building material reuse implications. Their spatial form directly affects embodied carbon, cost, and preservation outcomes. Developing these alternatives requires architectural and planning expertise to define feasible building-scale interventions and to ensure that modeled futures reflect the technical, regulatory, and material realities of circular construction.

Available Tools

A range of platforms support 3D visualization in planning and preservation:

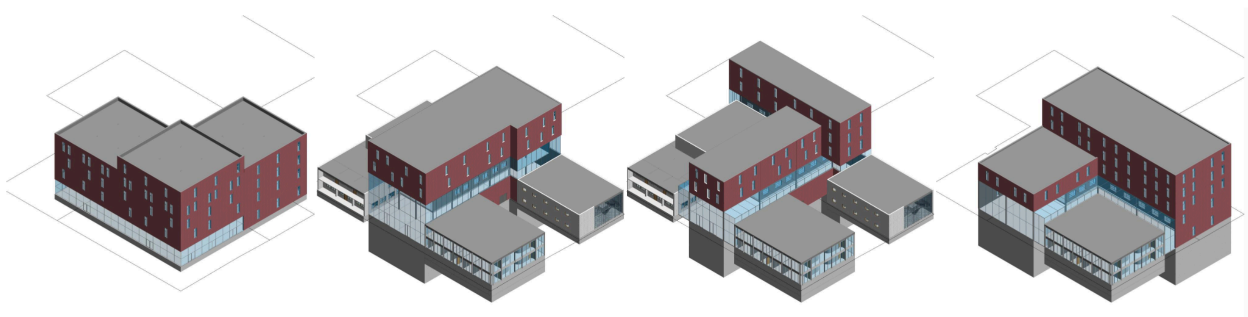
- **Building Information Modeling (BIM)**: Autodesk Revit enables detailed massing studies, material takeoffs (quantitative estimates of building components and materials), and structured attribute data that can feed into carbon or cost analysis.
- **GIS-based 3D visualization**: ArcGIS Pro and Scene Viewer can display 3D buildings with attributes linked to policies, reuse scenarios, or carbon impacts.
- **Web-based 3D viewers**: ArcGIS Online, CesiumJS, and custom WebGL applications (e.g., Three.js) provide accessible, browser-based environments for interacting with models.
- **Interoperable formats**: IFC, OBJ, and glTF support movement of 3D assets across BIM, GIS, and web platforms.

These tools differ in resolution, data structures, and intended audiences, but together they form a pipeline for scenario exploration and public engagement.

Tools Used in Our Study

In our research project, the team developed a BIM model in Revit to generate and compare reuse and redevelopment scenarios through massing studies. These models provided parcel-level alternatives, building attributes relevant to reuse and deconstruction, and structured geometry suitable for embodied-carbon and cost assessment (Figures 6a-g below). Embodied-carbon estimates were produced using Revit-based workflows, including the Tally plug-in, and are discussed in detail in Section IV.

Revit outputs were exported into ArcGIS Pro as georeferenced 3D layers. From ArcGIS Pro, the models were published as 3D web scenes and integrated into StoryMaps, enabling interactive, narrative-driven scenario exploration for expert and public audiences.



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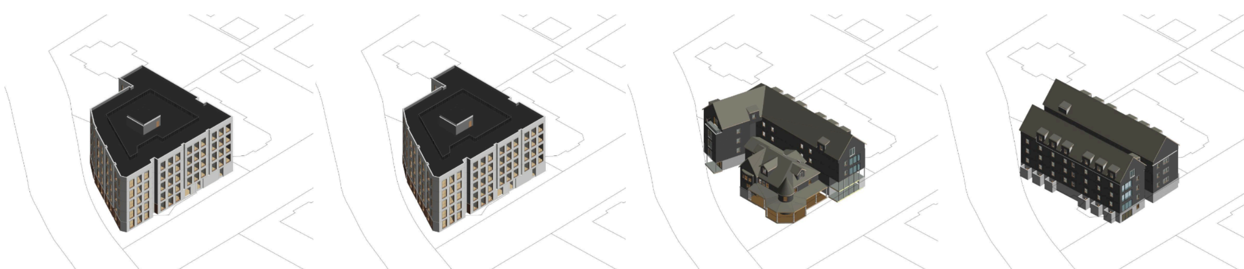

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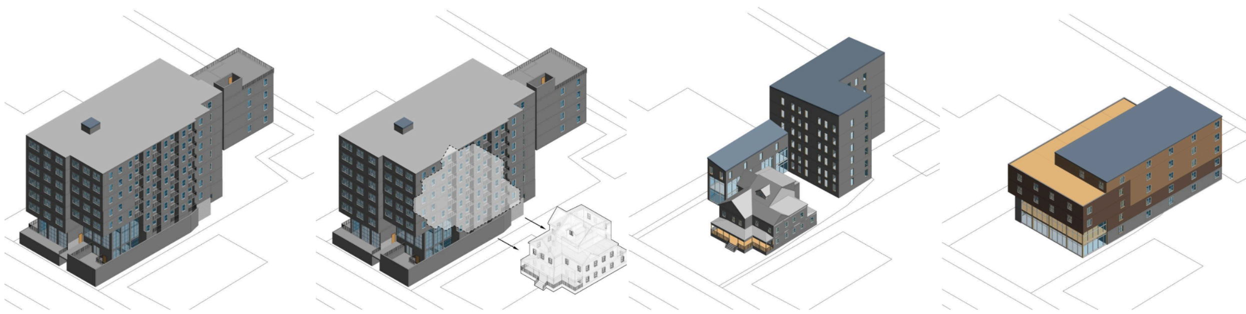

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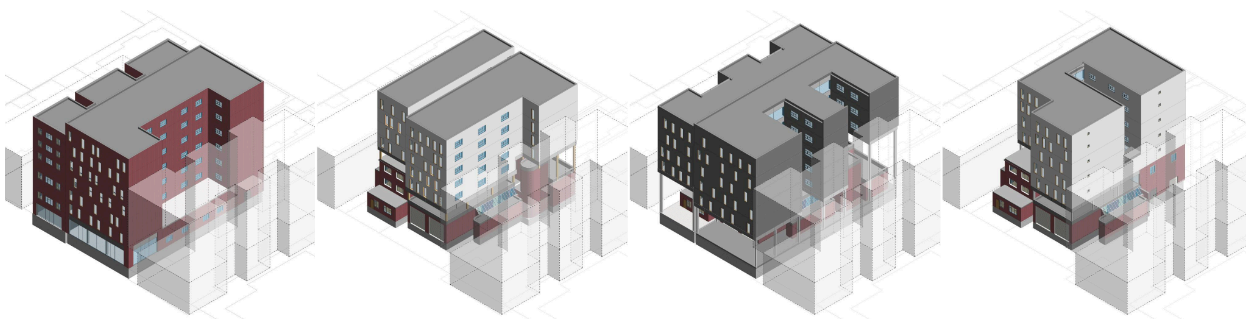

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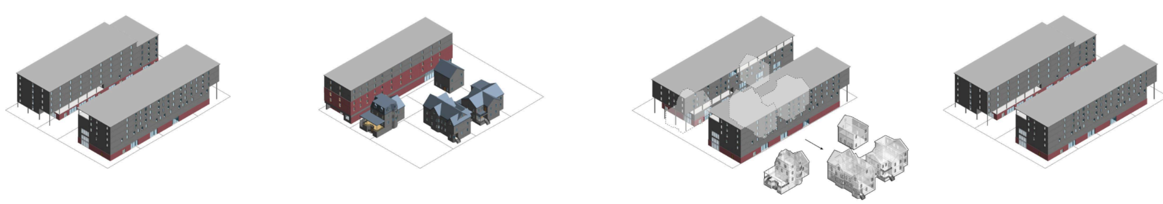

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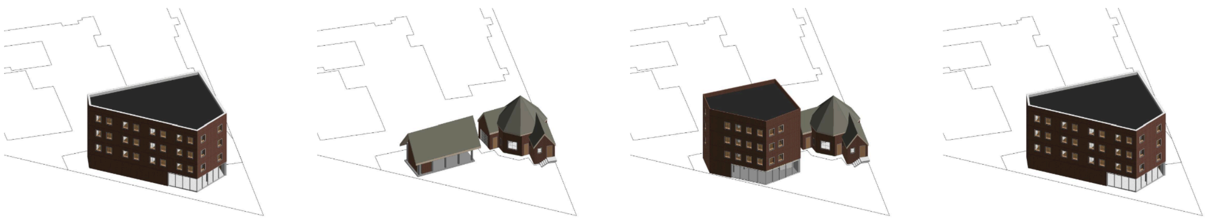

6g.

Figures 6a-g were produced to analyze and present choices with preservation along a spectrum of reuse.

A parallel track involved developing a web-based 3D platform for circularity scenario exploration, discussed in Section V.

New Tools and Considerations

The landscape for 3D scenario planning is evolving, with several emerging considerations:

- **Integration with carbon and cost modeling**: Revit massing studies can feed directly into embodied-carbon workflows (CARE Tool, EC3) and cost-estimation processes. These values can then be linked to GIS attributes or scenario dashboards.
- **Improved interoperability**: The increasing adoption of open formats like IFC and glTF allows smoother transitions between BIM, GIS, and web platforms. This reduces friction when publishing 3D content across multiple tools.
- **Attribute-rich 3D layers**: GIS platforms now support attaching scenario attributes—reuse scores, deconstruction potential, carbon savings—to each 3D object. This strengthens analytical and comparative capacity beyond visualization alone.

- **AI-assisted modeling workflows**: AI coding assistants can streamline model preparation, automate data cleaning, generate scripts for Revit or ArcGIS (e.g., Python, Dynamo), and help build custom 3D viewers when off-the-shelf tools are insufficient.
- **Governance and maintainability**: As with ABM, the durability of a 3D scenario model depends on documentation, version control, and transparent metadata, especially when 3D layers incorporate analytical values used in policymaking.

IV. Scenario Planning with Embodied Carbon Modeling

Why Consider Embodied Carbon Reporting

Carbon emission is the dominant driver of climate change. It measures the release of carbon dioxide and other greenhouse gases (GHGs) into the atmosphere. Carbon Neutrality, or the reduction and elimination of carbon emissions, is the main goal of global efforts for mitigating climate change, as defined by the Paris Agreement.

Embodied Carbon Modeling is the prediction of the embodied carbon emission of scenario planning. It provides the direct quantitative parameter for measuring sustainability for scenarios and serves as a crucial output of the study and a source of knowledge for the development stakeholders' decision-making and the general public. Moreover, integrated with BIM software such as Revit, Embodied Carbon Modeling is also a crucial tool for developing scenarios (Figure 7).

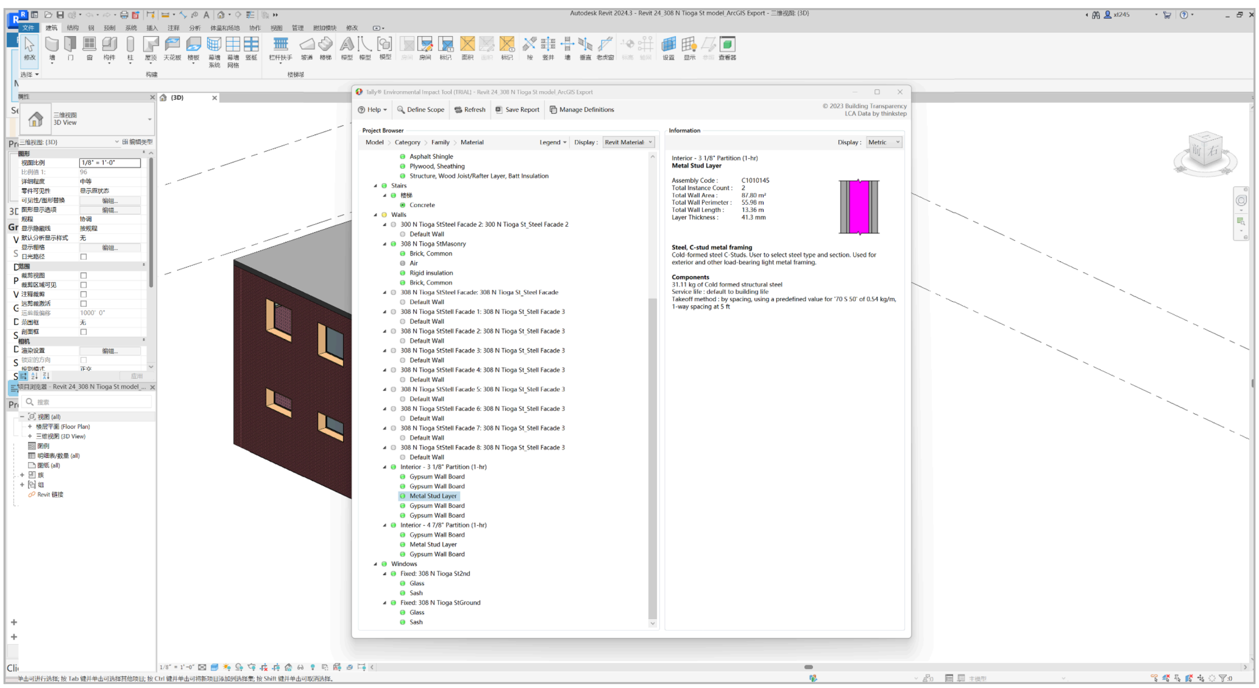

Figure 7. A screenshot of Embodied Carbon Modeling using Tally for Revit.

Embodied carbon emission uses a carbon footprint as a measuring unit, which is the total amount of greenhouse gases (GHGs) in kilograms of CO2 equivalent. It also uses Life Cycle Analysis as a methodology to assess the building's total GHG emissions from raw material acquisition to disposal. This calculation includes the emissions during building stages such as: product, transportation, construction and installation, maintenance and replacement, end of life, and reuse potential (module D).[11]

LCA (Life Cycle Analysis) measures the carbon emission of a building in two categories: embodied and operational.[12] In our study, we chose only embodied carbon emission as an indicator of the scenario's climate impact, as it provides a more accurate sustainability indication of developers' decisions on the construction instead of its operation.

Embedded in an ABM Model

3D Modeling with Tally and CareTool

The embodied carbon emissions of scenarios are calculated through a combination of a BIM-integrated Life Cycle Analysis software - Tally - from BIM 3D models of planned development scenarios and a carbon footprint estimator for reuse and retrofit - CareTool.

BIM 3D software such as Revit creates 3D geometries of building components and assembles all layers of its material information into Family components. Therefore, BIM 3D modeling creates a library of the material used by item and quantity for scenarios in core-and-shell models.[13] Tally links Revit Family components to a library of Environmental Product Declarations (EPD), which includes the product stage [A1-A3] carbon footprint of materials and provides the environmental impact of the rest of the life cycle stages (see Figures 8 and 9). CareTool provides the estimate of carbon emission of construction works done for building retrofit, which Tally does not provide (see Figures 10 and 11). It calculates carbon footprint through a range of input parameters such as existing building floor area, number of above and below-grade floors, building function, and levels of structural system, envelope, interior, and MEP reuse.

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[11] Life-Cycle Stages as defined by EN 15978 also include operational energy [B6-B7].

[12] Embodied Carbon Emission measures the total greenhouse gas (GHG) emissions from the entire lifecycle of building materials and infrastructure, covering raw material extraction, manufacturing, transport, construction, maintenance, and end-of-life disposal; Operational Carbon Emission measures the emissions from building use based on the anticipated or measured energy and natural gas consumed at the building site over the lifetime of the building.

[13] 3D building models which only include structural cores (including columns, beams, structural walls, floor slabs, and foundations) and exterior enclosure (including exterior walls, exterior windows, curtain walls, and exterior doors). They do not include interior partition walls, furnishings, and MEP.

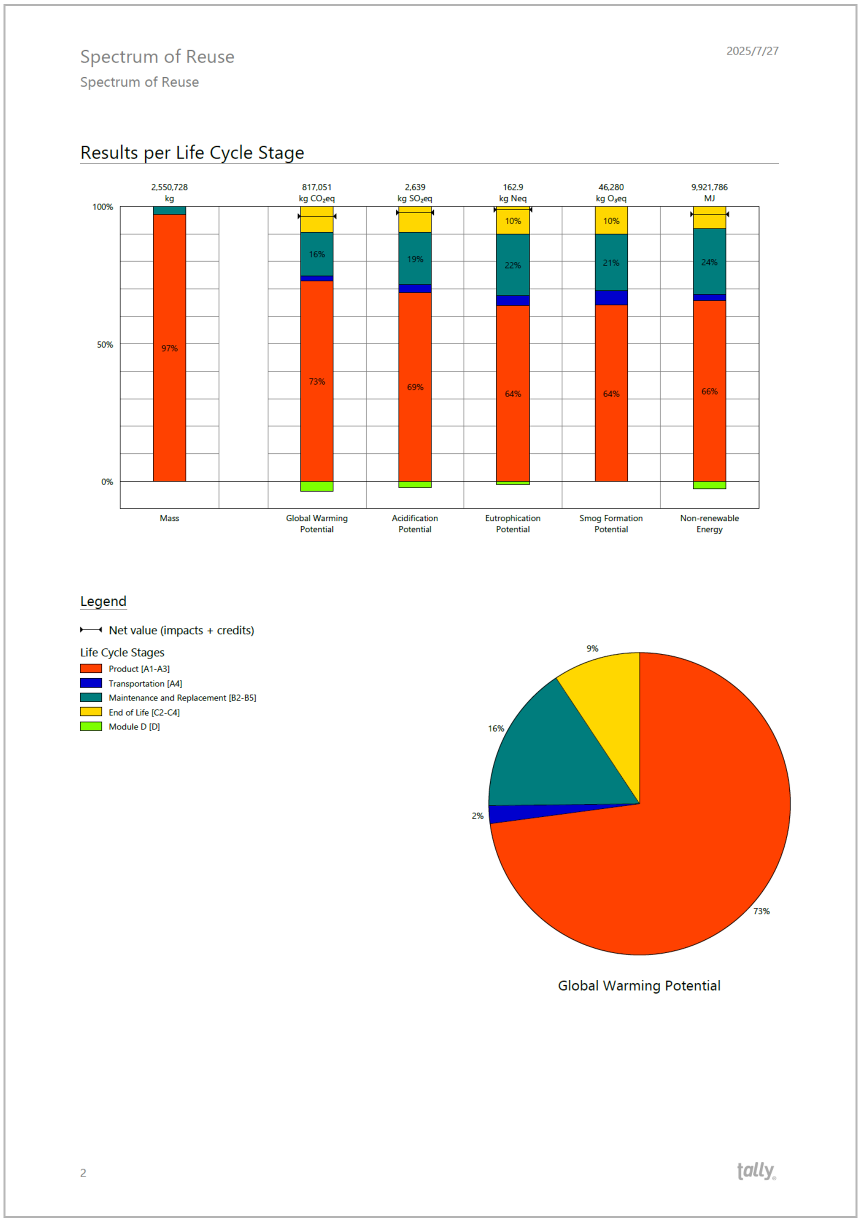

Figure 8. Results for a scenario modeled in Tally for Revit.

Figure 9. Results for a scenario modeled in Tally for Revit.

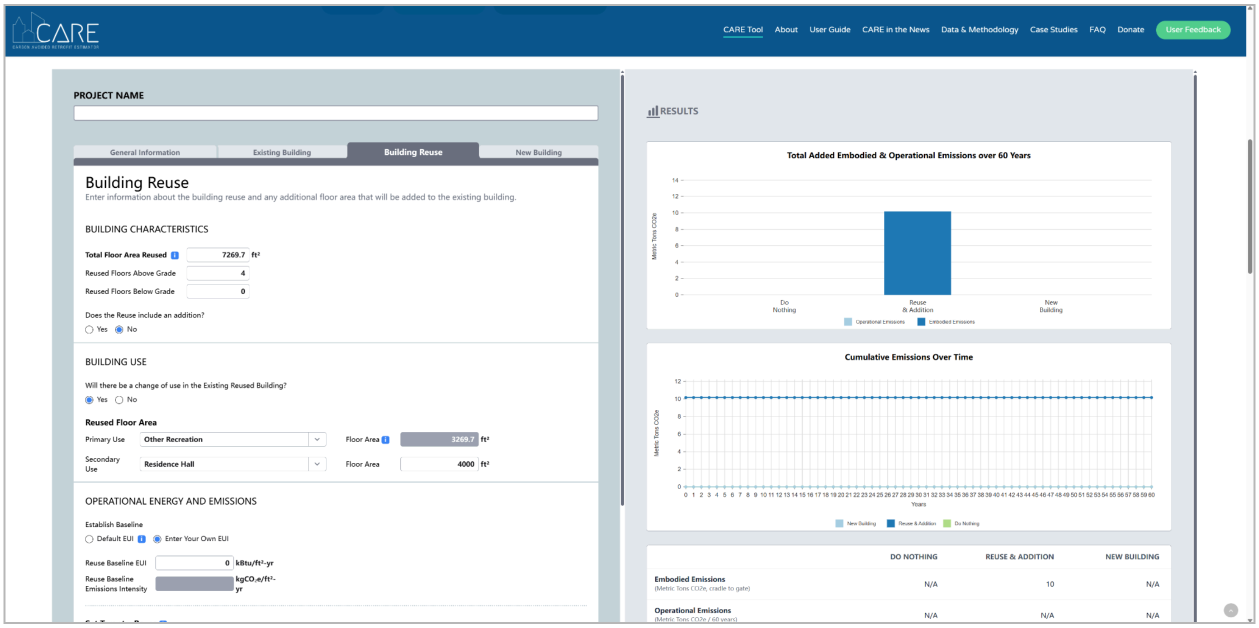

Figure 10. Screenshot of CareTool.

Building Reuse

BUILDING CHARACTERISTICS

Does the Reuse include an addition?	**No**
Total Floor Area Reused	**7269.7 ft²**
Reused Floors Above Grade	**4**
Reused Floors Below Grade	**0**
Total Floor Area of Addition	**N/A**
Addition Floors Above Grade	**N/A**
Addition Floors Below Grade	**N/A**

BUILDING USE

Will there be a change of use in the Existing Reused Building?	**Yes**

REUSED FLOOR AREA

Primary Use	**OtherRecreation**
Floor Area	**3269.7 ft²**
Secondary Use	**ResidenceHall**
Floor Area	**4000 ft²**

ADDITION

Primary Use	**N/A**
Floor Area	**N/A**
Secondary Use	**N/A**
Floor Area	**N/A**

OPERATIONAL ENERGY AND EMISSIONS

Establish Baseline	
Reuse Baseline EUI	**0 kBtu/ft²-yr**
Reuse Baseline Emissions Intensity	**N/A**
Set Target - Reuse	
Reuse: Target reduction in energy use	**N/A**
Reuse EUI Target	**0 kBtu/ft²-yr**
Reuse Emissions Intensity	**N/A**
Installing all electric systems and equipment?	**No**
Set Target - Addition	
Does addition have a distinct EUI target?	**No**
Addition: Target reduction in energy use	**N/A**
Addition EUI Target	**N/A**
Installing all electric systems and equipment?	**No**
Set Target - Renewables	
Percentage of electricity produced by on-/off-site renewables	**N/A**

Reuse Operational Emissions Intensity 0.0 $kgCO_2e/ft^2$-yr

EMBODIED EMISSIONS

	EMBODIED EMISSIONS INTENSITY
Structural System Reuse	**0 $kgCO_2e/ft^2$**
Extent of Structural Reinforcement or Replacement	**N/A**
Lateral Upgrade	**No**
Envelope Reuse	**0.7 $kgCO_2e/ft^2$**
Exterior Walls	**MasonryMinor**
Windows/Glazing	**Minor**
Roofing	**Minor**
Insulate Walls	**No**
Interior Reuse	**0.4 $kgCO_2e/ft^2$**
Minor: repair or restore finishes only	**N/A**
Medium: add new finishes to existing structure	**20%**
Major: total interior renovation, including new partitions and finishes	**N/A**
Mechanical, Electrical, Plumbing Systems Reuse	**0.3 $kgCO_2e/ft^2$**
Minor	
Addition	
N/A	
Modifiers	
No modifiers	

Reuse Embodied Emissions Intensity 1.4 $kgCO_2e/ft^2$-yr

CARE TOOL // **PROJECT 12/21/2025** // **2**

Figure 11. Screenshot of outputs from CareTool.

V. Scenario Planning with Publishing Interactive Story Maps

Interactive story maps provide a publishing and communication layer for scenario planning. Interactive story maps are web-based, narrative interfaces that combine maps, 3D scenes, text, images, and embedded media to communicate spatial analysis and scenario outcomes to both technical and non-technical audiences (see figure 12). Rather than producing new analyses, they aid in organizing, contextualizing, and making accessible the outputs of modeling workflows explained elsewhere in this handbook.

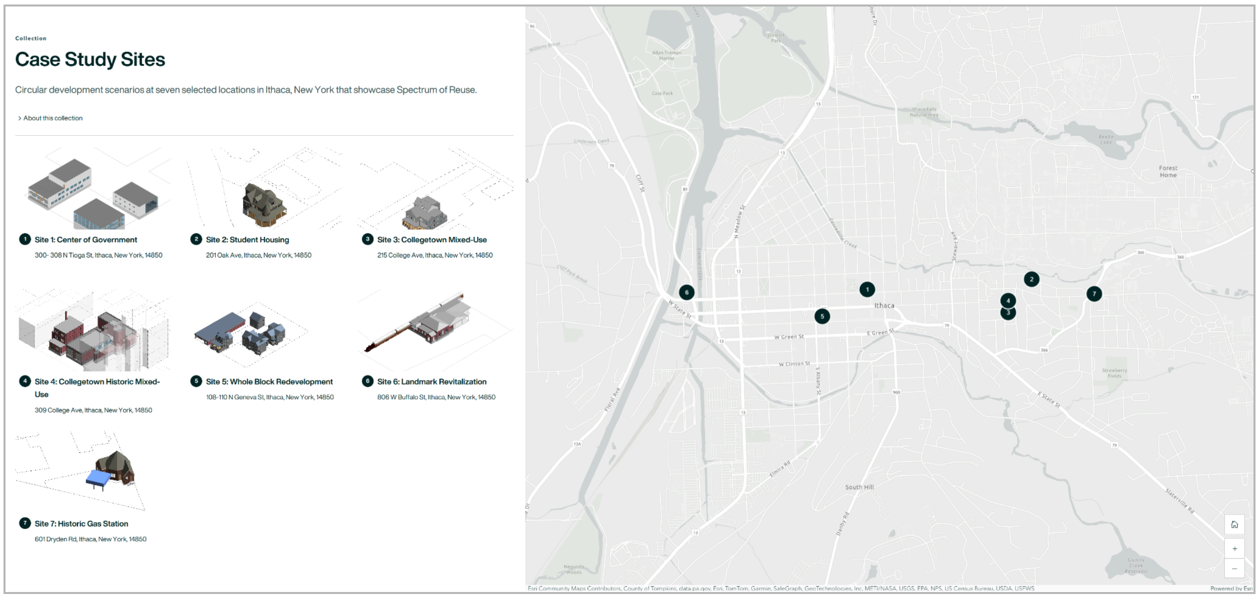

Figure 12. An example of an overview map embedded within an ESTRI StoryMap. This was an overview map produced for the Spectrum of Reuse project.

In this project, ESRI StoryMaps were used primarily to publish and interpret Phase 2 research—3D BIM-based scenario planning and embodied-carbon analysis—while also illustrating how similar approaches could be extended to other modeling methods, including agent-based modeling (figure 13).

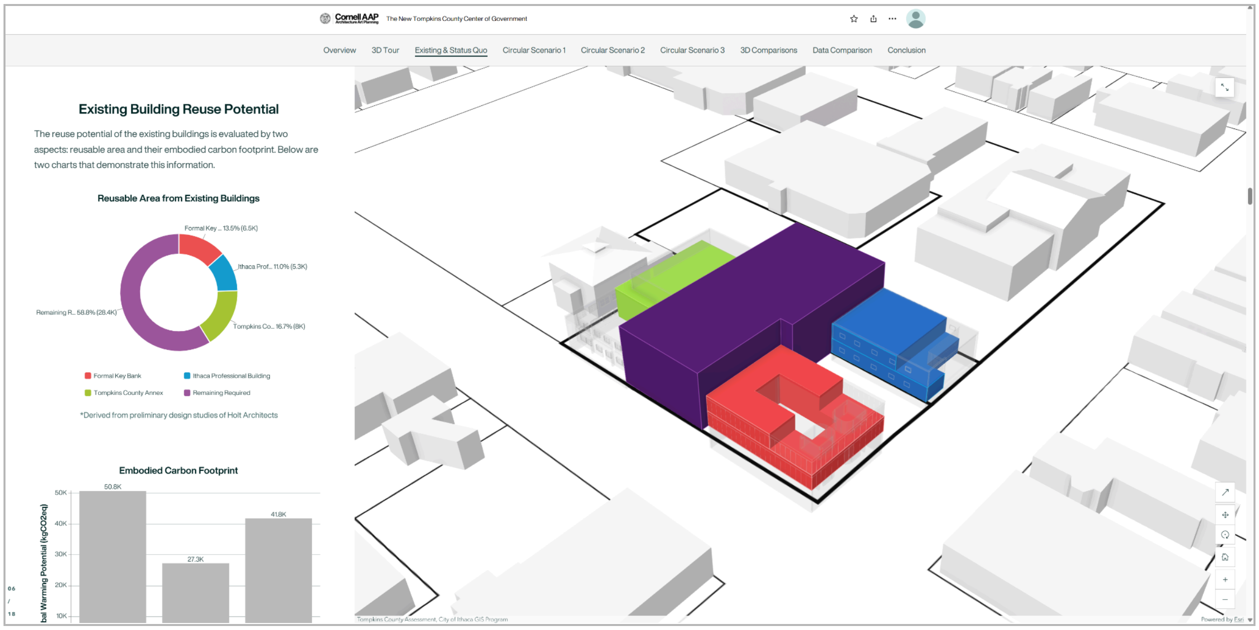

Figure 13. Example of visualizing the potential to reuse existing buildings in an ESRI StoryMap.

Why Consider Using Interactive Story Maps

Scenario planning typically produces heterogeneous outputs: spatial data, 3D models, quantitative metrics, assumptions, and tradeoffs. Interactive story maps offer a structured way to assemble these materials into a navigable narrative that explains how scenarios were constructed, what distinguishes them, and what implications they carry for preservation, circularity, and development decision-making.

For preservation and planning audiences, story maps serve several functions:

- they translate technically complex analyses into legible, spatial narratives;
- they support transparency by making assumptions and comparative metrics visible;
- they allow stakeholders to explore scenarios at their own pace;
- they function as durable, shareable artifacts that extend beyond reports or workshops.

Role of Story Maps Within a Multi-phase Workflow

This research unfolded in two distinct but related phases:

- Phase 1 developed an agent-based model to explore city-scale dynamics of development, reuse, and policy intervention.
- Phase 2 focused on parcel-scale scenario planning through 3D BIM modeling of building massing, embodied-carbon analysis, and comparative evaluation of circular development strategies.

ArcGIS StoryMaps were used primarily to publish and communicate the results of Phase 2, where building-scale geometry, material assemblies, and performance metrics could be clearly visualized and compared across scenarios. While StoryMaps could also be used to publish ABM results, this project did not deploy them extensively for Phase 1.

Available Tools

Several platforms support interactive, map-based publishing:

- ArcGIS StoryMaps, which integrates maps, 3D scenes, text, images, and embedded media in a web-based environment;
- Custom web platforms, built using JavaScript frameworks, which offer greater flexibility but require more development effort;
- Hybrid approaches, where ArcGIS-hosted content is embedded within external dashboards or web viewers.

Among these options, ArcGIS StoryMaps offers a low barrier to entry for planning and preservation offices already working within GIS ecosystems.

Tools Used in Our Study

In Phase 2 of this project, ArcGIS StoryMaps was used to publish and interpret scenario-planning results derived from 3D BIM modeling and embodied-carbon analysis. The workflow included:

- developing core-and-shell BIM models in Revit for multiple development scenarios at each site;
- calculating embodied-carbon impacts using Revit-based workflows (including Tally) and CareTool;
- exporting scenario geometries and attributes into ArcGIS Pro as georeferenced 3D layers;

- publishing these layers as interactive 3D web scenes;
- organizing scenarios into story maps that explain assumptions, compare outcomes, and highlight tradeoffs across reuse strategies (Figures 14 and 15).

Across seven case study sites in Ithaca, this process resulted in twenty-eight development scenarios—one status quo scenario and three circular alternatives per site—each evaluated across circularity, embodied carbon, preservation, feasibility, and qualitative urban criteria.

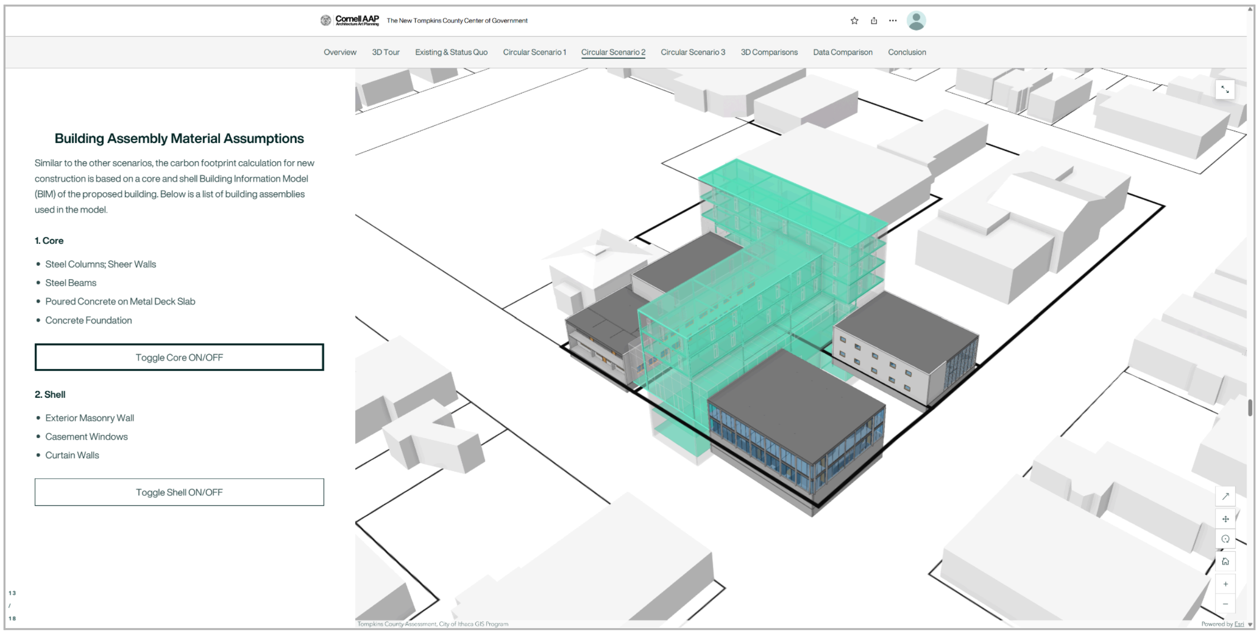

Figure 14. Visualization of building assembly embedded in an ESRI StoryMap.

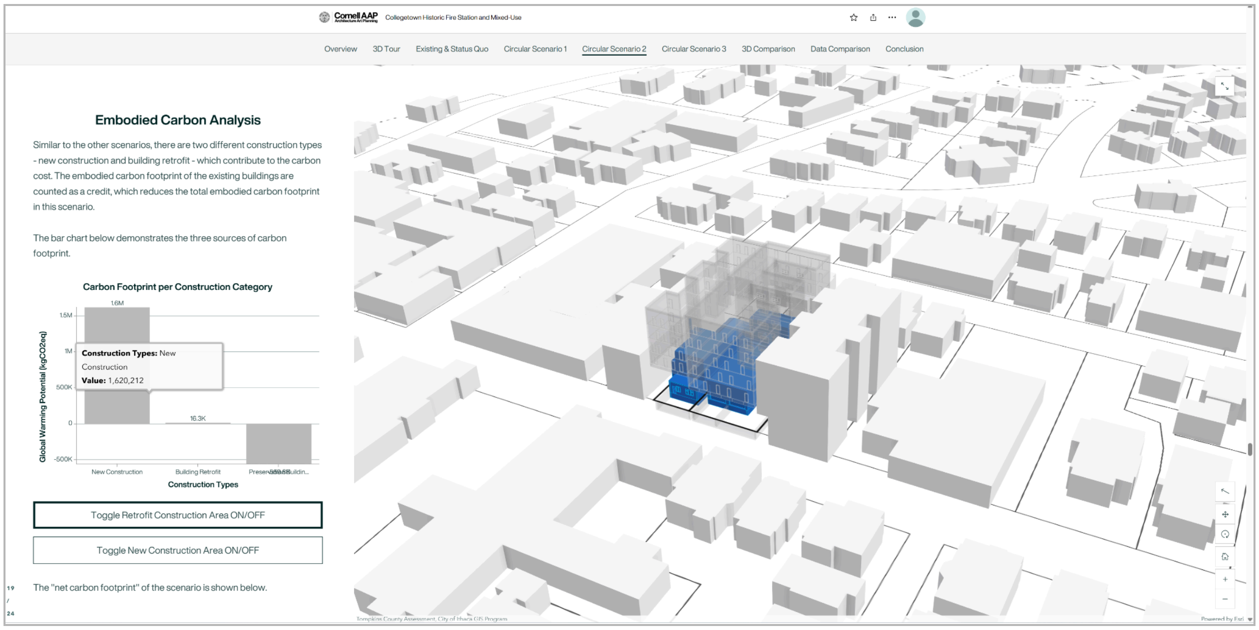

Figure 15. Example of displaying embodied carbon analysis in ESRI StoryMap.

What Story Maps Make Possible

Within this workflow, story maps enabled:

- horizontal comparison of scenarios across sites, supporting evaluation of alternative reuse and redevelopment pathways;
- visualization of embodied-carbon differences alongside spatial form, linking performance metrics to architectural and urban outcomes;
- integration of quantitative metrics with qualitative preservation and design judgments, making tradeoffs explicit and interpretable;
- public-facing exploration of reuse strategies that would otherwise remain embedded in technical models.

By situating scenarios within recognizable urban contexts, story maps also support community engagement and public participation. Three-dimensional representations of buildings and blocks improve legibility for non-specialist audiences, helping stakeholders understand scale, massing, and neighborhood impact and enabling more informed discussion around preservation, redevelopment, and circular construction strategies.

Story maps further functioned as an index into more detailed materials, including underlying BIM models, analytical documentation, and external platforms, which are available separately.

Additional Considerations: Emerging Modes of Dissemination

Interactive story maps can also serve as gateways to emerging spatial media, including digital twin platforms, web-based 3D environments, and augmented-reality applications. These approaches make it possible to experience alternative scenarios in situ—for example, viewing different development futures layered onto existing urban fabric through mobile devices.

While these techniques were not fully deployed in this project, they point toward future directions in preservation and planning practice, where scenario planning, 3D visualization, and realtime spatial media converge to support deeper public understanding and deliberation.[14] Story maps provide a flexible publishing framework capable of linking to or embedding these formats across devices and contexts.

[14] Ahn, Changbum Farzin Lotfi-Jam, Christopher Graham, et al., "Critical Urban Informatics for Urban Digital Twin Models," *Nature Cities* 2 (2025): 114–116, https://doi.org/10.1038/s44284-024-00171-0 .

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Appendix - Developer Survey

Cornell University

Welcome

Understanding Developer Choices in Ithaca Using Agent-Based Modeling

The Cornell University Realtime Urbanism Lab and Just Places Lab have embarked on a research project to apply advanced modeling techniques to understand the decision-making of various actors in reinvestment in existing buildings and new construction.

Advanced modeling techniques in this research project include agent-based modeling and scenario planning. Agent-based modeling is a computer simulation tool used to understand how complex, real-world phenomena emerge out of the interactions of key actors within an environment. Scenario planning involves presenting stakeholders with an array of possible future outcomes that can be used to produce robust decision-making under uncertain conditions.

As leaders in local development, we would like to learn from your experiences in the reinvestment and development of property in Ithaca. Your responses will enrich the computer model we are developing, which will integrate community insights with local spatial data, to develop a robust tool for scenario planning.

Why Your Input Matters

By contributing to this survey, you are not just sharing your perspective, but are actively participating in crafting tools that will help planners to understand decision-making in cities and consider how different development strategies can influence the way projects get built in Ithaca.

Confidentiality and Use of Data

Your survey responses will be confidential and used only for the purposes of this study and will only be shared in aggregate form. If you elect to participate in our post-survey interview process, we may ask for permission to quote you or to use the examples you share in future presentations and publications.

Survey Time Frame: This survey will take approximately **15-30 minutes** of your time. There is no compensation for participating.

Additional Interview: After the survey, we will ask you to provide additional insights into how the agent-based model is modeling the way that you and other developers select parcels and make investment decisions. We will schedule a follow up interview with you that will take approximately 30 minutes of time.

Should you have any follow up questions, feel free to reach out to us with the contact information below.

Warmly,

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Director, Just Places Lab Cornell University
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Farzin Lotfi-Jam
Assistant Professor, Department of Architecture
Director, Realtime Urbanism Lab Cornell University
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Understanding Development Practices

Understanding Development Practices

In this section, we seek to understand the types of project you embark on, their scale budget flexibility, and timelines, along with your goals. Your experiences with different project types, use of incentives, and collaboration strategies are key to modeling the specifics of development dynamics in Ithaca.

Q1. What kinds of development projects have you undertaken in the last 10 years? (Check all that apply)

- ☐ Single-family residential (new construction)
- ☐ Multi-family residential (new construction)
- ☐ Retail (new construction)
- ☐ Mixed use (new construction)
- ☐ Industrial (new construction)
- ☐ Non-market rate or low income housing (new construction)
- ☐ Non-market rate or low income housing in existing buildings
- ☐ Adapting older buildings for new purposes
- ☐ Remodeling or rehabilitating multi-family or mixed use buildings
- ☐ Remodeling or rehabilitating retail or industrial buildings
- ☐ Remodeling single-family residential buildings
- ☐ Restoring and revitalizing historic buildings
- ☐ Other:

Q2. How often do your projects involve the preservation, or restoration, or addition/expansion to a historic building?

- ○ All the time
- ○ Often
- ○ Sometimes
- ○ Once or very occasionally
- ○ Never

Q3. How often do you utilize the following incentives:

	Never and don't plan to	Never, but would consider in the future	Once or very occasionally	Sometimes	Often	All the time
National Historic Tax Credits	○	○	○	○	○	○
New York State Historic tax credits	○	○	○	○	○	○
Local Incentives for Historic Properties	○	○	○	○	○	○
Federal Low Income Housing Tax Credits - 9% for new construction	○	○	○	○	○	○
Federal Low Income Housing Tax Credits - 4% for existing buildings	○	○	○	○	○	○
New York State Low Income Housing Tax Credits - 9% for new construction	○	○	○	○	○	○
New York State Low Income Housing Tax Credits 4% for existing buildings	○	○	○	○	○	○
Incentives or Tax Breaks for Brownfields	○	○	○	○	○	○
Use other Development Incentives	○	○	○	○	○	○

Q4. Are there any other incentives that you utilize or are considering utilizing in future development projects? By incentives we mean monetary assistance or project streamlining by government agencies.

Q5. Which of the below statements best describes your investment approach? (Check all that apply)

- ☐ I purchase properties, develop them, and sell them. I am interested in properties that I can turn around within 2 years.
- ☐ I purchase properties, develop them, and sell them. I tend to invest in properties that take longer than two years to turn around.
- ☐ I purchase, don't develop, and retain property for longer periods with an expectation of an increase in asset value or for other strategic objectives.
- ☐ I purchase properties, develop them, retain ownership, and offer them for rent
- ☐ I don't purchase properties, but develop them for property owners.

Q6. How geographically dispersed are your development projects?

- ◯ In Tompkins County only
- ◯ Within multiple locations in the Finger Lakes/Central New York
- ◯ In and beyond the Finger Lakes region/Central New York - within New York State
- ◯ In locations in several states within the Northeast
- ◯ Throughout the U.S.

Q7. In considering your mission as a developer, how important are the following values when you invest in a property? Please drag and drop to rank the following from 1 (most important) to 4 (least important) in decision-making.

Profitability

Sustainability

Community Perception

Social Equity

Q8. How do you primarily make decisions regarding your development projects? Please drag and drop to rank the following from 1 (most important) to 5 (least important) in decision-making.

Based on personal intuition or experience

By consulting with a team of experts or advisors

Through detailed market and financial analysis

By considering community needs and impacts

Focusing on client-specific requirements

Q9. How often do you communicate with other professionals in your industry to discuss development practices? (including direct collaboration, causal chat, mentoring, and knowledge diffusion)

- ◯ Every day
- ◯ About once or twice a week
- ◯ About once a month
- ◯ A few times a year
- ◯ Never

Q10. How much influence does this information have on your

decision-making?

- ◯ A lot
- ◯ Quite a bit
- ◯ Some
- ◯ A Little
- ◯ None

Q11. What kinds of information do you primarily discuss with your other developers regarding sustainability, preservation, and development innovation? Please drag and drop to rank the following from 1 (most interested) to 5 (least interested) in order of your interest.

Sustainable construction techniques and eco-friendly practices

Strategies for deconstruction and building material reuse

Preservation methods for historical or culturally significant structures

Introduction to innovative practices for construction

Cost savings and profit margin increases through innovations

Q12. How likely are you to:

	Not at all	A Little	Somewhat	Quite	Very	Do this already
Engage in salvage before demolition of a building (meaning soft-stripping or the removal of valuable building materials and components)	◯	◯	◯	◯	◯	◯

Please add any notes or questions you have related to Question 1-13.

Site Suitability

Site Suitability

Please share your insights on site selection criteria for building reuse and new development in Ithaca. This section aims to understand your strategies regarding location, historic preservation, profitability, and site attributes. Your responses are crucial for our agent-based model to reflect real-world development preferences, assisting in informed urban planning and historic preservation.

Questions for Building Reuse (Preservation, Remodeling, Additions or Adaptive Reuse of Existing Buildings)

Please answer the following questions related to projects involving existing buildings. If you are not involved in remodeling, adaptive reuse, or preservation of existing buildings, please indicate that.

Q14. I am involved in Preservation, Remodeling, Additions or Adaptive Reuse of Existing Buildings:

- ○ Yes
- ○ No

○ I haven't, but plan to

Q15. When selecting a location for preservation or reinvestment in existing buildings, how important is proximity to following areas?

	Not at all	A Little	Somewhat	Quite	Very
Proximity to Cornell University	○	○	○	○	○
Proximity to Ithaca College	○	○	○	○	○
Location in or near downtown Ithaca	○	○	○	○	○
Proximity to retail stores	○	○	○	○	○
Proximity to Route 13	○	○	○	○	○
Proximity to parks	○	○	○	○	○
Proximity to bus stops	○	○	○	○	○
Proximity to waterfront	○	○	○	○	○
Proximity to areas where redevelopment or reinvestment has taken place recently on surrounding properties	○	○	○	○	○
Proximity to areas where redevelopment or reinvestment in surrounding properties is anticipated in the future	○	○	○	○	○

Q15a. Do these accurately reflect the factors you consider? Please add any notes:

Q16. How important are the following factors in evaluating the profitability of reinvestment in an existing building? Please drag and drop to rank the following from 1 (most important) to 10 (least important) in decision-making.

The value of buildings or other improvements on the site relative to value of the land

Relative cost of new construction compared to cost of building reuse

The character and/or historic value of the building

Anticipated maintenance and operational costs for property owner or tenant after reinvestment

Anticipated future development around the site

Marketability to new owners or tenants

Ability to increase rents or sell at a higher value

The ability to attract investors or partners in the project

The ability to utilize grants or tax incentives

Other:

Q16a. Do these accurately reflect the factors you consider? Please add any notes:

Q17. When considering a project involving an existing building, how important are following? Please drag and drop to rank the following from 1 (most important) to 8 (least important) in decision-making.

Condition of buildings likely be removed

Age of buildings likely be removed

Soil condition

Construction type of building

Availability of adequate utilities/infrastructure

Zoning

Anticipated flexibility in zoning or ability to change zoning

Location in Planned Unit Overlay Zone

Q17a. Do these accurately reflect the factors you consider? Please add any notes:

Q19. For projects that involve existing building, what is the typical time span? (Check all that apply)

- ☐ <1 year per project
- ☐ 1-3 years per project
- ☐ >3 years per project

Q20. For projects that involve existing buildings, what is the range of investment cost? (Check all that apply)

- ☐ <$25,000 per project
- ☐ $25,000-$50,000 per project
- ☐ $50,000-$250,000 per project
- ☐ $250,000-$1 million per project
- ☐ $1-$3 million per project
- ☐ $3-$10 million per project
- ☐ >$10 million per project

Questions related to New Development (Construction of New Buildings)

Please answer the following questions related to projects involving new construction. If you do not develop new buildings, please indicate that.

Q21. I develop new buildings:

- ○ Yes
- ○ No
- ○ I haven't, but plan to

Q22. When selecting a location for any new development, how important is proximity to following areas?

	Not at all	A Little	Somewhat	Quite	Very
Proximity to Cornell University	○	○	○	○	○
Proximity to Ithaca College	○	○	○	○	○
Location in or near downtown Ithaca	○	○	○	○	○
Proximity to retail stores	○	○	○	○	○
Proximity to Route 13	○	○	○	○	○
Proximity to parks	○	○	○	○	○
Proximity to bus stops	○	○	○	○	○
Proximity to waterfront	○	○	○	○	○
Proximity to areas where redevelopment or reinvestment has taken place recently on surrounding properties	○	○	○	○	○
Proximity to areas where redevelopment or reinvestment in surrounding properties is anticipated in the future	○	○	○	○	○

Q22a. Do these accurately reflect the factors you consider? Please add any notes:

Q23. How important are the following factors in evaluating the profitability of new development on a site? Please drag and drop to rank the following from 1 (most important) to 10 (least important) in decision-making.

The value of buildings or other improvements on the site relative to value of the land

Relative cost of new construction compared to cost of building reuse

The character and/or historic value of the building

Anticipated maintenance costs for property owner after project

Anticipated future development around the site

Marketability to new owners or tenants

Ability to increase rents or sell at a higher value

The ability to attract investors or partners in the project

The ability to utilize grants or tax incentives

Other:

Q23a. Do these accurately reflect the factors you consider? Please add any notes:

Q24. When considering a property for new development, how important are the following? Please drag and drop to rank the following from 1 (most important) to 8 (least important) in decision-making.

Condition of buildings likely be removed

Age of buildings likely be removed

Soil condition

Construction type of building

Availability of adequate utilities/infrastructure

Zoning

Anticipated flexibility in zoning or ability to change zoning

Location in Planned Unit Overlay Zone

Q24a. Do these accurately reflect the factors you consider? Please add any notes:

Q25. Have your past or current new development projects involved the removal of:

	Never, and don't plan to in the future	Never, but plan to in the future	1-2 Projects	3+ Projects
Historic landmark(s) designated by the City of Ithaca	○	○	○	○
Contributing properties in a local historic district	○	○	○	○
Non-contributing properties in a local historic district	○	○	○	○
Individually listed properties on the National Register of Historic Places	○	○	○	○
Contributing properties located in a historic district on the National Register of Historic Places	○	○	○	○
Non-contributing properties located in a historic district on the National Register of Historic Places	○	○	○	○

Q25a. Do these accurately reflect the factors you consider? Please add any notes:

Q26. What is the typical time length for your projects involving new development? (Check all that apply)

- ☐ <1 year per project
- ☐ 1-3 years per project
- ☐ >3 years per project

Q27. For projects that involve new development, what is the range of investment cost? (Check all that apply)

- ☐ <$25,000 per project
- ☐ $25,000-$50,000 per project
- ☐ $50,000-$250,000 per project
- ☐ $250,000-$1 million per project
- ☐ $1-$3 million per project
- ☐ $3-$10 million per project
- ☐ >$10 million per project

Deconstruction vs. Demolition

Alternatives to Demolition

The following section is intended to gather your perspectives on the possibility of building reuse or deconstruction and building material reuse as alternatives to demolition. Deconstruction is the systematic disassembly of an existing building.

Q28. How likely would you be to adaptively reuse and building instead of demolishing it, or saving a large portion of the building if...

	Not at all	A Little	Somewhat	Quite	Very	Do this already
You received incentives for reusing a building	○	○	○	○	○	○
If you received positive press for the environmental aspects of doing it	○	○	○	○	○	○
If permit approvals were streamlined if you deconstructed instead of demolished	○	○	○	○	○	○
There were a substantial reduction of greenhouse gas emissions through reuse these were calculated and publicly compared to demolition	○	○	○	○	○	○
The development was branded “net zero”	○	○	○	○	○	○
It was substantially cheaper to reuse a building instead of demolishing it	○	○	○	○	○	○

Q29. How likely would you be to systematically deconstruct a building instead of demolish one if...

	Not at all	A Little	Somewhat	Quite	Very	Do this already
You received a grant that eliminates the difference in cost between deconstruction and demolition	○	○	○	○	○	○
If you received positive press for the environmental aspects of doing it	○	○	○	○	○	○

	Not at all	A Little	Somewhat	Quite	Very	Do this already
If permit approvals were streamlined if you deconstructed instead of demolished	○	○	○	○	○	○
There were a substantial reduction of greenhouse gas emissions through reuse these were calculated and publicly compared to demolition	○	○	○	○	○	○
The development was branded “net zero”	○	○	○	○	○	○

Q30. Up to what percentage of project budget can you spend for deconstruction rather than demolition of a building? (Check all that apply)

- ☐ <10 percent
- ☐ 10-20 percent
- ☐ >20 percent

Q31. Up to how much more time can you allocate to your project by doing deconstruction rather than destruction of a building? (Check all that apply)

- ☐ <3 months
- ☐ 3-6 months
- ☐ >6 months

Q32. How likely would you be to use reclaimed building materials in new construction projects if...

	Not at all	A Little	Somewhat	Quite	Very	Do this already
You received a grant that eliminates the difference in cost between reclaimed materials and new materials	○	○	○	○	○	○
If you received positive press for the environmental aspects of doing it	○	○	○	○	○	○
If permit approvals were streamlined if you deconstructed instead of demolished	○	○	○	○	○	○
There were a substantial reduction of greenhouse gas emissions through reuse these were calculated and publicly compared to demolition	○	○	○	○	○	○
The development was branded "net zero"	○	○	○	○	○	○
It saved money	○	○	○	○	○	○

Please feel free to add further thoughts on building reuse, deconstruction and the reuse of reclaimed materials in new construction:

Ending

Thank you for participating in this survey!

Would you be willing to meet with us via Zoom or in-person to see the model work and provide further feedback on it? We could schedule this at your convenience. If Yes or Maybe, please indicate your name and preferred contact information:

- ◯ Yes
- ◯ Maybe
- ◯ No

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