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Harvesting New York City - Old-Growth Urban Forestry

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1 Abstract

New York is known as a metropolis of skyscrapers; however less than 1.5% of the 1 million buildings in the city stand over seven stories tall. Over 95% are thought to be of wood-frame or masonry and wood construction.

Most of this building stock was constructed using wood sourced from old-growth forests across the eastern seaboard. The city now sits on a stockpile of wood which germinated before New Amsterdam became New York, and which was felled while signatories of the Declaration of Independence were still President; this is structurally valuable hard, dense and high strength-to-weight ratio wood. As our buildings degrade and require renovation or replacement the city must ensure that this resource is not wasted, for environmental and economic reasons.

The total number of buildings is large, but because of the rapid and repetitive way that NYC was constructed the variation in building type and structural element sizes across the building population is small. Cross referencing NYC department databases using geographic information systems allowed the Department of Buildings to produce an estimate of the number of buildings in the city of each type. Assessment of historic pattern books, prescriptive regulations, and inspection of existing buildings allows generic estimates of wood dimension and quantity per building type. Combined, this data allows the estimation of the annual rate of release of wood from demolition in NYC - a predicted supply available for future use. A review of existing practices in wood salvage, processing and reuse is then assessed in context, outlining proposals for future local policy and research work.

Keywords: Wood; timber, lumber; deconstruction; reuse; salvage; longleaf pine; old-growth.

2 Introduction

2.1 A misunderstood building stock

The popular image of New York City construction may be a steel-framed Manhattan skyscraper, however over 95% of the city's buildings are within the outer four boroughs [1] and over 95% could be of wood frame or masonry and wood construction [2].

New York is a big city; the population of the five boroughs at the center of the metropolitan region is estimated at 8.4million [3]. This population increased in three approximate phases: a slow increase of 7,000/year until 1840, a period of rapid increase to 1930 at 70,000/year, followed by a slower rate of 16,000/year until today [4]. By 1925 New York had overtaken London to become the largest city in the world [5].

Unlike London this population lived and worked in buildings rapidly constructed using wood from plentiful old-growth forests up and down the Eastern Seaboard, such as Eastern White Pine from the North East and Longleaf Pine from the South East. This old-growth wood is a valuable resource - it is harder, denser and has higher strength-to-weight ratios than modern plantation-grown wood - and it is no longer available (less than 5% of the Longleaf pine forests remain [6], with similar reports for Eastern White Pine). But how much old-growth wood is encapsulated in the city's buildings? Is it 1,000m^3 or 10,000,000m^3?

2.2 Can we estimate how much wood?

More than 70% of the city's current building stock was constructed pre-1950 [7] before the modern era of performance design to specific criteria. They were constructed to historic building types using empirical designs from pattern books (one- or two-family homes, auxiliary garages), or super-regulated prescriptive templates to meet changing 19th Century fire and ventilation regulations (tenement buildings, industrial buildings). The city was largely built on a regular grid of lots approximately 25'x100' and within a short 80-year period preceding 1930, limiting the number of different building types and variations.

Using modern mapping and information management tools one can cross-reference built environment archive data to categorize the number of building types within the city's fabric. Using pattern books and construction templates one can approximate the size and spacing of structural elements and thus the quantity of wood in each building type.

2.3 Why should we estimate how much wood?

There is international consensus that human activity has led to climate change, and to reduce its severity we must reduce our future impact on the planet. Buildings and construction account for nearly 40% of global energy-related carbon dioxide emissions [8], and construction material sources are one of the major contributors.

There are existing structural wood resources in our major cities; as buildings are demolished this resource is released. By quantifying the potential available wood resource encapsulated we can plan how to mine the resource effectively. By reusing salvaged wood we reduce landfill, store embodied carbon, reduce future forest felling, and release valuable timbers which are otherwise no longer available.

3 Encapsulated wood quantities

3.1 Defining building types and their wood contents

To estimate the wood quantities within NYC the building population is subdivided into historic building types which reappear throughout the city. Based on reviews of the building stock of the five boroughs, estimates are made for typical wood joist dimensions and spacing, the typical size of a floorplate, and the number of stories (Figure 1). Where relevant, which wood frames or significant internal partitions were estimated by wall stud dimensions and spacing.

3.2 Estimating the number per building type

Robustly categorizing the approximately 1 million-strong building population of NYC requires detailed data on each building, and corroboration of accuracy through various sources. Data is available from a number of sources, however while capable of providing some specific information (i.e. Land Use categorization) these databases are often corrupt on a local scale (i.e., missing records), on a date scale (i.e., construction dates pre-1950) or focus only on a sub population (i.e., Landmarks).

The author at the Department of Buildings undertook a review of databases from the Department of Buildings, Housing Preservation and Development, City Planning and the Department of Finance's Primary Land Use Tax Lot Output (PLUTO), and using geographic information systems to cross-reference this data to categorize NYC's building stock with reference to the previously identified building types (Figure 1). Within this large population potential miscategorizations of up to tens of thousands are acknowledged, but are considered an acceptable margin of error to provide a useful overall estimate.

3.3 Estimating the rate of release of wood

By combining the information on wood within each building type, and the frequency of each building type within NYC, approximations are made for the total quantity of encapsulated wood, and the average quantity per wood-containing building (Table 1). This total quantity of encapsulated wood in the NYC is estimated at over 14 million m^3, with an average quantity of 14m^3 per wood-containing building. These estimates are of primary structure wood only, excluding floorboards, most partition studs, laths and other smaller repositories.

The rate of release of wood in NYC is a function of the demolition rate of these wood-containing buildings. On the premise that the buildings being demolished are likely the deteriorating wood-containing building stock rather than more modern structures, rates of wood release can be estimated based on the current building demolition rate of 1,000 per year.

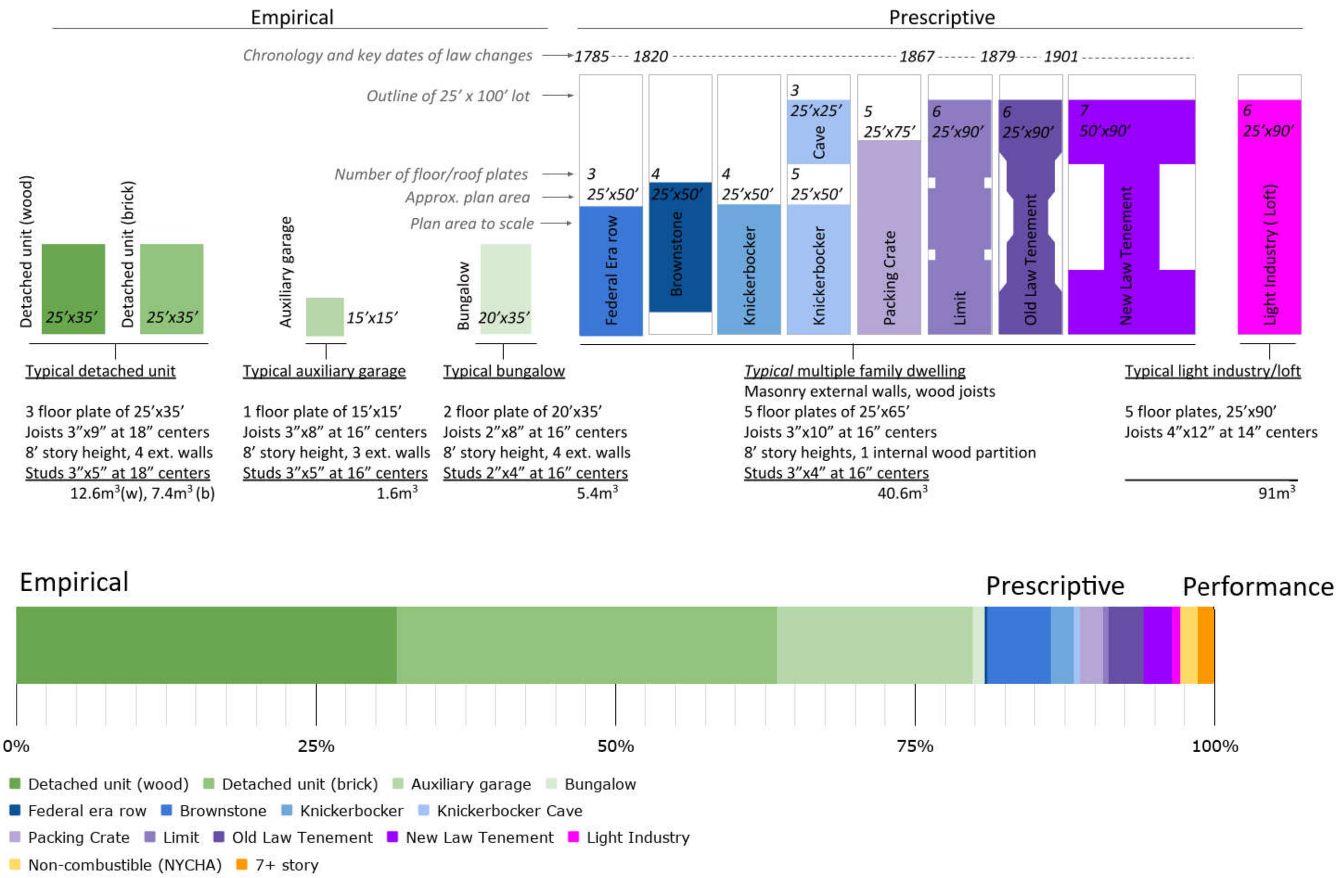

Figure 1. Wood-containing historic building type typical plans and dates [9]; wood quantity estimates and NYC building stock distribution

This equates to a rate of wood release of 14,000m^3 per annum. As the wood-containing building stock continues to age, this rate can be expected to increase.

4 Using released wood

4.1 Salvaging released wood

Understanding the potential quantity of released wood is insufficient if the wood is not salvaged when it is released. Independent organizations currently salvage wood in NYC for non-structural use [10]. The supply of wood is unpredictable and the number of organizations involved in wood salvage in NYC - and the volumes they can process - are consequently small.

Deconstruction and wood salvage industries are more prevalent in other parts of the US where local government has encouraged the removal of large abandoned housing populations [11]; or local ordinances encourage deconstruction by legislating that certain buildings are deconstructed instead of demolished, or by prescribing waste diversion for reuse or recycling [12].

The authors recommend that NYC local government facilitate deconstruction and wood salvage through local ordinances:

- Identifying potential sources of wood release when applications for demolition are received, and requiring the client to contact a suitable wood salvage facility to schedule collection.
- Requiring certain types of building to be deconstructed, either buildings constructed before a certain age, or through identification of building types with typically high proportions of wood.

4.2 Processing salvaged wood

Salvaged wood requires processing before it can be reused, whether wood is partially denailed for external agricultural use, or completely denailed, milled, sanded and regraded for structural use. Processing salvaged wood is only economically viable if there is a guaranteed end-use which will pay for this expenditure.

Table 1. Estimated wood quantities in NYC

Building Type	No. [1000]	Wood /bldg. [m^3]	Wood total [x1000m^3]
Detached unit (wood)	330	12.6	4,166
Detached unit (brick)	330	7.4	2,423
Auxiliary garage	170	1.6	271
Bungalow	10	5.4	54
Brownstone	55	40.6	6,610
Federal era row	3		
Knickerbocker	20		
Knickerbocker cave	5		
Packing Crate	20		
Limit	5		
Old Law tenement	30		
New Law tenement	25		
Light Industry/Loft	7	91	637
Non-combustible	15	-	-
7+ story	15		
Total	1010		14,191

Resource management and life cycle arguments have been proposed for the reuse of salvaged wood in primary structural elements [13]. If a reliable large quantity of salvaged wood is available, structural reuse can provide a suitable large-volume recipient market as part of the city's new-build construction sector. This could produce more diverse light industrial jobs in the city, and reduce congestion and costs associated with importing material.

The primary barrier to structural reuse of salvaged wood is the regrading process. Traditional visual or mechanical structural grading relies on prior data of a relatively homogenous single-species single-source wood supply with consistent dimensions; salvaged wood can be a heterogeneous multi-species multi-source variable dimension supply.

However structural regrading of salvaged wood has demonstrated feasibility of visual regrading [14] and mechanical vibration-based regrading [15], as well as indicating the possibility of useful yields if suitable grade limits are set [16].

The authors recommend that NYC local government facilitate reuse of salvaged wood in a larger market by investing in structural regrading procedures for the local stock, through:

- Providing regrading consultancy and equipment for local salvage industries to use
- Collecting a database of salvaged wood and regrading, to continue to improve grading reliability and wood yield.

4.3 Reusing salvaged wood

To take advantage of salvaged wood regraded for structural reuse there must be a suitable target market. The 2018 IBC building regulations limit use of small dimension wood in type III and V construction to scenarios with 1 hour or less Fire-Resistance Ratings, and 4-5 stories. Larger dimension wood in type IV-HT allow for less restrictive fire resistance, and higher buildings heights of 6 stories [17]. Recently, proposals have been adopted for 2021 IBC to extend the use of laminated mass timber for buildings up to 18 stories. Both Washington and Oregon plan to accept the proposals [18].

These changes are part of an expanding market for mass timber in new mid-rise high-density construction, which salvaged wood can be a part of. Laminated wood products, such as glulam and cross-laminated timber (CLT), are excellent opportunities for using a more heterogeneous or lower grade feedstock to produce higher grade engineered wood products [19] and testing of the feasibility of the manufacturing process is currently being explored [15].

The authors recommend that NYC local government facilitate reuse of salvaged wood within laminated engineered wood products by:

- Accepting the 2021 IBC proposals to extend the permitted use of mass timber in construction
- Partnering with local engineering institutions and laminated wood product manufacturers to develop pilot schemes for glulam and CLT using salvaged wood feedstock
- Educating local built environment professionals, such as clients, contractors, architects, and engineers about the possibilities of using engineered salvaged wood products.

5 Conclusions

New York City is a metropolis in a unique situation: a megacity rapidly constructed from few standardized structural templates, and a now-depleted high-value material resource. The data available on this building stock allows us to estimate that 14,000m^3 of old-growth wood is released annually from the necessary renewal of deteriorating buildings.

This quantity is significantly more than the existing local salvage industry can process. This paper has recommended policy and research interventions to develop a process to convert this salvaged wood into new structural wood products available to a burgeoning local construction market, facilitating this potential resource being used effectively.

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