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From Sapling to Maturity - Exploring Structural Diversity in Urban Forests

Justin Morgenroth

New Zealand School of Forestry

University of Canterbury

David Nowak

USDA Forest Service

Motivation for Study

Big trees seemed to be disappearing from the landscape all around me


Source: http://fineartamerica.com/featured/giant-tree-in-city-hag.html

Perception of a Problem

"Large old trees are disproportionately vulnerable to loss in many ecosystems worldwide as a result of accelerated rates of mortality, impaired recruitment, or both"

Lindenmayer, D.B., Laurance, W.F., Franklin, J.F., Likens, G.E., Banks, S.C., Blanchard, W., . . . Stein, J.A.R. (2014). New Policies for Old Trees: Averting a Global Crisis in a Keystone Ecological Structure. *Conservation Letters, 7(1), 61-69. doi: 10.1111/conl.12013*

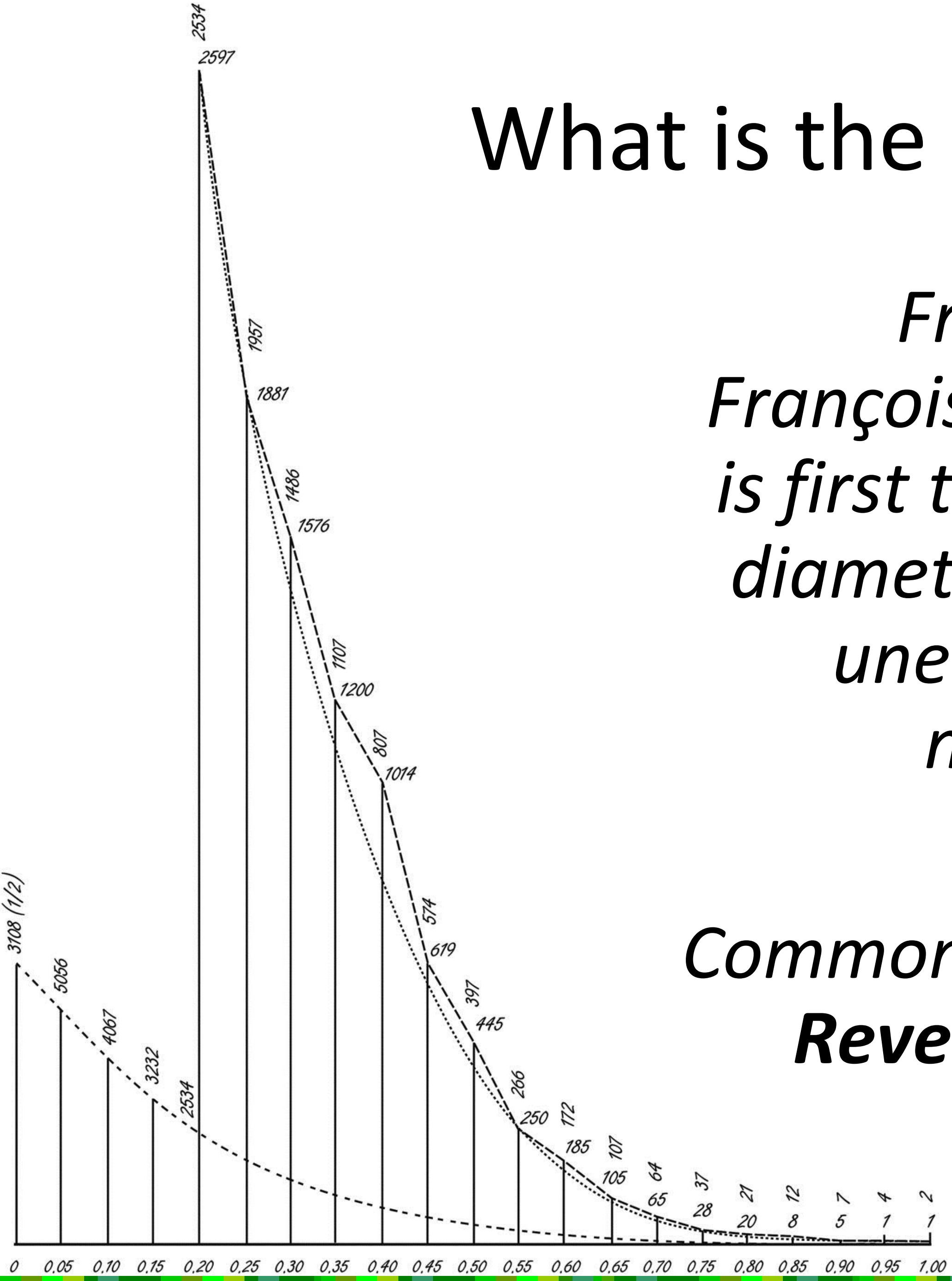
Perception or Reality?

- *Is loss of large trees problematic in our cities?*
- *Do our cities have proportionally low numbers of large trees?*
- To answer these questions, we need a long-term urban forest inventory

Tree Diameter Distributions

- From tree inventories, we can get diameter distributions
- Gain understanding of tree size patterns
  - Size used as a surrogate for age
- What is the ideal distribution?
- Are there any good rules of thumb?

What is the ideal distribution?



French forester François de Liocourt (1898) is first to formally describe diameter distributions for uneven aged forest management

*Commonly referred to as the **Reverse-J** distribution*

de Liocourt, F., 1898, De l'amenagement des sapinières, in: *Bulletin Trimestriel, Société Forestière de Franche-Comté et Belfort, Julliet, pp. 396-409.*

What is the ideal UF dbh distribution?

Urban Ecology, 7 (1982/1983) 159- 171 159
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DIVERSITY AND STABILITY IN A STREET TREE POPULATION

N.A. RICHARDS

College of Environmental Science and Forestry, School of Forestry, State University of New York, Syracuse Campus, Syracuse, NY 13210 (U.S.A.)

(Accepted 5 May 1982)

ABSTRACT

Richards, N.A., 1983. Diversity and stability in a street tree population. *Urban Ecol.*, 7: 159--171.

The relationship of species diversity to the stability of a street tree population is explored, using data from Syracuse, NY. Because streetside spaces are complexly-stressed environments, one generally observes that relatively few species prove wide adaptation and good longevity in a particular community, and that there is greater species diversity among recently planted trees than among older trees in the population. The few species surviving to be well represented among the older trees are likely to be better prospects for contributing to population stability in the uncertain future than are short-lived, ill-adapted, or little-tested species that may be added to increase diversity. Population stability depends on species adaptation to the diversity of streetside conditions in a community over time, rather than on species diversity per se. Good age diversity, to provide adequate successful replacements, is essential for population stability. Undue emphasis on species diversity in replacement plantings may further threaten stability by causing inadequate replacement of the proven adapted species in the older population.

- Richards is most quoted in UF literature
- Cited by many of our best scientists, but is distribution ideal or applicable?
- Richards calls them *"my approximate guidelines"*

Richards, N. A. (1983). Diversity and stability in a street tree population. *Urban Ecology, 7(2), 159-171.*

My Approximate Guidelines…

- Richards' "*approximate guidelines*"

"For adapted, long-lived species […] in Syracuse, […] a good age distribution for population stability would be about ***40% trees under 20 cm*** *diameter,* ***30% 20 – 40 cm*** *trees in the early functional stage,* ***20% 40 – 60 cm*** *functionally mature trees, and* ***10% older trees*** *with most of their functional life behind them."*

Richards, N. A. (1983). Diversity and stability in a street tree population. *Urban Ecology, 7(2), 159-171.*

What is the ideal distribution?

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Structure of a forested urban park: Implications for strategic management

Andrew A. Millward [a,*], Senna Sabir [b]

[a] Department of Geography, Ryerson University, 350 Victoria Street, JOR632, Toronto, ON M5B 2K3, Canada

[b] Environmental Applied Science and Management, Ryerson University, Toronto, ON M5B 2K3, Canada

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ABSTRACT

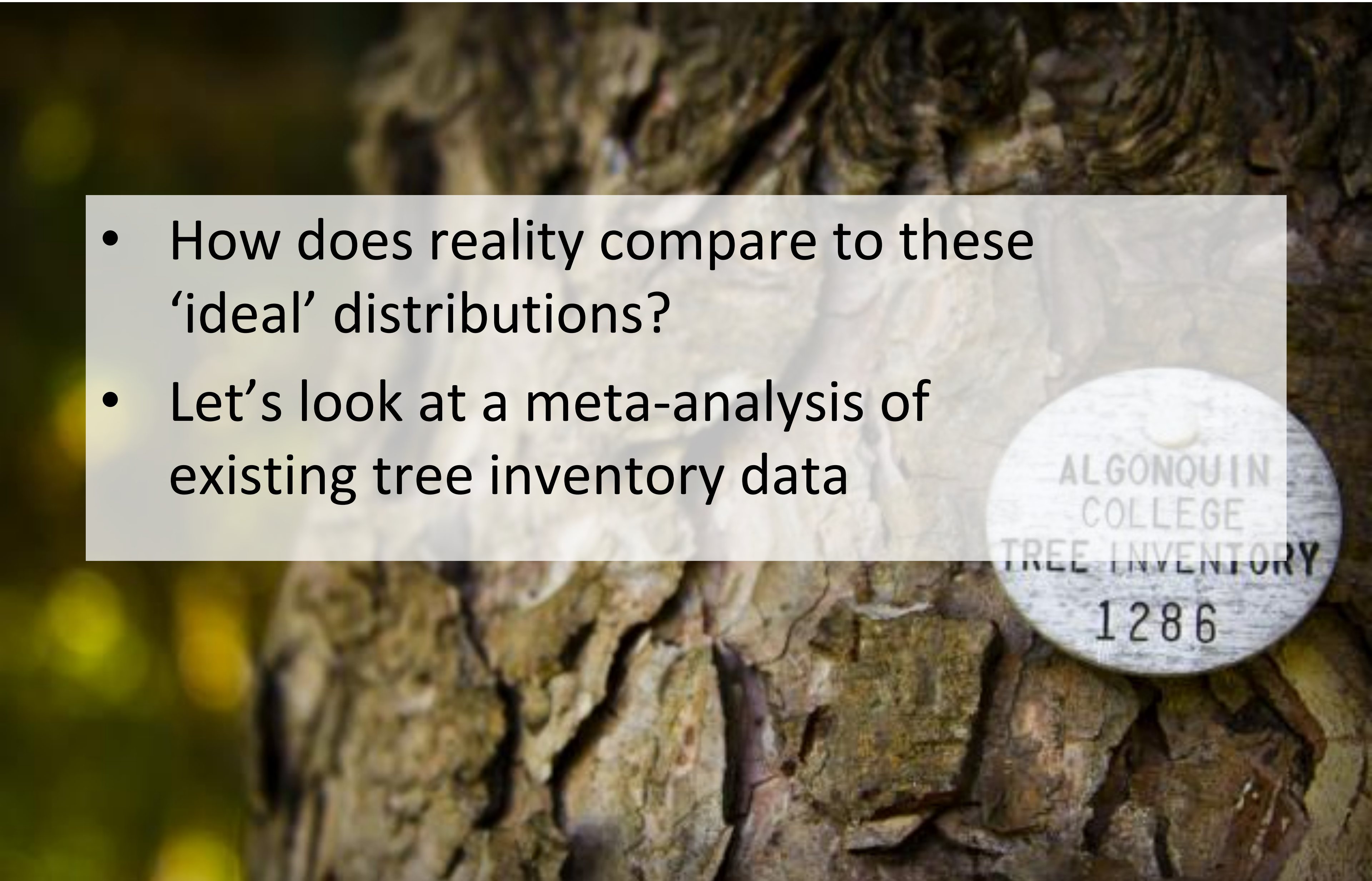
Informed management of urban parks can provide optimal conditions for tree establishment and growth and thus maximize the ecological and aesthetic benefits that trees provide. This study assesses the structure, and its implications for function, of the urban forest in Allan Gardens, a 6.1 ha downtown park in the City of Toronto, Canada, using the Street Tree Resource Analysis Tool for Urban Forest Managers (STRATUM). Our goal is to present a framework for collection and analysis of baseline data that can inform a management strategy that would serve to protect and enhance this significant natural asset. We found that Allan Garden's tree population, while species rich (43), is dominated by maple (*Acer* spp.) (48% of all park trees), making it reliant on very few species for the majority of its ecological and aesthetic benefits and raising disease and pest-related concerns. Age profiles (using size as a proxy) showed a dominance of older trees with an inadequate number of individuals in the young to early middle age cohort necessary for short- to medium-term replacement. Because leaf area represents the single-most important contributor to urban tree benefits modelling, we calculated it separately for every park tree, using hemispheric photography, to document current canopy condition. These empirical measurements were lower than estimates produced by STRATUM, especially when trees were in decline and lacked full canopies, highlighting the importance of individual tree condition in determining leaf area and hence overall forest benefits. Stewardship of natural spaces within cities demands access to accurate and timely resource-specific data. Our work provides an uncomplicated approach to the acquisition and interpretation of these data in the context of a forested urban park.

- Millward & Sabir modify Richards and propose:
- “…a generalized ideal distribution […] that would see **40%** of a tree population fall within a DBH class of **0 – 15 cm, 30%** from **15 – 60 cm, 25%** in class **60 – 90 cm,** and **5%** classified as **90 cm** and above.”

Millward, A.A., & Sabir, S. (2010). Structure of a forested urban park: Implications for strategic management. *Journal of Environmental Management, 91(11), 2215-2224. doi: http://dx.doi.org/10.1016/j.jenvman.2010.06.006*

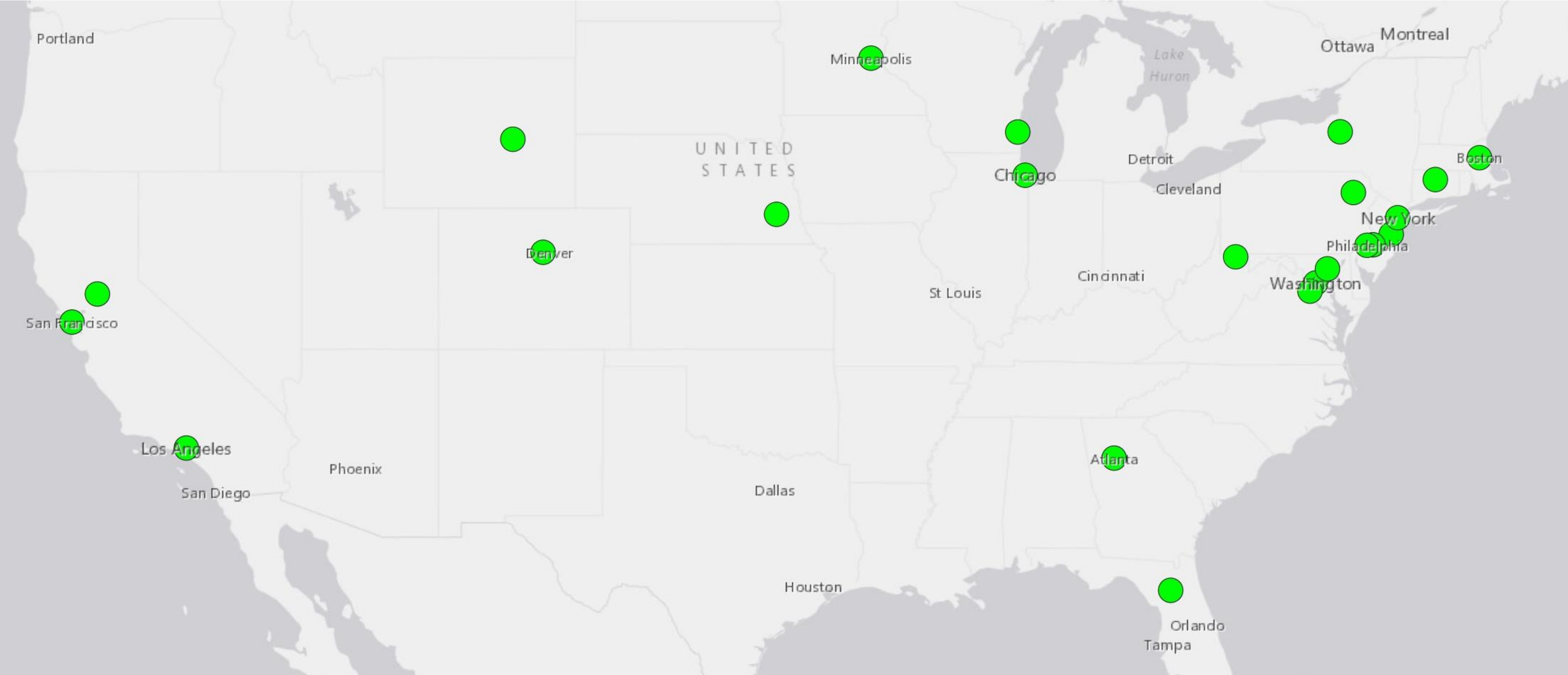
Ideal Distributions vs. Reality

- How does reality compare to these ‘ideal’ distributions?
- Let’s look at a meta-analysis of existing tree inventory data



Diameter Distribution Meta-Analysis

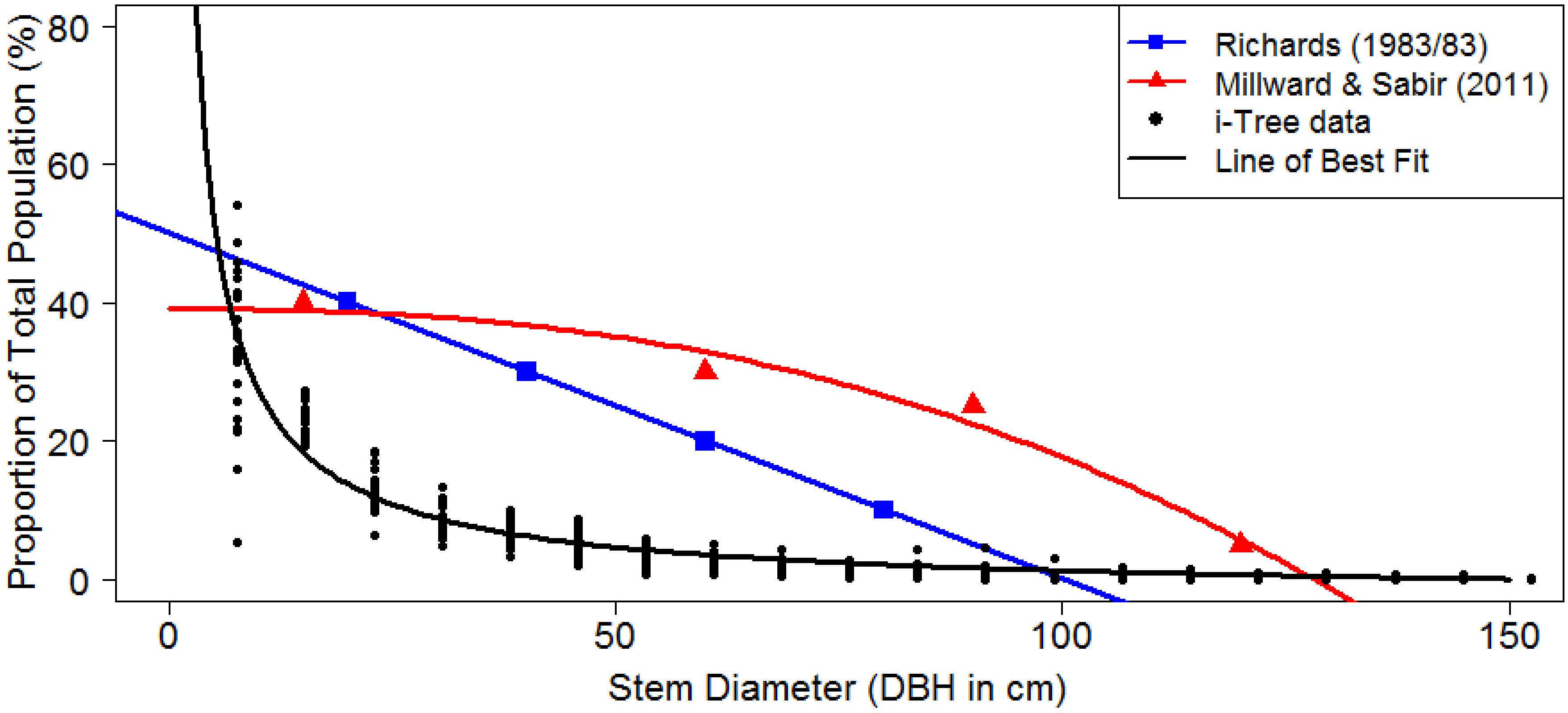
- 23 i-Tree inventories →
- Plot diameter distributions of % trees by 7.5 cm DBH classes



i-Tree Inventory Cities

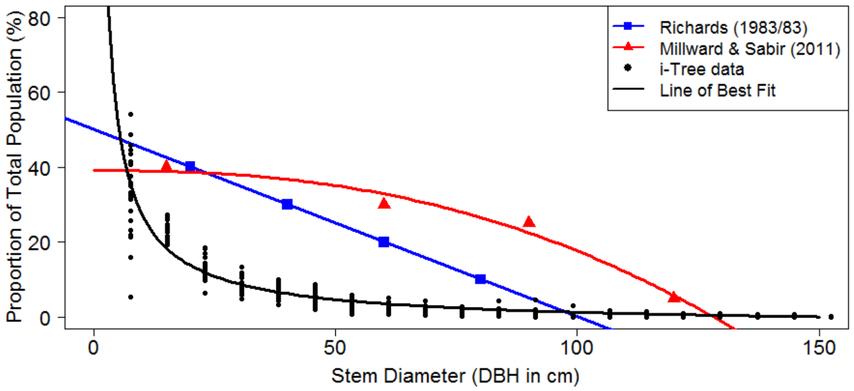
City	State	Population
Atlanta	Georgia	456,002
Baltimore	Maryland	622,793
Boston	Massachussetts	655,884
Casper	Wyoming	60,086
Chicago	Illinois	2,722,389
Freehold	New Jersey	11,973
Gainesville	Florida	128,460
Golden	Colorado	20,201
Hartford	Connecticut	124,705
Jersey City	New Jersey	262,146
Lincoln	Nebraska	272,996
Los Angeles	California	3,928,864
Milwaukee	Wisconsin	599,642
Minneapolis	Minnesota	407,207
Moorestown	New Jersey	20,594
Morgantown	West Virginia	31,073
Philadelphia	Pennsylvania	1,560,297
Sacramento	California	485,199
San Francisco	California	852,469
Scranton	Pennsylvania	75,281
Syracuse	New York	144,263
Washington	D.C.	658,893
Woodbridge	Virginia	4,055

Meta-Analysis → Results



Ideal Distributions vs. Reality

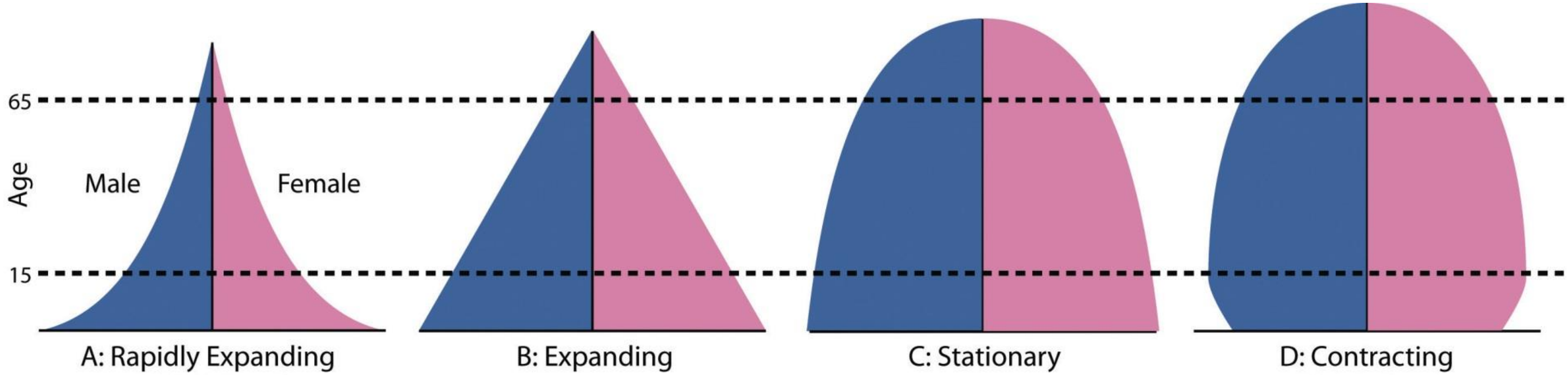
- Reality certainly does not match ‘ideal’
- In reality, we have lower proportion of large trees than under ‘ideal’ conditions

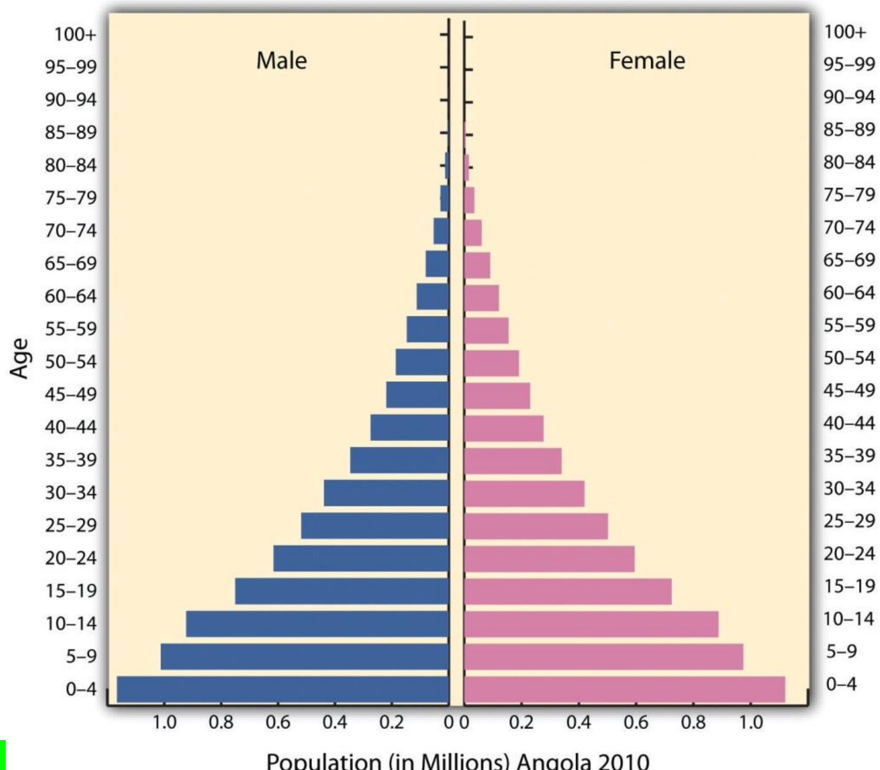


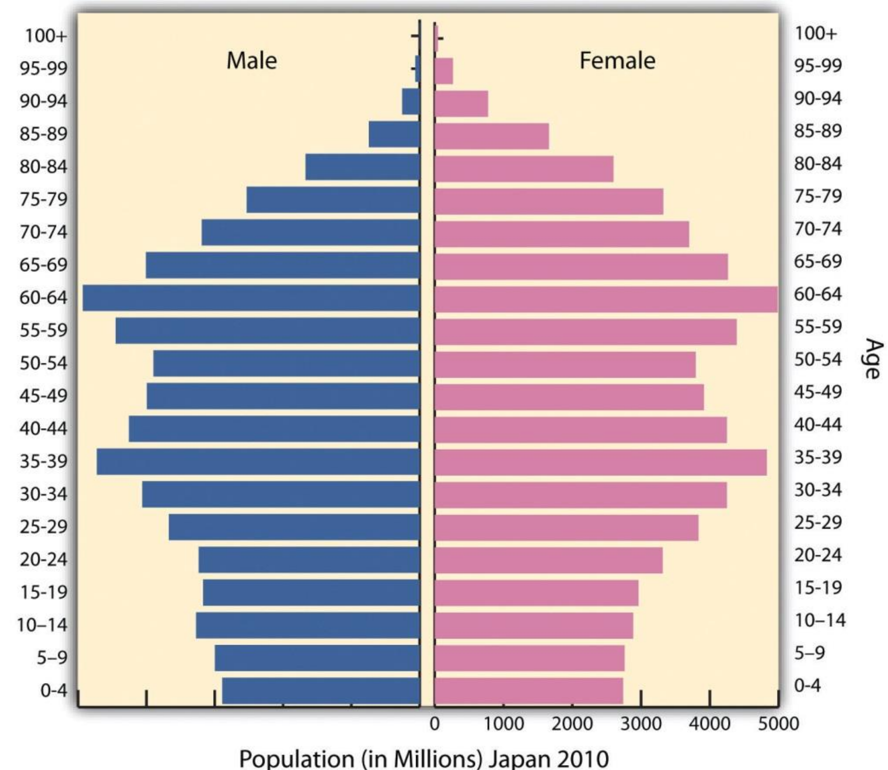
- But this is assuming that the ‘ideal’ distributions are correct
- What do the ‘ideal’ distributions tell us about our UF?

Segway into Population Demography

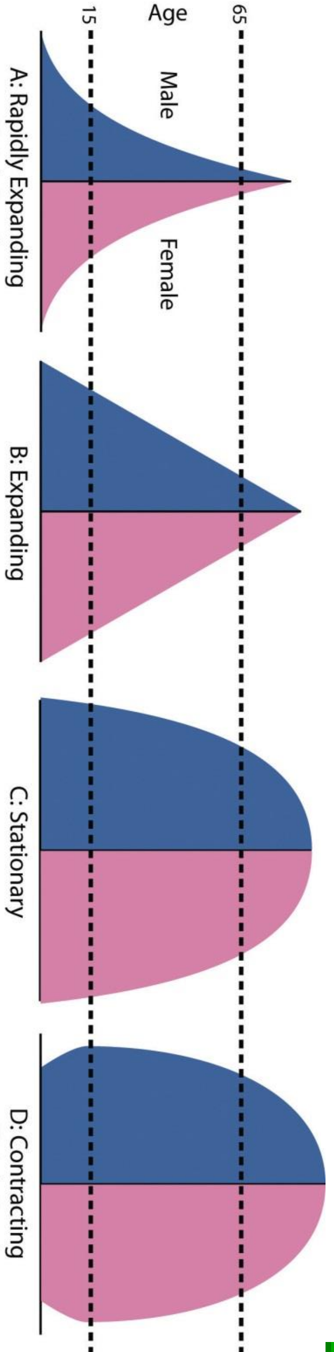
Human Population Demography

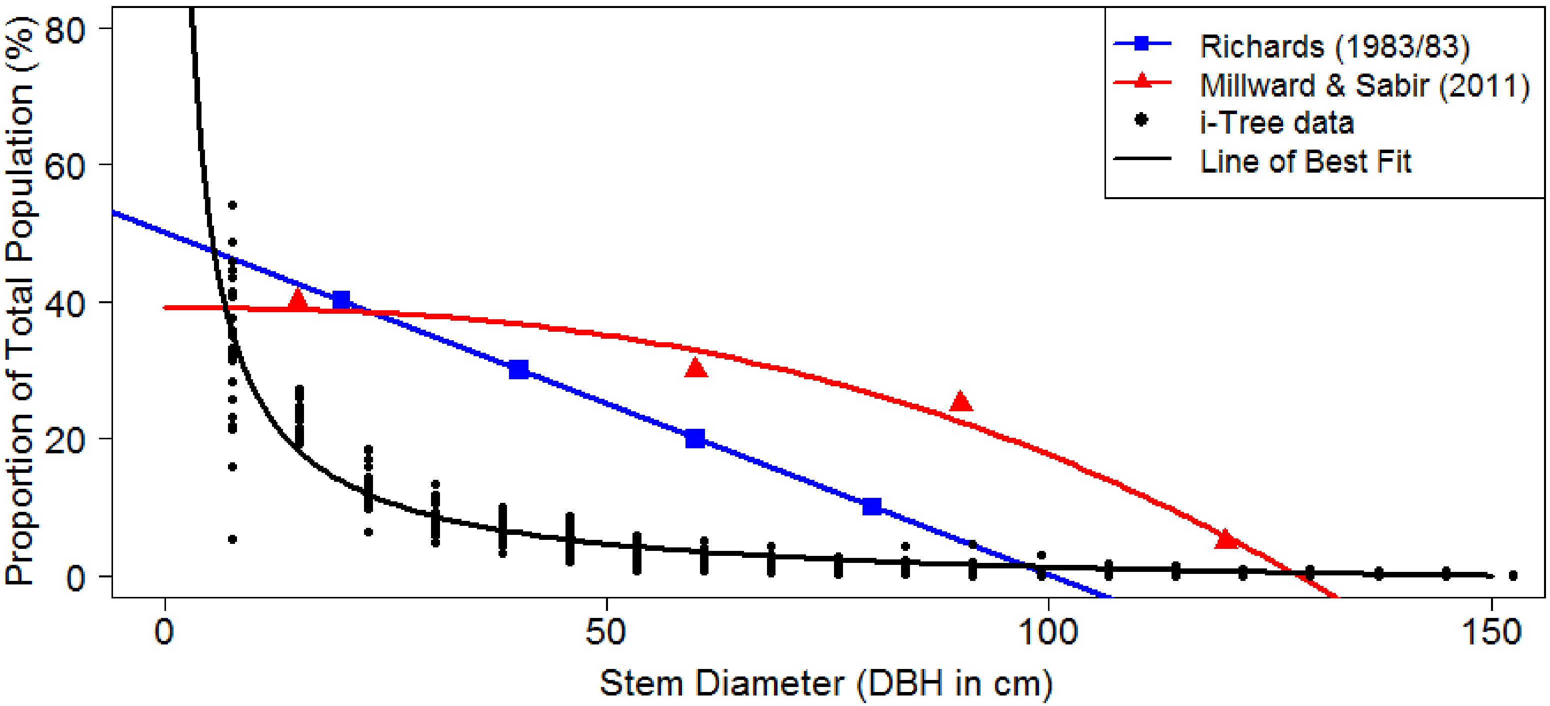






Demography and Tree Size Distribution

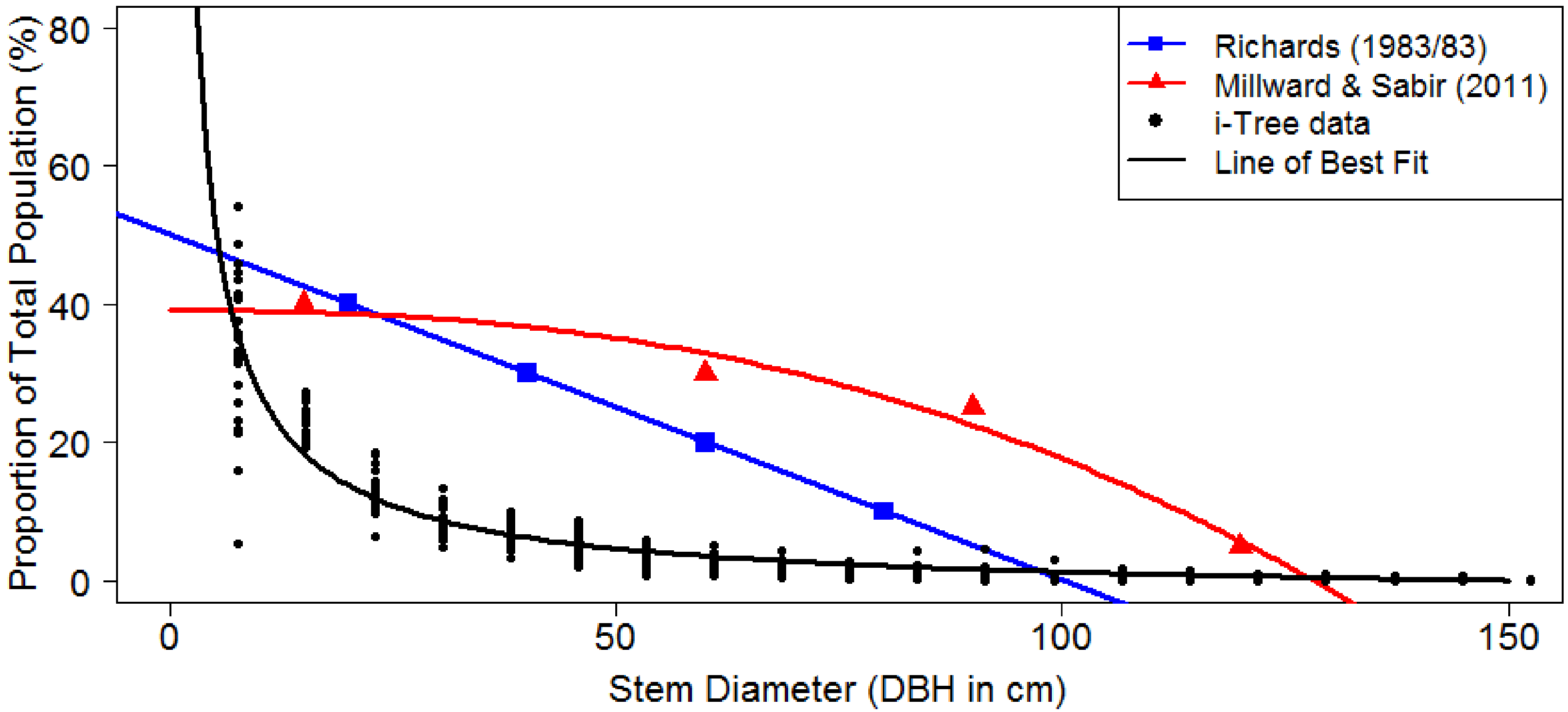




Tree Size Distribution

- What we have: Rapidly expanding
- What we want (according to Richards): Expanding
- What we want (according to Millward & Sabir): Stationary
- What do these demographic descriptions mean with respect to our urban tree populations?

Tree Size Distribution



	Rapidly Expanding (Actual Distribution)	Expanding (Richards)	Stationary (Millward & Sabir)
Planting Rate	High	Decreasing	Low
Mortality Rate	High	Decreasing	Low
Large Tree Proportion	Low	Moderate	High
Relative Diversity Index	62%	92.3%	88.3%

Where Have all the Mature Trees Gone?

- Meta-analysis identified **rapidly expanding** tree populations
- A shift towards a stationary distribution is desirable to increase proportion of large trees in cities
- High mortality/removal rates prevent higher proportion of large trees


Photo Credit: Patrick Reynolds

Photo Credit: Patrick Reynolds

Comments and Questions Welcome