Commentary

Chapter 11.50 Trees In Development Situations

The introductory sections and the sections for Tree Preservation (11.50.040) and Tree Density (11.50.050) are shown in their entirety for reference.

11.50.010, 11.50.020, 11.50.030

No changes are proposed in these sections; they are shown for reference.

CHAPTER 11.50 - TREES IN DEVELOPMENT SITUATIONS

Sections:

11.50.010 Purpose.

The regulations of this Chapter support and complement other City development requirements, with a focus on achieving baseline tree preservation and total tree capacity on a site, considering the anticipated use and level of development. This Chapter regulates the removal, protection and planting of trees through the development process to encourage development, where practicable, to incorporate existing trees, particularly high quality or larger trees and groves, into the site design, to retain sufficient space to plant new trees, and to ensure suitable tree replacement when trees are removed. It is the intent of these provisions to lessen the impact of tree removal and to ensure mitigation when tree preservation standards are not met.

11.50.020 When a Tree Plan is Required.

(Amended by Ordinance No. 188816, effective March 16, 2018.) A tree plan is required in conjunction with all development permits, unless there are no Private Trees 12 inches or more in diameter, no City Trees 6 inches or more in diameter, and/or no Street Trees 3 inches or more in diameter, and the site or activity is exempt from Section 11.50.050 On-Site Tree Density Standards; and Section 11.50.060 Street Tree Planting Standards. If multiple development permits are required for a development proposal, including demolitions and subsequent construction, the same Tree Plan shall be included with each permit. For tree removal when no development permit is required, following completion of the development permit, or when tree preservation does not apply per Subsection 11.50.040 A.1., see Chapter 11.40.

11.50.030 Development Impact Area Option For Large Sites and Streets.

(Amended by Ordinance No. 188278, effective April 14, 2017.) Where development is proposed on a site larger than one acre or where work is occurring in the street and is not associated with an adjacent development site, the applicant may choose to establish a development impact area. For sites using the development impact area option, tree preservation requirements shall be based on the trees within the development impact area and tree density will be based on meeting Option A as applied only to the area within the development impact area. Trees may be planted to meet tree density requirement elsewhere on the site.

Commentary

11.50.040. Tree Preservation Standards

A. Where these regulations apply.

The word “any” is added to clarify that any ground disturbance triggers tree preservation requirements; not ground disturbance greater than 100 square feet.

B. Exemptions

Exemption B.1 shows the removal of the exemption from tree preservation standards for IG1, EX, and CX zones. The exemption from tree preservation is retained in the IH zone to maintain adequate supply for industrial jobs in the IH zone as required by Statewide Planning Goal 9, Economic Development. This exemption applies to sites as defined in Title 33, Planning & Zoning, not rights-of-way.

11.50.040 Tree Preservation Standards.

(Amended by Ordinance Nos. 187675, 188278, 188816, 188959, 189078 and 189795, effective December 12, 2019.)

A. Where these regulations apply.

1. This Section applies to trees within the City of Portland and trees on sites within the County Urban Pocket Areas in the following situations. On sites where these regulations do not apply, tree removal is subject to the requirements of Chapter 11.40, Tree Permit Requirements.

a. On sites. Development activities with any ground disturbance or a construction staging area greater than 100 square feet on unpaved portions of the site within the root protection zone, as defined in Subsection 11.60.030 C.1.a., of one or more Private Trees 12 or more inches in diameter and/or one or more City Trees 6 or more inches in diameter.

b. In streets. Development activities with ground disturbance or construction staging not limited to existing paved surfaces where there are one or more Street Trees 3 or more inches in diameter.

2. Any Heritage Trees and trees required to be preserved through a land use condition of approval or tree preservation plan cannot be removed using the provisions in this Chapter, but may be counted toward the tree preservation requirements of this Section.

B. Exemptions. The following are exempt from the tree preservation standards of this Section:

1. On portions of sites located within an IH~~, IG1, EX, or CX~~ zone.

2. On sites that are less than 5,000 square feet in area.

3. On sites that have existing or proposed building coverage of 85 percent or more.

4. Trees that are dead, dying, dangerous, or a nuisance species, as documented in a Tree Plan per Subsection 11.50.070 B. These are subtracted from the total number of trees to be addressed by the standards.

5. Trees exempted from this standard by a land use decision.

6. Tree preservation requirements approved in a land division or planned development review under Title 33, Planning and Zoning and the requirements of that review are still in effect.

Commentary

11.50.040. Tree Preservation Standards

C. Tree Preservation Requirement

No changes are proposed to the general retention and mitigation standard that 1/3 of the non-exempt trees 12 inches and larger in diameter located completely or partially on the development site must be preserved or a fee paid in lieu of preservation.

7. Repair and replacement of existing fences and decks that are not changing in footprint or length when no trees are to be removed as a part of the project.

C. Tree Preservation Requirement. Any trees preserved shall be protected in accordance with the specifications in Section 11.60.030. The regulations for Private Trees in Subsection 11.50.040 C.1. sunset after December 31, 2024. After December 31, 2024 the regulations in effect will be those in effect on January 1, 2015.

1. Private Trees.

a. General tree preservation.

(1) Retention. An applicant shall preserve and protect at least 1/3 of the non-exempt trees 12 inches and larger in diameter located completely or partially on the development site, unless mitigation occurs per Subsection 11.50.040 C.1.a.(2) below. Retaining trees at least 6 and less than 12 inches in diameter that are documented in a report prepared by an arborist or landscape professional to be Garry Oak (Quercus garryana), Pacific Madrone (Arbutus menziesii), Pacific Yew (Taxus brevifolia), Ponderosa Pine (Pinus ponderosa), or Western Flowering Dogwood (Cornus nuttallii) species are not included in the total count of trees on the site but may be used toward meeting the preservation standard.

(2) Mitigation. For each tree not preserved and protected below the 1/3 requirement, payment to the Tree Planting and Preservation Fund is required as shown in Table 50-1. The fee is calculated using the per-inch Restoration Fee for Tree Removal in the adopted fee schedule for Title 11. In cases where more than one tree is proposed for removal in excess of that allowed by Subsection 11.50.040 C.1.a.(1), the mitigation payment required to meet the 1/3 retention standard is based on the largest tree or trees proposed for removal.

Commentary

11.50.040. Tree Preservation Standards (Cont'd)

C. Tree Preservation Requirement (Cont'd)

Table 50-1 is proposed to eliminate the mitigation cost category for 20-36" trees, and to change the cost category for 36" trees or greater to begin at 20" trees or greater. This change means that trees 20" or greater must pay a mitigation fee in lieu of preservation at a rate equal to the cost per inch of tree removed, or "inch-per-inch" fee in lieu.

11.50.040.C.1.b is proposed to change the threshold for required preservation or mitigation fee in lieu of preservation from 36" or greater to 20" or greater. This means that all non-exempt trees 20" or greater must be preserved or a fee in lieu of preservation paid; regardless if the 1/3 preservation standard of 11.50.040.1(a)(1) is already met with the preservation or fee in lieu of preservation. However, trees greater than 20" may be used to meet the 1/3 preservation standard.

11.50.040.C.1.b(2) changes the name of the Planting and Establishment Fee in Lieu for development to be consistent with the name of the fee as shown on the adopted Urban Forestry Fee Schedule, which was changed since the writing of this code.

11.50.040.C.1.c changes the number and title of this sub-paragraph to be clear that the notice requirement continues to apply to trees that are not preserved that are 36" or greater.

Table 50-1
Required Mitigation

Size of Tree Removed (inches in diameter)	Required Mitigation
At least 12 and less than 20	The cost of (2) two-inch diameter replacement trees
~~At least 20 and less than 36~~	~~The cost of (4) two-inch diameter replacement trees~~
At least 20~~36~~ or more	The cost per inch of tree removed

b. Preservation of trees 20~~36~~ inches or greater.

(1) Retention. An applicant shall preserve and protect all non-exempt trees 20~~36~~ inches in diameter or greater located completely or partially on the development site, unless mitigation and notice occurs per Subsections 11.50.040 C.1.b.(2) and 11.50.040 C.1.b.(3), below. Retention or mitigation of these trees may also be used to meet the standards for general tree preservation in Subsection 11.50.040 C.1.a. above.

(2) Mitigation. For each tree 20~~36~~ or more inches in diameter not preserved and protected, payment to the Tree Planting and Preservation Fund is required as shown in Table 50-1. The fee is calculated using the per-inch ~~Restoration Fee for Tree Removal~~ Planting and Establishment Fee in Lieu for development in the adopted fee schedule for Title 11.

c.~~(3)~~ Notice for trees 36 inches or greater not preserved and protected. If a tree 36 inches or greater in diameter is not preserved and protected as allowed by Subsection 11.50.040 C.1.b.(2) above, the property owner or the property owner's representative must post a notice on the site and send a notice to the recognized Neighborhood Association and District Coalition in which the site is located. The notices are for notification purposes only. The notices do not provide for public comment on the proposal or for appeal of the proposal. The property owner or the property owner's representative must provide a signed certification to the Bureau of Development Services that a notice was posted on the site and a notice was sent to the Neighborhood Association and District Coalition. The development permit may not be issued until the business day following the day the notification period is completed.

Commentary

11.50.040. Tree Preservation Standards (Cont'd)

C. Tree Preservation Requirement (Cont'd)

11.50.040.C.1.c 11.50.040.C.1.d and 11.50.040.C.1.e are renumbered and a reference changed due to renumbering.

(1)~~(a)~~ The posted notice must:

(a)~~(i)~~ Be posted on the site for at least 45 calendar days prior to development permit issuance;

(b)~~(ii)~~ Be posted within 10 feet of the street lot line nearest the tree or trees to be removed;

(c)~~(iii)~~ Include the date of posting and the date of the end of the notification period;

(d)~~(iv)~~ Include a site plan at least 8.5 x 11 inches in size showing the location and description of the trees(s) to be removed including diameter inch size(s); and

(e)~~(v)~~ Include contact information for the property owner or the property owner's representative.

(2)~~(b)~~ The notices to the Neighborhood Association and District Coalition must:

(a)~~(i)~~ Be e-mailed or mailed to the Neighborhood Association and District Coalition using the contact information maintained by the Office of Community & Civic Life. If mailed, the notice must be sent via certified or registered mail. The date of the e-mail or the mailing must be at least 45 calendar days prior to development permit issuance;

(b)~~(ii)~~ Include a description of the trees(s) to be removed including diameter inch size(s); and

(c)~~(iii)~~ Include contact information for the property owner or the property owner's representative.

d.~~(4)~~ Exemption of tree preservation mitigation payments for affordable housing developments. Projects are exempt from the mitigation requirements in Subsection11.50.040 C.1.b.(2) if the development will be an affordable housing development approved for system development charge exemptions under Section 30.01.095. The amount of the mitigation exemption shall be pro-rated to a percentage equal to the percentage of dwelling units on the development site that are approved for the systems development charge exemption in Section 30.01.095. The Director of the Portland Housing Bureau may adopt administrative rules for the administration of Subsection 11.50.040 C.1.d.~~b.(4).~~

Commentary

11.50.040. Tree Preservation Standards (Cont'd)

C. Tree Preservation Requirement (Cont'd)

11.50.040.C.1.c 11.50.040.C.1.d and 11.50.040.C.1.e are renumbered and a reference changed due to renumbering.

e.~~e.~~ Exception for Capital Improvement Projects. Trees on private property that are part of a capital improvement project and within the development impact area are regulated as City and Street Trees.

2. City and Street Trees.

a. Retention. For development on City owned or managed sites, new public streets, or improvements to existing streets, applicants are required to consult with the City Forester at the preliminary project design phase if City or Street Tree removal is likely to occur to complete the project. The purpose of this consultation is to identify potential impacts and opportunities to retain existing trees, as well as any measures required to protect trees on site, on adjacent sites, or in the street.

b. Mitigation. Any required mitigation specified below shall occur on the site, in the street planter strip, or in the same watershed either by planting or a payment into the Tree Planting and Preservation Fund. The City Forester may reduce or waive the following mitigation requirements.

(1) Approved Street Tree removal in conjunction with improvements to partially or fully unimproved streets. Each tree at least 12 inches in diameter that is allowed to be removed shall be replaced with at least one tree. Trees planted to meet Street Tree Planting Standards will be credited toward meeting this requirement.

(2) Any other Street or City Tree allowed to be removed that is 6 or more inches in diameter shall be replaced with at least one tree in addition to trees required to meet required tree density or Street Tree planting standards.

11.50.050 On-Site Tree Density Standards.
(Amended by Ordinance Nos. 187675, 188278 and 188959, effective May 24, 2018.)

A. Where these Regulations Apply. This Section applies to sites within the City of Portland and the County Urban Pocket Areas. Unless exempted in Subsection 11.50.050 B., the following are subject to the On-Site Tree Density Standards:

1. New Development;

2. Exterior alterations to existing development with a project valuation that is more than the threshold stated in Subsection 33.258.070 D.2.a.

Commentary

11.50.050 On-Site Tree Density Standards

B. Exemptions

Exemption B.1.c shows the removal of the exemption for on-site tree density standards for IG1, EX, and CX zones. The exemption from on-site tree density standards is retained in the IH zone to maintain adequate supply for industrial jobs in the IH zone as required by Statewide Planning Goal 9, Economic Development. This exemption applies to sites as defined in Title 33, Planning & Zoning, not rights-of-way.

B. Exemptions.

1. The following development activities are exempt from the on-site tree density standards:

a. A specific condition of land use review approval exempts the site from these density standards;

b. The site is within the Portland International Airport Plan District or Cascade Station/Portland International Center Plan District and is subject to the Airport Landscape Standards; see Title 33, Planning and Zoning.

c. On portions of sites located within an IH~~, IG1, EX, or CX~~ zone.

d. Work conducted under Demolition, Site Development, Septic, Plumbing or Zoning Permits.

2. Sites with the following primary uses are exempt from the on-site tree density standards:

a. Railroad Yards;

b. Waste Related;

c. Agriculture;

d. Aviation and Surface Passenger Terminals;

e. Detention Facilities;

f. Mining;

g. Radio Frequency Transmission Facilities; or

h. Rail Lines and Utility Corridors;

C. New development shall meet City specifications and standards in Chapter 11.60 and the on-site tree density requirements in Subsection D., below. Exterior alterations shall meet City specifications and standards in Chapter 11.60 and the on-site tree density requirements in Subsection D., below, but are only required to spend 10 percent of project value on the requirements in Subsection D. and the nonconforming upgrades required by Chapter 33.258, Nonconforming Situations.

Commentary

11.50.050.D On-Site Tree Density Requirements

There are no changes proposed to tree density standards. They are shown for reference.

D. On-Site Tree Density Requirements.

1. Required Tree Area. The required tree area is based on the size of the site and the type and size of proposed and existing development as shown in Table 50-2. Applicants may choose Option A or Option B for calculating required tree area except only Option A may be used to apply standards to a "Development Impact Area".

Table 50-2
Determining Required Tree Area

Development Type	Option A	Option B
One and Two Family Residential	40 percent of site or development impact area	Site area minus building coverage of existing and proposed development
Multi Dwelling Residential	20 percent of site or development impact area	
Commercial/Office/ Retail/Mixed Use	15 percent of site or development impact area	
Industrial	10 percent of site or development impact area	
Institutional	25 percent of site or development impact area	
Other	25 percent of site or development impact area	

Commentary

11.50.050.D On-Site Tree Density Requirements (Cont'd)

There are no changes proposed to tree density standards. They are shown for reference.

2. Required Tree Density. The required tree area shall be planted with some combination of large, medium or small canopy trees at the following rates:

Table 50-3
Number of Required Trees and Minimum Planting Area

Canopy size category (at maturity)	**Number of trees required per size of tree area**	**Min. required planting area per tree (min. dimension)**
Large	1 per 1,000 s.f.	150 s.f. (10' x 10')
Medium	1 per 500 s.f.	75 s.f. (5' x 5')
Small	1 per 300 s.f.	50 s.f. (3' x 3')

Refer to Chapter 11.60, Technical Specifications, to calculate tree canopy size categories. When the canopy size category of the tree species is not or cannot be determined, the tree will be considered a small canopy tree.

3. Tree Density Credits

a. Trees planted on site to meet any required stormwater or other landscaping requirement may be counted toward the On-site tree density requirements.

b. Trees that are retained and protected, including trees preserved per Section 11.50.040, may be credited as follows:

(1) Trees between 1.5 and less than 6 inches in diameter count as one small canopy size tree.

(2) Trees 6 or more inches in diameter count as one medium canopy size tree for each full increment of 6 diameter inches.

c. Payment in lieu of planting. The applicant may pay a fee to the Tree Planting and Preservation Fund per Section 11.15.010 equivalent to the cost of planting and establishing one 1.5-inch caliper tree. The fee per tree shall be credited at a rate of one medium canopy size tree.

d. On sites less than or equal to 3,000 square feet, healthy non-nuisance species trees planted or retained in the street planting strip may be credited as described in this Subsection.

Commentary

11.50.060-11.50.095

No changes to the remaining sections in chapter 11.50 are proposed. The titles of the sections are provided for reference.

11.50.060 Street Tree Planting Standards.

[No change]

11.50.070 Tree Plan Submittal Requirements.

[No change]

11.50.080 Changes to Approved Tree Plans and Emergency Tree Removal.

[No change]

11.50.090 Administrative Review.

[No change]

11.50.095 Appeals.

[No change]

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Appendix C: Summary of Community Interviews

Portland Title 11, Trees – Code Amendments

Stakeholder Interviews

Highlights

Updating Portland's Tree Code

The City of Portland is shaping proposals to strengthen tree preservation during development. Three City bureaus – Development Services, Planning & Sustainability, and Parks & Recreation – are seeking community input on upcoming proposals. The City will be conducting surveys and holding educational meetings to share analysis and research on this topic, and inviting views of community members.

It is widely recognized urban trees make vital contributions to the environment and human health, while lessening the adverse effects of climate change. In 2011, Portland adopted its first unified Tree Code to regulate tree preservation, removal, planting and pruning. The current Tree Code took effect in 2015.

In 2019, public concern about the removal of large trees led to recommendations by the Planning and Sustainability Commission and the Urban Forestry Commission to further strengthen regulations by removing the exemptions for tree preservation and planning for private trees or trees on City-owned or managed sites in some industrial, commercial, and employment zones. The Urban Forestry Commission also recommended decreasing required preservation and "inch-per-inch" fee-in-lieu tree diameter threshold from 36 inches to 20 inches for private trees.

City Council responded by directing the bureaus to consult with stakeholders and develop options for addressing these recommendations. The City is also developing a scope of work for more comprehensive updates to further strengthen Portland's Tree Code. Stakeholders will be invited to weigh-in on what topics should be considered.

Stakeholder Interviews

As an early step in stakeholder outreach, the City's consultants – Barney & Worth, Inc. – interviewed a cross-section of 27 interested stakeholders: tree and wildlife advocates, development community, potentially affected property owners, neighborhood associations, equity groups, members of City Commissions and advisory groups, and representatives of City bureaus involved in Tree Code issues. Interviews were conducted in-person and by telephone with persons who are involved or have an interest in decisions surrounding tree preservation. Some participants took part in the previous policy discussions on Tree Code amendments. Interviewees were asked to share their perspectives related to Portland's trees and the proposed amendments, along with their vision and suggestions for the future.

This report reflects the advice, feelings and attitudes of the individuals interviewed. It is not intended to provide a scientifically valid profile of community opinion as a whole.

Appendix C: Summary of Community Interviews

Highlights

The following highlights summarize the leading points offered by stakeholders who were interviewed for the update of the Portland Title 11, Trees – Code Amendments.

a. **Trees are valued by Portlanders for their contributions to livability, beauty and "sense of place".** Their role in air and water quality, cooling effects, climate change mitigation and other health and environmental benefits is well understood. Trees are viewed as deserving and needing protection.

b. **It is broadly recognized that trees are not evenly or equitably distributed throughout the City.** Some neighborhoods enjoy dense canopies of mature trees and shaded streets, while other, primarily low-income communities are "tree deficient". Research has identified "heat islands" associated with lack of trees, resulting in higher summer temperatures and adverse health effects on residents of these communities.

c. **There is widespread agreement the current Tree Code is not working well.** While Portland is seen as a "well-treed city" compared with other parts of the country, almost everyone agrees the Code is overly complex, difficult to understand and enforce, inadequately funded and staffed, inequitable, and plagued by inconsistency and conflicting requirements.

d. **Portland's Tree Code conflicts with other City codes and policies.** Title 11 and Chapter 33 seem uncoordinated and unnecessarily duplicative, while other City rules and requirements are contradicted by the Tree Code. As a result, there are structural conflicts among City Bureaus on tree protections, with permit applicants forced to navigate these stormy waters or choose which rules to follow.

e. **The Tree Code fails to clarify "what we want to protect**." Lack of clarity about tree protection goals feeds contrasting views on whether all properties should be treated the same, or whether better results would be achieved by site-specific assessments. Some observers feel Portland's trees are "generally fine" and see the Code as overly restrictive, while others think the current tree canopy is "woefully inadequate"

f. **Stakeholders are left guessing about how mitigation funds are used.** While many are aware of the fee-in-lieu mitigation option and can calculate the fee per tree removed, few have any idea how the monies are invested. Many express hope the funds are used to plant trees in low-income communities where they are lacking.

g. **Participants have sharply contrasting views on the proposed removal of some industrial and commercial lands from tree preservation and planting requirements.** Some see removing the exemption as an important step toward treating all properties fairly and for creating/protecting

canopy in adjacent low-income neighborhoods. Others believe the rules should prioritize development and use of industrial/commercial sites to promote jobs and economic opportunity.

h. **Perspectives differ significantly on the proposed reduction of the threshold for the inch-per-inch mitigation fee from 36" to 20" diameter.** Opinions range from a conviction that preserving smaller diameter trees will hasten progress toward meeting canopy goals, to a belief that the size threshold is arbitrary, inequitable and would create perverse effects.

i. **Most stakeholders acknowledge increased urban density, affordable housing and tree preservation are competing goals and that more work/creative thinking is needed to address this problem.**

j. **There is strong support for a comprehensive update of the Portland Tree Code, and participants suggest a rich treasure of topics to be addressed.** Some recommend the comprehensive review take place *before* any specific amendments are considered; otherwise, we "have it backwards".

Appendix C: Summary of Community Interviews

Proposed topics are shown below.

Suggested Topics for Upcoming Tree Code Update

Streamline Process

- Reduce complexity; simplify
- Align conflicting rules (Title 11 and Chapter 33; tree related requirements of other Bureaus)

Improve Results

- Clarify tree protection goals, addressing criteria in addition to tree size
- Analyze best practices in other cities
- Allow for site flexibility
- Offer incentives: "Use more carrots than sticks! Don't make it hard to do the right thing."
- Make cost part of decision-making, especially for small scale urban-infill projects
- Develop appeals process for specific situations based on equitable criteria
- Ensure adequate resources for implementation
- Provide assistance to low-income communities for tree planting/nurture

Plan for the Future

- Develop landscape level "green infrastructure plan" focused on trees that sets goals; where trees should be planted; the desired future canopy; diverse tree species and age classes; and climate change resilience.
- Make trees a primary strategy for addressing climate change in Portland.

A list of the persons interviewed and discussion questions are attached.

Appendix C: Summary of Community Interviews

Portland Title 11, Trees – Code Amendments

Jeff Bachrach	Bachrach Law, Planning & Sustainability Commission, Development Review Advisory Committee (DRAC)
Tom Bouillion & Matt Paroulek	Port of Portland
Corky Collier	Columbia Corridor Association
Susan Ellis & Tyler Mann	Bureau of Development Services
Rick Faber	Portland Parks & Recreation – Urban Forestry
Leah Fisher	Southeast Uplift
Andrew Gallahan	Portland Parks & Recreation – Urban Forestry
Ezra Hammer	Home Builders Association
Morgan Holen	Consulting Arborist
Jon Issacs	Portland Business Alliance
Maryhelen Kincaid	Former Chair – DRAC
Ted Labbe	Urban Greenspaces Institute
Oriana Magnera	Verde, Planning & Sustainability Commission
Catherine Mushel	Trees for Life
Linda Nettekoven	Hosford-Abernathy Neighborhood Association
Wendy Rahm	Downtown Neighborhood Association
Bob Sallinger & Micah Meskel	Portland Audubon Society
Michelle Schulz	BOMA
Suzannah Stanley	NAIOP
Ginny Stern & Peter Sallinger	Portland Youth Climate Council
Megan Van de Mark	Urban Forestry Commission
Ellen Wax	Working Waterfront Coalition
Justin Wood	Fish Construction NW, DRAC

Portland Title 11, Trees – Code Amendments
Stakeholder Interviews

Name: _____Phone: _____

Organization:_____Email: _____

DISCUSSION GUIDE

Introduction

The City of Portland is considering amendments to strengthen tree preservation under the City Code. City officials are interested in hearing the views of community leaders on possible changes to tree regulations.

1. How have you been involved with trees in the City of Portland or with Portland's Tree Code? Did you participate in earlier policy discussions about possible changes to tree protections?

   _____

   _____

   _____

2. What phrases come to mind that best characterize the City of Portland's trees and the communities that reside here? What are the most important contributions trees make to our city and the communities that reside here?

   _____

   _____

   _____

3. How do you compare current conditions for Portland's trees with what you would like to see? Are there any barriers to achieving that vision?

   _____

   _____

   _____

4. What's your general outlook on the current tree protections in Portland's City Code? Are they working well? What isn't working? (Explain.)

   _____

   _____

   _____

Appendix C: Summary of Community Interviews

Proposed Amendments

The areas being considered for changing Portland's Tree Code include:

- Removing exemptions from tree preservation and planting requirements on private lands and city-owned parcels zoned for economic development, including specific commercial, industrial and employment zones.
- For private trees, reducing the tree size threshold for "inch-per inch" mitigation in lieu of preservation from 36 inches in diameter to 20 inches for trees subject to tree preservation requirements.

5. A. Are you familiar with the current tree preservation requirements and/or the proposed changes? Do you understand the purpose of the changes? Do you have any questions about the current rules or proposed changes?
   Current rules: _____

   _____

   _____

   Proposed changes: _____

   _____

   _____

   B. Are you familiar with the mitigation fund and how those monies are allocated?

   _____

   _____

   _____

6. What is your outlook on the possible Code changes? What results do you expect?

   Removing exemptions for tree protection and tree planting in some industrial and commercial zones:

   _____

   _____

   _____

   Reducing the tree size threshold for inch-per-inch mitigation from 36" to 20" diameter:

   _____

   _____

   _____

7. What are the benefits and drawbacks of requiring tree preservation in industrial and commercial areas? Are there more effective ways to balance economic and environmental goals in changing the Tree Code?

   _____

   _____

   _____

8. Do you have any thoughts on how housing could be affected, particularly by reducing the preservation threshold to 20", or how to balance tree protections with community housing needs?

   _____

   _____

   _____

9. How could communities of color, marginalized or low income communities be affected by changes to the Tree Code?

   _____

   _____

   _____

10. The City of Portland is also developing a scope of work for more comprehensive updates to further strengthen Portland's Tree Code. The scope will be presented to City Council later this year.
    What additional topics would you like to see that comprehensive review consider?

    _____

    _____

    _____

11. What things should the City Council consider in making decisions on additional tree protections? Are there any values that should guide their decisions?

    _____

    _____

    _____

Stakeholder Engagement

12. A. Are there any other people or organizations you would recommend we contact at this early stage to get their views on tree preservation in Portland's Code?

_____

_____

_____

B. What information will be of greatest interest to them? What would be of interest to you / your organization about tree protections and the proposed Portland Code amendments?

_____

_____

_____

13. What is the best way for the City of Portland to get information to you as this issue moves ahead?

☐ Attend a meeting

☐ Get information on the website: portlandoregon.gov/bds

☐ Receive email updates

☐ Other: _____

Wrap-up

14. Can you offer a single most important piece of advice for the City of Portland as it considers amendments to tree protections in the City Code?

_____

_____

_____

15. Any further comments or suggestions?

_____

_____

_____

Portland Title 11, Trees – Proposed Code Amendments

Online Survey – April/May 2020

HIGHLIGHTS Rev. 6/2/20

Participation: 2,064 completed surveys

1,277 written comments;

5:46 typical time to complete

Survey Results

Q#1 – Highest priorities for Code amendments (% very important/important)
There is near-consensus among survey respondents on priorities for Tree Code amendments.

95% – Preserving and planting more trees in industrial areas in close proximity to the Willamette River, Columbia Slough, the Columbia River, or other environmentally sensitive natural areas.

92% – Preserving trees in certain industrial and commercial sites, when possible.

92% – Preserving and planting trees in industrial areas in close proximity to low-income communities and communities of color.

86% – Collecting fees paid into the tree planting and preservation fund when trees must be removed.

82% – Ensuring all industrial, commercial, and residential areas are subject to the same tree preservation requirements.

Lower priorities

29% – Minimizing the cost of developing industrial sites.

29% – Maximizing the amount of land available for industrial uses to accommodate middle-income job growth.

Q#2 – Highest priorities for mitigation fee (% very important/important)
Likewise, there is strong agreement on objectives for the mitigation fee.

91% – Improving environmental and health outcomes

87% – Preserving more trees when construction occurs on private property

78% – Increasing mitigation fees enabling more trees to be planted and preserved elsewhere

77% – Minimizing the cost of housing, including affordable housing

Lower priorities

32% – Minimizing the cost of development

Q#3 – How to <u>improve tree preservation</u> for private development

The leading strategies for improving tree preservation on private property include:

83% – Better incentives

70% – More flexibility

64% – More community education: how to preserve trees, improve public health

55% – Higher mitigation fees

***Q#4* – Topics for future comprehensive update of Portland's Tree Code**

Around half of respondents suggest topics for a Tree Code update.

Common Themes

Recurrent themes are listed below.	**Total Mentions**
Preserve/preservation/replace/replacement/protect	253
Large tree/heritage tree/mature tree/old tree/big tree/native/native species	202
Code/rules/enforcement/fine/mitigation fee	175
Affordable/affordable housing/housing/low income	168
Tree canopy/canopy	126

Climate change/carbon/light-heat-noise/pollution	98
Industry/industrial area/development	87
Incentives/incentivize/subsidize/waiver/tax breaks	67
Invasive species/invasive/ivy	40
Flexible/flexibility/option	40
Public education/education/educate/classes	38

Suggestion Box

A sampling of participants' suggestions, in their own words:

"Plant fruit trees in areas where residents are economically poor so they can harvest fruit."

"Trees help people reduce their energy costs and medical costs."

"I would love if trees around Portland had their species labeled on them so that children, adults and families could learn about trees."

"Save heritage tree seed to replant."

"Removal with replacement of healthy trees should be considered."

"I really want to plant some evergreens, but all that's allowed is deciduous – useless as windbreaks."

"Affordable tree arborist help in lower income areas."

"Specific incentives to replace invasive tree species with better trees."

"Larger protection of native trees and more incentives on replanting native trees."

"It is critical that industrial landowners be required to protect the environment. Growing our urban forest is an essential part of our response to climate change."

"More emphasis on the tree canopy as habitat." "Preserving trees which are homes to animals." "Attention to wildlife corridors increasing green space."

"Increase fines for people who illegally remove trees."

"Reduce fees for removal of trees when necessary to remove a diseased tree."

"Consider offering trees and teams to plant them on private property for homes who want to increase tree canopy."

"We are in a drought and climate change, fewer and fewer replacement trees will survive."

"More trees more trees more trees."

Appendix D: Summary of Community Survey

Q#5,6,7,8 **– Participant Profile**

Survey respondents are from all parts of the city, with proportionately greater representation from participants who are female, white and homeowners.
More than 40% of respondents identify with advocacy groups for environment/climate/trees/wildlife/community.

Geographic

- Citywide representation: 30+ zip codes
- Many respondents (43%) live in close-in neighborhoods: SE, N/NE, NE and S/SW

Demographic

59%	female
89%	white (Portland average is 77%)
79%	homeowners (53%)
18%	rent (47%)
2%	own industrial or commercial property
2%	rent industrial or commercial property

Affiliations

90%	interested community member
53%	own/manage property
16%	environmental/climate advocacy group
14%	community-based organization
11%	tree/wildlife advocacy group
6%	government agency
4%	tree care/arborist
4%	business/industry group
3%	development/construction firm
11%	another affiliation

Online Community Forum – July 14-August 3, 2020

HIGHLIGHTS

Participation: 591 completed surveys

1,479 written comments on surveys

22 comments/questions submitted by email

2,176 participants (2,573 total visits)

Survey Results:

Q#1 – Do you support the proposal to remove the exemption from tree preservation in CX and EX and IG1 zones?

83% – Yes

16% – No

Q#2 – Do you support the proposal to remove the exemption from tree density in the CX and EX and IG1 zones?

83% – Yes

17% – No

Q#3 – Do you support the proposal to retain the exemption from tree preservation in the IH zone?

14% – Yes

85% – No

Q#4 – Do you support the proposal to retain the exemption from tree density in the IH zone?

14% – Yes

86% – No

Q#5 – Do you support the proposal to reduce the tree diameter threshold from 36" to 20" for private trees wherever tree preservation is required?

81% – Yes

18% – No

Appendix E: Summary of Online Community Forum

Representative Comments:

Trees are a precious resource; tree canopy should expand citywide; we need more trees

Trees help in climate crisis: reduce temperature, improve air quality

Industrial lands are often located in environmentally sensitive areas

Too many trees are removed without replacements

Hold industrial landowners accountable for protecting tees

Heavy industry is the biggest air polluter

All zones should do their part in protecting trees

Preserving smaller trees will lead to larger ones

In the City, 20" is a large-ish tree – or – this is a small tree

Exemptions should be considered from tree size threshold

Concerned about removing diseased/damaged trees

This is a shameless money grab

Homeowners should be able to remove trees

Appendix F: SWCA Tree Canopy Analysis

City of Portland Tree Canopy Analysis Final Report

Estimates of Tree Canopy Characteristics Through GIS Object Based Image Analysis

JUNE 2020

PREPARED FOR

City of Portland:

Bureau of Planning and Sustainability

Bureau of Environmental Services

PREPARED BY

SWCA Environmental Consultants

CITY OF PORTLAND TREE CANOPY ANALYSIS FINAL REPORT

ESTIMATES OF TREE CANOPY CHARACTERISTICS THROUGH GIS OBJECT BASED IMAGE ANALYSIS

Prepared for

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SWCA Project No. 56879.03

June 2020

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INTRODUCTION

This report was produced for the City of Portland Tree Canopy Analysis Project. The goal of the project is to develop an estimate of tree canopy characteristics for lands classified as Industrial and Commercial (IG1, IG2, IH, and EG2 specifically) by analyzing geographic information systems (GIS) data using object-based image analysis (OBIA) techniques and regression analysis to develop equations for estimating allometric measurements, specifically dividing individual tree crowns (ITCs) into four diameter at breast height (DBH) categories (less than 20 inches, 20 to 27.9 inches, 28 to 35.9 inches, and 36 inches or greater).

Steps in the GIS Analysis

To model ITCs and general structure, two publicly available datasets were used, both obtained from the Regional Land Information Survey (RLIS) and developed by Metro: 1) a 3-foot resolution canopy height surface model (CHM) using 2014 LiDAR and normalized difference vegetation index (NDVI) data derived from four-band imagery and 2) a 3-foot resolution, classification model, delineating the CHM into coniferous and deciduous phyla. A segmentation routine was applied to the CHM (outlined below in *Methodology*) to define the general shape and area of ITCs and derive their height as well as assign a coniferous or deciduous classification based on its intersection with the coniferous-deciduous data layer.

To derive DBH from estimated crown widths, City of Portland Park Tree Inventory data were used in a regression analysis to develop equations of best fit by general structure, one set for coniferous trees and another for deciduous. These equations were applied to ITCs and these predicted DBH values were plotted versus the measured DBH values in an independent dataset—the City or Portland street tree inventory.

Based on the number of modeled ITCs within the study area, site visits were conducted on six public and two Port of Portland properties, wherein all tree within a 150-foot-diameter plot were catalogued and geolocated. For each tree of greater than 12 inches DBH the height, crown width, DBH, species, and general condition (living, dead, or stressed) were assessed and recorded. These tree measurements were used to further assess the performance of the modelled results, attempting to capture locations with growing conditions different from the sort encountered in the park and street tree inventories, i.e., dense copses or stands and/or trees in natural or semi-natural conditions in contrast to the groomed and regulated planting conditions of the trees within the tree inventories.

The reader is cautioned that differences between modelled outputs and observed measurements are inevitable. There are a variety of sources of error and discrepancy inherent to remotely sensed data, these limitations include, but are not limited to seasonal and/or yearly variability for acquisition times of the various data products, resolution limitations in the CHM, possible classification errors in the coniferous-deciduous data layer, temporal variability of park and street tree inventory data, and the limitations of image segmentation, which creates hard breaks between objects—in this case trees—which may not accurately model the landscape, particularly in areas with dense stands of trees with heavily overlapped tree crowns. A fuller analysis and quantification of the uncertainty and errors in the model outputs is detailed in the *Model Validation and Performance* and *Findings* sections of the report below.

METHODOLOGY

The approach used to estimate DBH uses an OBIA that in turn uses two primary processes. The first component is segmentation, wherein GIS processes are used to group like pixels together into a single shape or object. In this analysis the peak within groups of raster cells in the high-resolution, LiDAR-derived, CHM are identified and a variable width analysis window around this modelled treetop groups cells into a modelled tree crown as using a function of the relationship between tree height and crown width in observed allometric data (derived in this case from a regression analysis of City of Portland Park Tree inventory crown height and crown width measurements). The second component of the OBIA is classification of these segments into two categories, by phyla. The Coniferous-Deciduous canopy model developed by Metro from LiDAR and NDVI data is intersected with the segmentation output, and the final output contains attributes for crown width, crown area, crown height, and classification by general structure as either deciduous or coniferous.

The second phase of the analysis involves using the modelled outputs created in the OBIA and using it to estimate the DBH value for each individual tree crown. To generate the equations needed to derive these estimates, the preponderance of forestry research has determined that the strongest allometric relationship for DBH is with a tree's crown width. U.S. Forest Service researchers developed the Urban Tree Database and Allometric Equations general technical report (McPherson et al. 2016), which provides equations for estimating a variety of measurements so long as the species is known. An attempt to classify trees by species proved to be untenable, given the scope and lack of available high-resolution hyperspectral or multispectral imagery for this project, therefore it was necessary to develop other means of estimating DBH from available data. City of Portland Park Tree Inventory data were binned into coniferous and deciduous data subsets and regression analyses were applied to these subsets to generate equations of best fit (a linear and power function).

The last phase of the analysis is an assessment of the performance of the model's predicted number of ITCs and DBH values. Each model result is compared with independent datasets not used in the development of the model, Portland Street Tree Inventory data, and tree measurement data collected during fieldwork. These point-based data layers are intersected with the tree segments to evaluate the accuracy of the count of observed versus modelled trees and measured DBH values are plotted versus predicted DBH values in a regression analysis to assess the amount of variance explained by the model.

Research and Technical Approach

A review of the forestry and remote sensing professional journal articles and academic literature, regarding the use of GIS data to model ITCs and tree canopy characteristics, provides a variety of approaches. For this analysis a process for identifying treetops and tree crowns was used, based on a marker-controlled segmentation algorithm to define tree crowns (Beucher and Meyer 1993), wherein a 3-foot resolution, LiDAR-derived CHM with a variable window filter (Popescu and Wynne 2004) that progressively scans through the CHM raster, grouping contiguous cells that form an inverted sink into a single vector polygon object.

The object-based model approach in this analysis uses a LiDAR-derived CHM developed by Metro from 2014 LiDAR point cloud data (Appendix A) and NDVI data and was analyzed with the ForestTools 0.2.0 package for R statistical computing software Version 3.6.3 (via a script and bridge plugin inside ArcGIS Pro 2.5). The ForestTools package offers functions for detecting treetops and outlining tree crowns based on local maxima and a variable window filter to search a neighborhood of cells around a cell with the highest hit. The tool analyzes the raster and if a cell is found to be the highest value in the moving

window it is tagged as the treetop and the size of the window varies as a function of height in the raster cells, operating under the assumption that taller trees have wider crowns.

Data Parameterization and Processing

Preprocessing of data involved projecting all data into HARN State Plane Oregon North FIPS 3601 (Intl Feet) where needed and defining the analysis extent. IG1, IG2, IH, and EG2 zoning designations were extracted from the data provided by the City of Portland and merged into a single feature. This merged zoning layer was buffered to 500 feet (enlarged to this size to fully encompass park and street tree inventory data for model calibration and validation) and broken into seven subsections (along natural breaks in the CHM). Dividing the analysis area into manageable blocks of data was necessary because of memory limitations inherent in the R Statistical Software, ForestTools package. This enlarged analysis extent permits the CHM to entirely cover the Industrial (IG1, IG2, and IH) and Commercial (EG2) tax lots without the possibility of clipping tree segments that only partially intersect a given tax lot, i.e., eliminating edge effects or loss of data that can occur at the edge of raster datasets being evaluated with a focal window.

With uncertainty about the overall composition and distribution of tree species within the Industrial and EG2 tax lots, a parameter to define the *variable window filter* search radius in ForestTools was derived from an analysis of the totality of the Portland Park Trees Inventory (the most complete dataset available with full allometric measurements). Crown heights and crown widths were plotted on a scatterplot and a linear equation of best fit was generated from a trendline in Microsoft Excel. The resulting linear equation $CR = 4.5 + 0.1754 * CH$ ($R^2 = 0.2704$) is used to define the *variable window filter* parameter in the ForestTools script (where *CR* equals Crown Radius and *CH* equals Crown Height). This assumes a minimum 9-foot diameter crown width, corresponding to a 3 × 3 grid of cells, the smallest area that can defined as a tree with a definable peak. Other parameters defined for the ForestTools process were a minimum height of 15 feet for treetops (the minimum vertical values in the CHM are 10 feet—this minimum value was likely chosen by Metro to filter out scrub-shrub vegetation picked up in the LiDAR point cloud data).

ForestTools generates point and polygon output layers with fields for height (derived from the local maxima), “WinRadius” (the size of the search window used to evaluate the area around a cell identified as a treetop) and the polygon layer has an additional field, “CrownArea” (in square feet). In some areas this output requires some post-processing due to peculiarities unique to the CHM used in this analysis because its height value is stored in integer format; the issue is that adjacent pixels with identical values identified as treetops are erroneously identified as ITCs around each point. With a combination of buffering the treetop points to 3.1 feet (enough to touch) and dissolving on height, followed by a spatial join with the polygon segments, these segments are merged, eliminating errors of commission (over segmentation). This output is further refined by applying a union with the coniferous-deciduous layer obtained from Metro’s RLIS database. This raster dataset was converted to vector polygonal data and joined with the ForestTools segments with the ArcGIS *union* tool to categorize each segment as either coniferous or deciduous, an important discriminant for estimating DBH as a function of crown width because of general structural differences between conifers and deciduous trees.

Estimated crown diameter values are added to the tree crown segments, calculated as a circle of best fit, from the area of the segment (where *CD* equals crown diameter in feet and *CA* equals crown area in square feet) *(Note: The value of π is rounded to 3.14159 for use in the field calculator in ArcGIS Pro 2.5)*:

$$(CD = 2 * \sqrt{\frac{CA}{\pi}})$$

Research conducted by the U.S. Forest Service (McPherson et al. 2016) determined that the crown diameter has the highest correlation to DBH out of a variety of allometric measurements. Without species determinations to apply specialized allometric equations to individual tree crown segments, the City of Portland Park Trees inventory was used as a surrogate dataset to estimate DBH values using a regression analysis. A scatterplot and regression analysis of the entire dataset (25,534 trees) with crown diameter (feet) as the independent variable and DBH (inches) as the dependent variable yielded trendlines of best fit. A linear trendline equation and a power trendline were applied in effort to achieve the highest R^2 correlation possible. Both regressions apply a line fitted to the scatterplot to minimize the amount of variance at any point on the between crown width (x-axis) and DBH (y-axis). The difference between the models is the linear trendline, which uses a linear equation to produce a simple straight line of best fit, and the power trendline uses an exponential function that produces a slightly curved line of best fit. *(Note: Park tree inventory data with null or 0 values for either DBH or crown width, and/or categorized as "dead" were omitted as data points in this analysis)*:

- Linear equation: $DBH = 1.3752 + 0.5463 * CD$ with an $R^2 = 0.5614$
- Power equation $DBH = 0.2527 * CD^{1.2075}$ with an $R^2 = 0.7233$

When the data is divided into subsets, by general structure with needleleaf and broadleaf categories, higher degrees of correlation were achieved according to regression analyses, which can be visualized in Figures 1 and 2:

- **Needleleaf trees** (10,742 trees) using a linear equation of best fit $DBH = 0.7595 * CD$ produced an $R^2 = 0.9242$. A power equation of best fit $DBH = 0.3286 * CD^{1.2225}$ produced an $R^2 = 0.7649$.
- **Broadleaf trees** (14,792 trees) using a linear equation of best fit $DBH = 0.4816 *$ CD produced an $R^2 = 0.9272$. A power equation of best fit $DBH = 0.1802 * CD^{1.2397}$produced an $R^2 = 0.8411$.

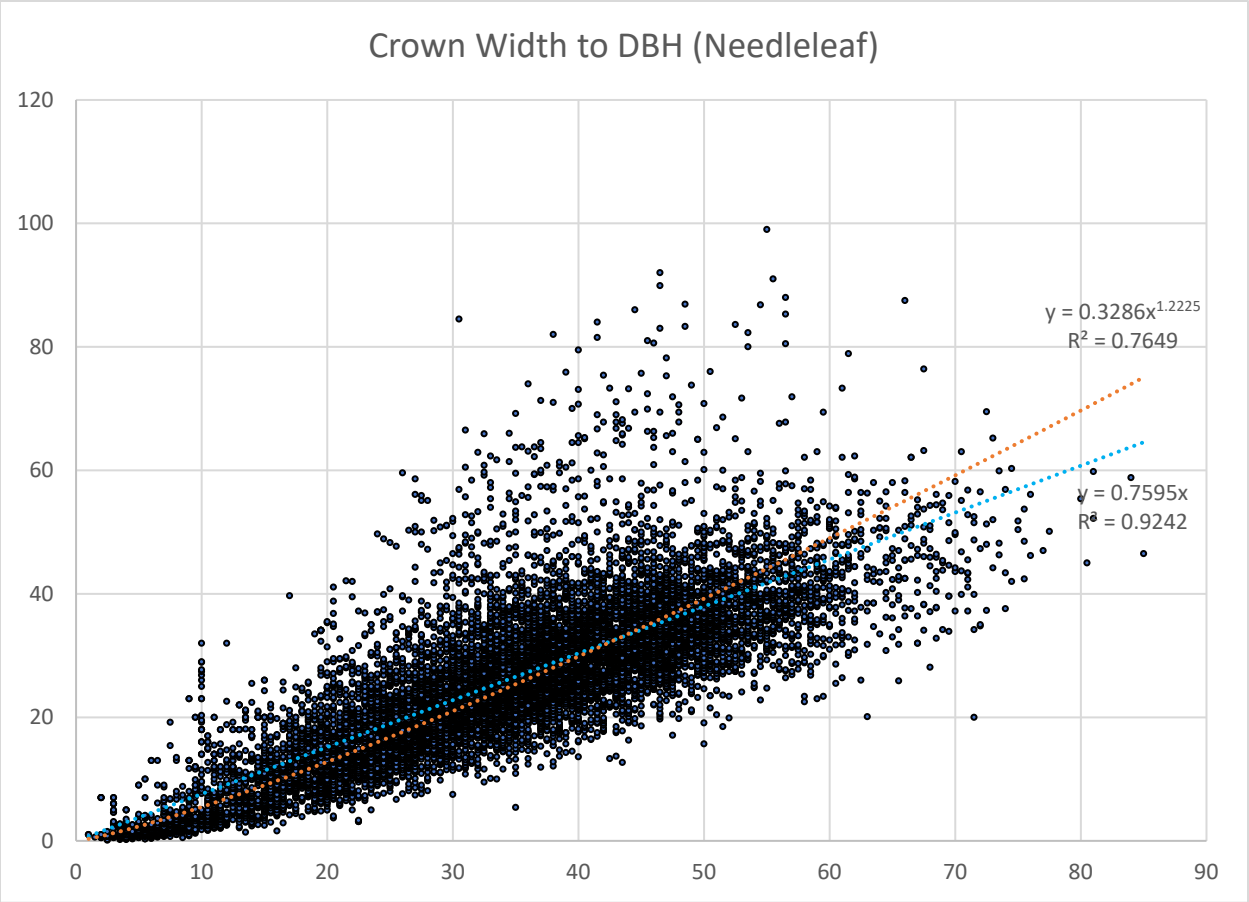

Figure 1. Needleleaf crown width to DBH regression equations.

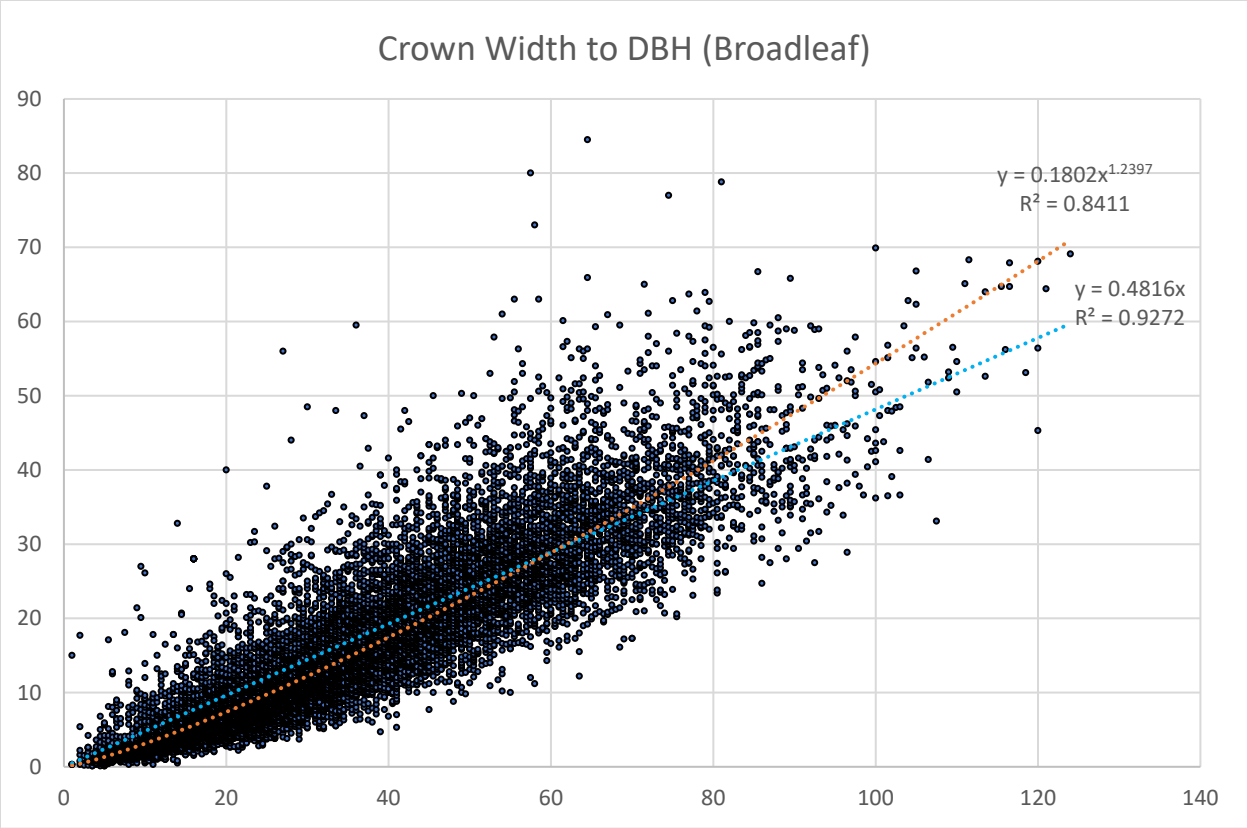

Figure 2. Broadleaf crown width to DBH regression equations.

As a result of these analyses, the tree segment DBH estimates are based on the needleleaf and broadleaf discriminant and includes a field for both equations of best fit, ***DBH_linear_est*** and ***DBH_power_est***, as well as fields for corresponding residuals, ***DBH_linear_res*** and ***DBH_power_res***, in cases where tree inventory point data intersect with individual tree segments. Data are subsequently categorized by DBH into the four size categories outlined in the delivery requirements (**Category 1** = less than 20 inches, **2** = 20–27.9 inches, **3** = 28–35.9 inches, and **4** = greater than or equal to 36 inches). Tree segments are subdivided into separate feature classes based on the intersection with IG1, IG2, IH, IR, and EG2 tax lots.

Sampling Methodology

In order to achieve a minimum 95% confidence level and 10% confidence interval of sampled trees, it was determined that a minimum of 96 trees should be catalogued and measured (based on 57,544 ITCs that intersect the Industrial and EG2 tax lots). These sampled trees were assessed for height, DBH, condition, number of stems, and species. In total, 138 trees were measured in five publicly accessible sample plots and two sample plots on Port of Portland owned properties, constrained to locations that were accessible and/or immediately adjacent to the Industrial and EG2 tax lots within the study area (Figure 3). Sample plots were 150 feet in diameter and included a mix of dense stands of trees (>90% canopy coverage) and medium density stands (50%–90% canopy coverage).

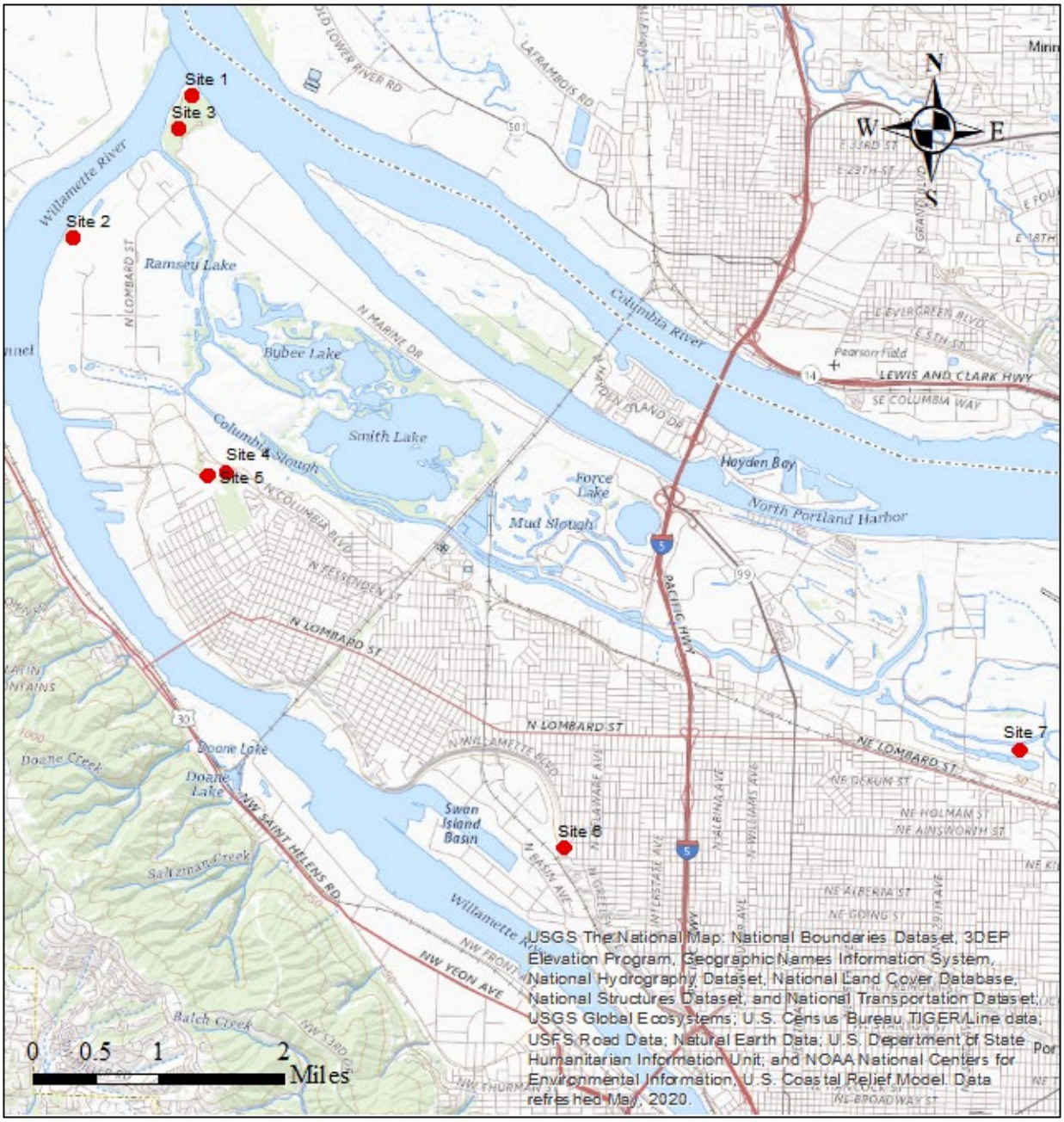

Figure 3. Map of field sites.

All trees within the sample plots with a greater than 12-inch DBH were geolocated and catalogued. A Geode submeter-accurate global positioning system (GPS) receiver, paired with an Android tablet running ESRI Collector for ArcGIS, was used to generate tree points (3-m minimum positional accuracy) and allometric measurements were recorded: height (with a clinometer and a 100-foot ground tape), crown width estimates (measured along the north-south and east-west axes), and DBH (with a Forestry Suppliers steel DBH tape). Additionally, condition and species were recorded (field photographs were taken of the bud, bark, and stem and of the whole tree where allowed).

Site conditions were generally dense stands of trees with a large number of thorny vines and nuisance vegetation, as well as other obstacles complicating height measurements. Trees were in leaf-off condition, but buds were emergent on most trees sampled and posed no significant obstacle to species identification. Samples were acquired between March 2 and 13, 2020.

Model Validation and Performance

The performance of the model was evaluated for accuracy and precision using several criteria. The first part of the accuracy assessment measured the ability of the segmentation algorithm to correctly identify the number of trees. The City of Portland Park Tree and Street Tree Inventories along with site sample data were used to evaluate errors of commission (over-segmenting ITCs) and omission (multiple tree inventory points intersecting a single ITC). The ability of the model to accurately predict the number of trees varied by location and stand characteristics. Comparing the park tree and street tree inventory tree points as well as the tree data collected during fieldwork with the marker-controlled segmentation algorithm resulted in an 82% accuracy rate for the count of ITCs. In total, 6,558 park and street tree inventory points were intersected by 5,380 ITCs, indicating that the segmentation tends to slightly aggregate and underestimate the total number of trees present in the study area. This underestimation illustrates the limitations of the CHM and how it only captures the highest hit minus the last hit of a LiDAR pulse during leaf-on conditions and cannot differentiate trees that are overtopped by dominant trees and tightly packed co-dominant trees. To the extent trees are widely spaced in the study area and distinct from one another, the model does a very good job of identifying and delineating them. In areas where trees stands are dense with complex multistory structures the model is less accurate. This observation is confirmed at least in part through samples collected during fieldwork, due in large part to the leaf-on acquisition date (flown in September 2014) of the LiDAR used to create the CHM. This was especially noticeable in stands of black cottonwood (*Populus trichocarpa*), which were 101 out of 138 collected samples. The stands in the Kelly Point Park and industrial areas near the Willamette River and Columbia River Slough demonstrated noticeable errors of omission in the tree segmentation routine. In the eight sample plots surveyed, the performance of the marker-controlled segmentation was only 65.3% accurate in identifying ITCs.

The segmentation routine's ability to estimate crown width was also analyzed. The residuals of measured crown widths to modelled crown widths yielded a mean of 2.0 feet, a median of 3.0 feet (positive values an indicate underestimation and negative values an overestimation), and standard deviation of 15.9 feet. In general, this means that the model tended to underestimate crown widths slightly on average, but 68.2% of all estimates are within approximately 16 feet of the mean. This variance is attributable in part to the hard breaks that the marker-controlled segmentation imposes on the objects derived from the CHM; any trees with overlapping crowns that cannot be distinguished and are assigned to one object or another yield underestimates and any trees overtopped by others or lumped together into a single object yield overestimates. The distribution of these residuals is visualized in Figure 4.

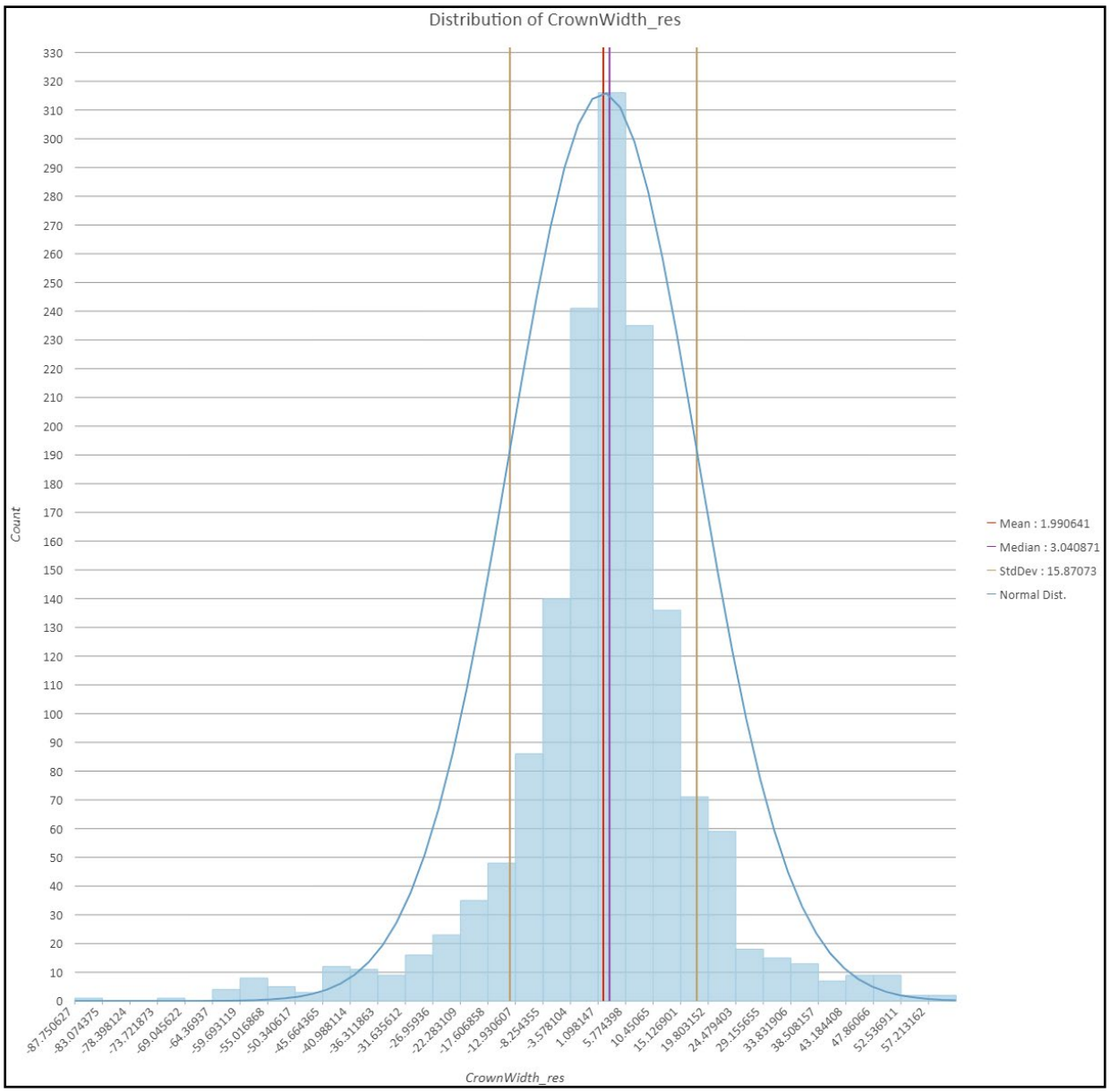

Figure 4. Estimated crown width residuals vs. measured crown widths.

Results of fieldwork and comparison of the data revealed that the segmentation protocol did a poorer job of delineating ITCs for stands dominated by black cottonwood due to their unique structure, i.e., densely packed stands with mingled crowns and generally very tall crown heights compared to relatively narrow, asymmetrical crown widths (Figure 5). It is possible that reprocessing these areas with homogenous stands with similar canopy characteristics might achieve a more accurate result by using field data as the basis for parameterizing the marker-controlled segmentation routine using species-specific height to crown-width measurements, versus the more generalized function derived from the totality of the City of Portland Park Tree Inventory. However, it is also possible that the unique composition of these tree stands might require other approaches to accurately segment them into ITCs, e.g., using a leaf-off LiDAR-derived CHM, or non-GIS-based approaches.

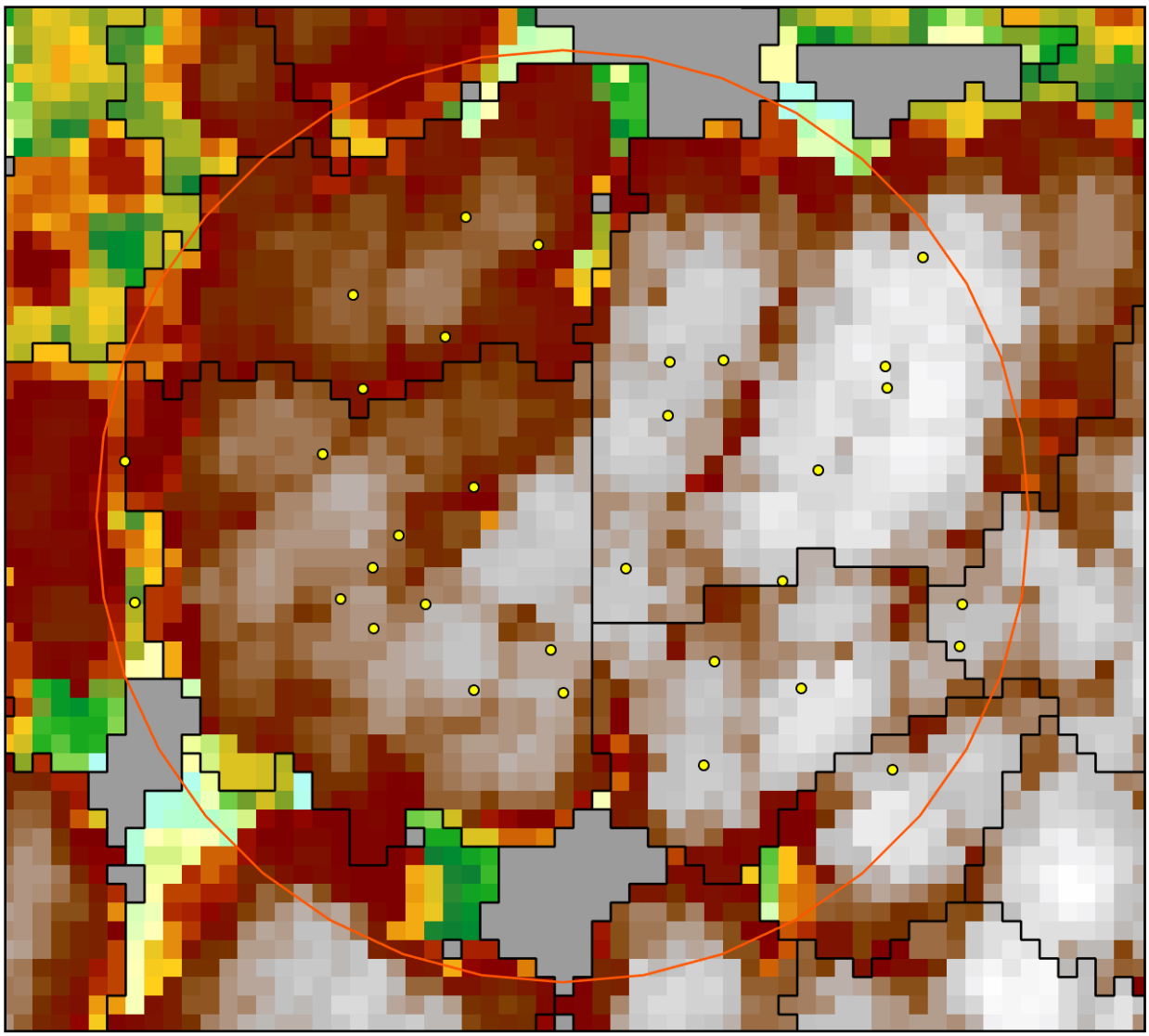

Figure 5. Example of segmentation of the CHM in a field site with a dense, multistory stand of trees dominated by black cottonwood.

The tabular results in the summary tables below include results where individual problematic tax lots dominated by black cottonwood are omitted from the Industrial and EG2 tax lots.

The third component of the accuracy assessment evaluates the performance of the regression functions for their capability to accurately estimate DBH from crown width by comparing predicted values with known values of DBH in the City of Portland Street Tree and Park Tree Inventories and the data collected from sample sites. These predicted versus measured values are plotted and analyzed with a regression of least-squares. The residuals of the linear equation estimate compared to street and park tree DBH values has a mean of 0.2 inch, a median of -0.4 inch, and a standard deviation of 7.9 inches (Figure 6). The residuals of the power equation estimate compared to the street and park tree DBH values has a mean 1.9 inches, a median of 1.6 inches, and a standard deviation of 8.2 inches. (Figure 7). The amount of variance between the linear and power regression models was $R^2 = 0.4036$ and $R^2 = 0.4022$ respectively, meaning that approximately 40% of the variation can be explained by either function (Figures 8 and 9).

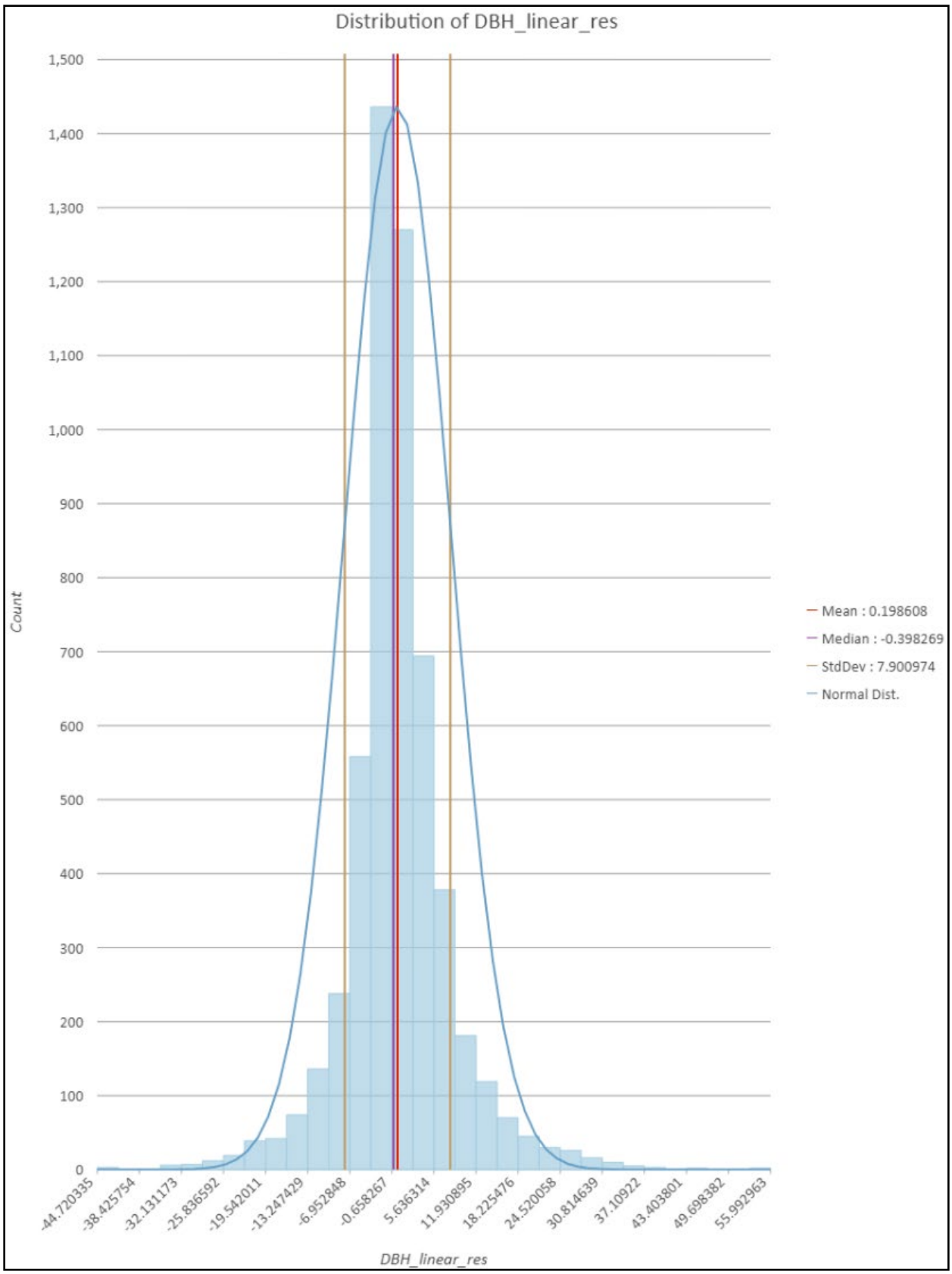

Figure 6. Linear function residuals for estimating DBH.

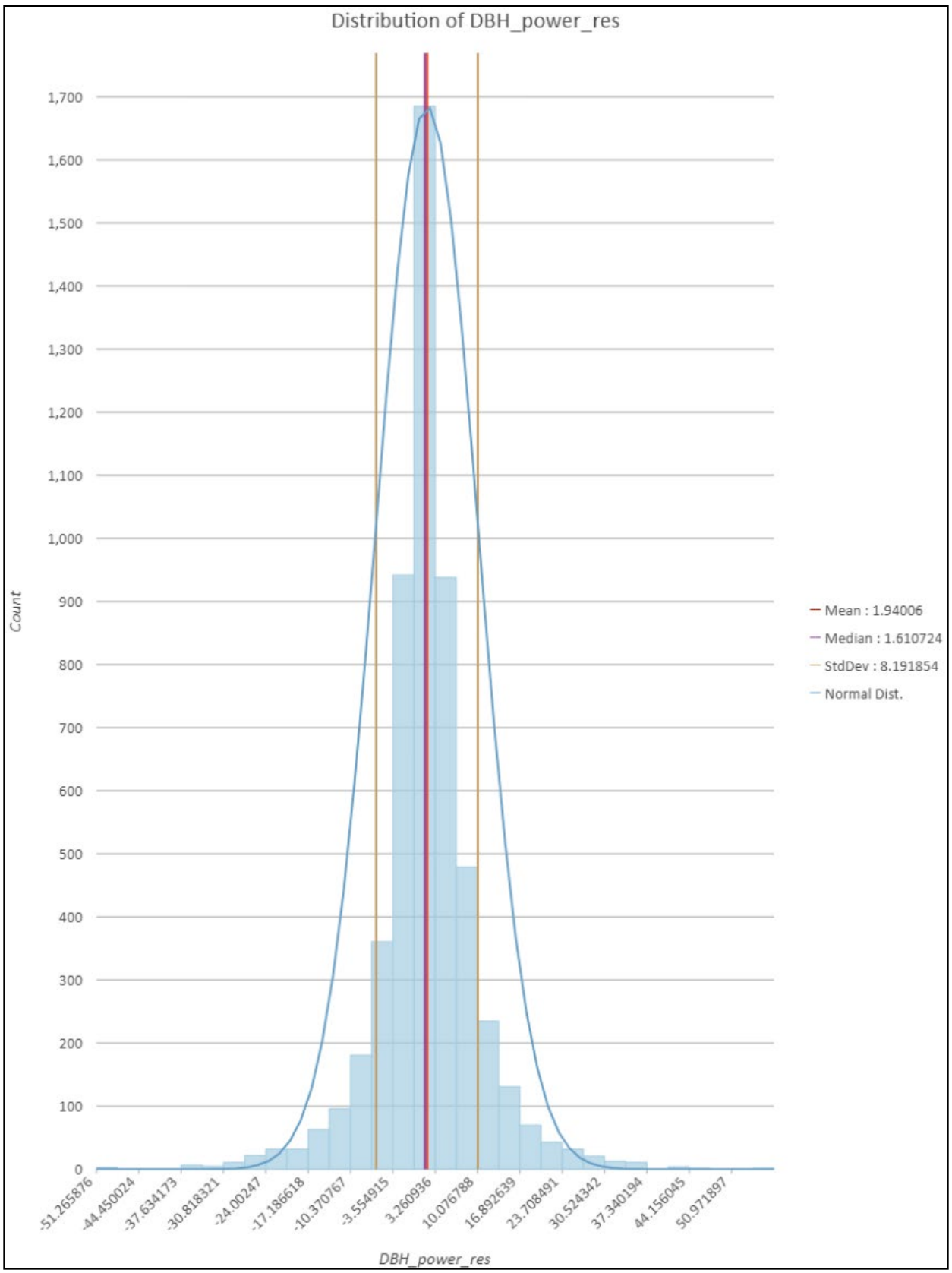

Figure 7. Power function residuals for estimating DBH.

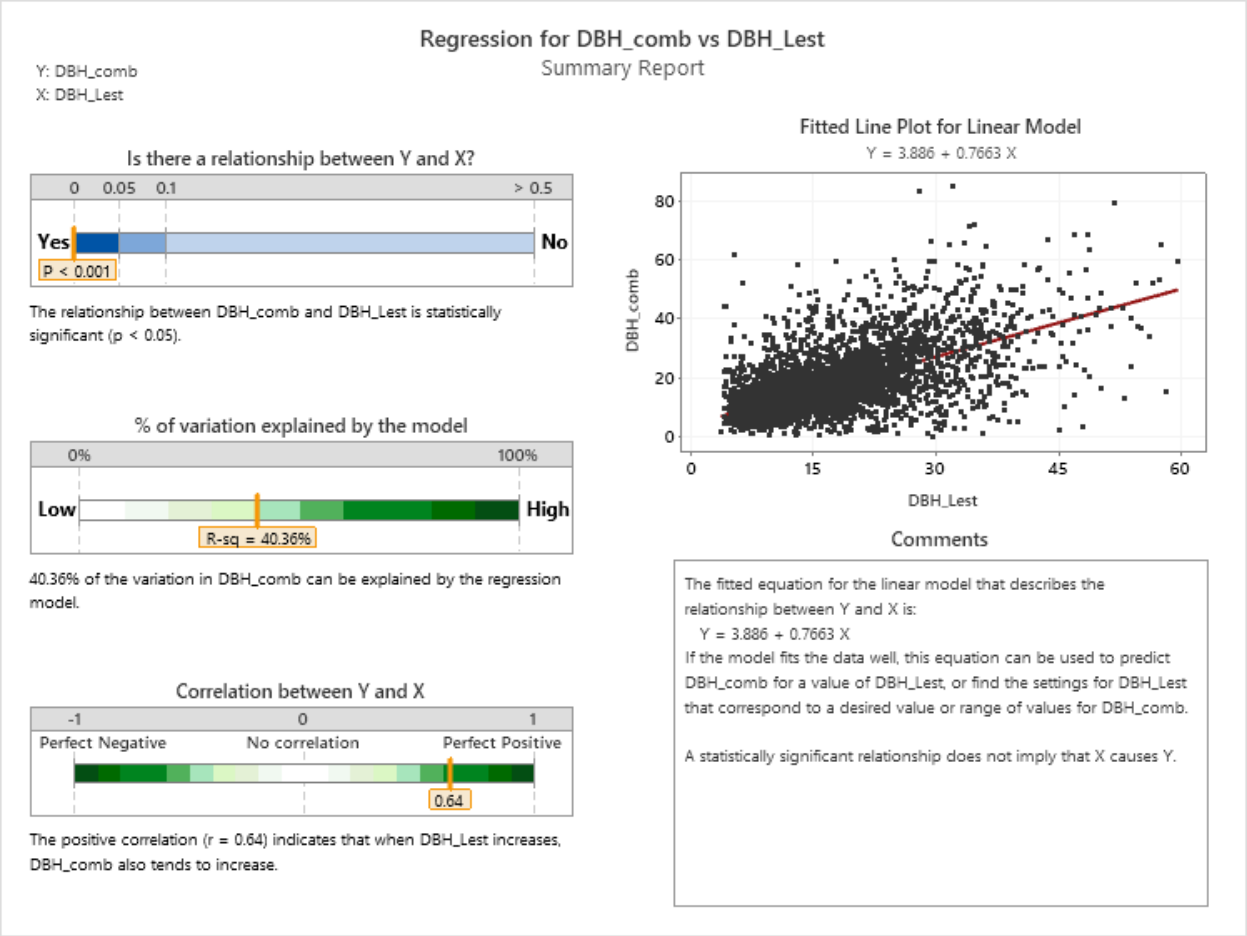

Figure 8. Regression analysis of predicted versus measured DBH values in the linear equation model.

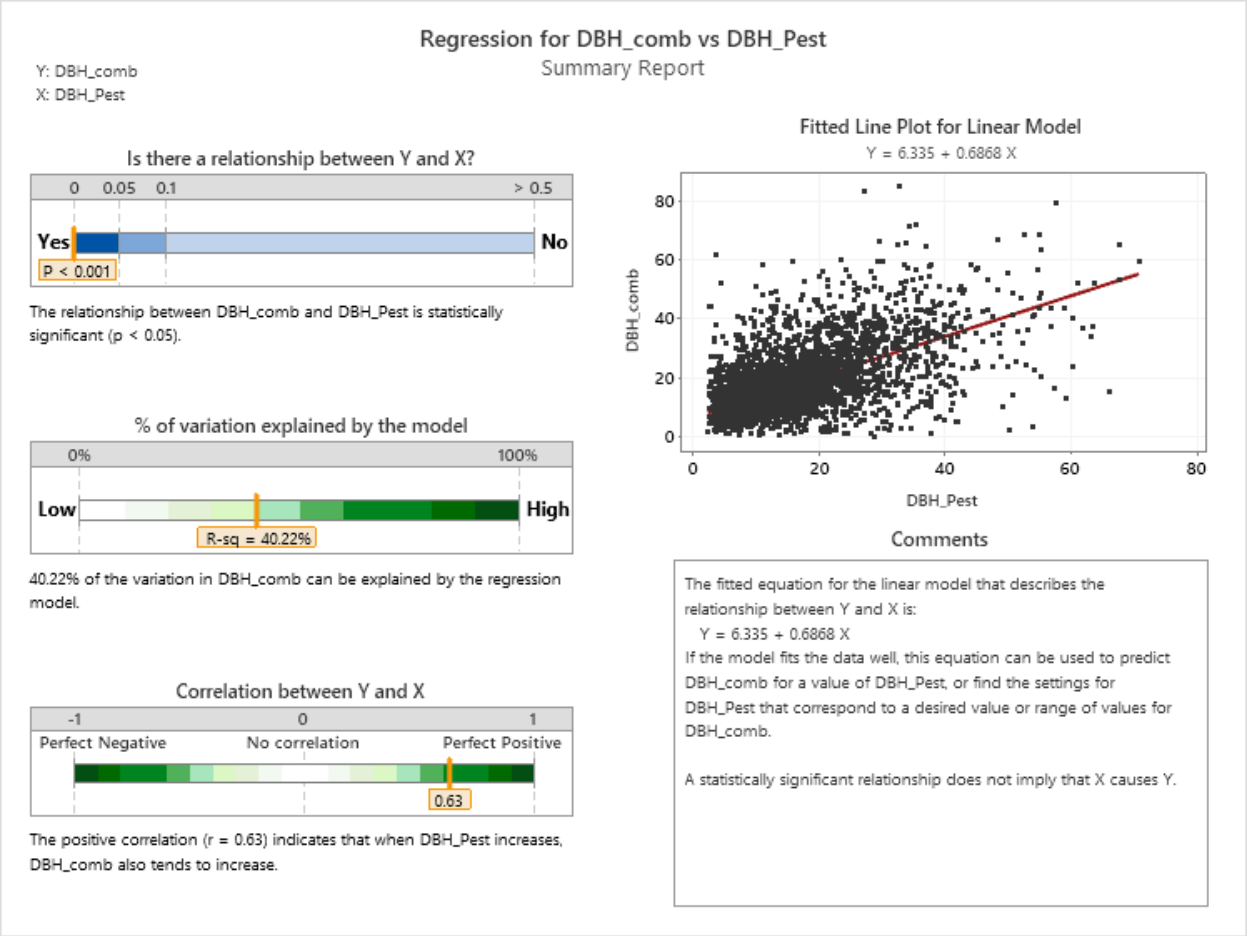

Figure 9. Regression analysis of predicted versus measured DBH values in the power function model.

FINDINGS

The summarized statistics in Tables 1 to 4 provide DBH estimates, canopy acres, and average trees per canopy acre using two different equations of best fit, a linear equation and a power function, with nearly identical R^2 values (0.4036 and 0.4022 respectively). Separate tables are also provided that omit several tax lots where the model performed noticeably poorer in dense stands known to be dominated by black cottonwood.

Summary Tables

Tree Segments Intersecting Tax Lots in the Analysis Area

Table 1. DBH Categories by Power Function*

Zone	<20 inches	20 to 27.9 inches	28 to 35.9 inches	≥36 inches	Total Trees**	Total Canopy Acres	Tax Lot Acres	Average Trees Per Tax Lot Acre
EG2	9,491 (90.2%)	663 (6.3%)	244 (2.3%)	122 (1.2%)	10,520	135.3	1,062.4	9.9
IG1	2,029 (90.1%)	115 (5.2%)	42 (1.9%)	46 (2.1%)	2,232	28.0	360.5	6.2
IG2	25,209 (89.5%)	1,929 (6.8%)	654 (2.3%)	373 (1.3%)	28,165	380.8	6,101.9	4.6
IH	14,781 (88.1%)	1,249 (7.4%)	433 (2.6%)	316 (1.9%)	16,779	255.1	4,658	3.6
All Tax Lots	51,510 (89.3%)	3,956 (6.9%)	1,373 (2.4%)	857 (1.5%)	57,696	799.2	12,182.8	4.7

* Needleleaf: $DBH = 0.3286 * CD^{1.2225}$, Broadleaf: $DBH = 0.1802 * CD^{1.2397}$)

** Tree counts are tabulated by intersection with respective tax lots. There are cases where individual tree segments intersect more than one tax lot, and thus are counted more than once.

Model Accuracy Statistics: measured DBH – predicted DBH, where total Industrial and EG2 model outputs intersect park and street tree inventory data

Residuals: mean = 1.9 inches, median = 1.6 inches, standard deviation = 8.2 inches, standard error = 0.1113 inches

Model Correlation: $R^2 = 0.4022$

Table 2. DBH Categories by Linear Function*

Zone	<20 inches	20 to 27.9 inches	28 to 35.9 inches	≥36 inches	Total Trees	Total Canopy Acres	Tax Lot Acres	Average Trees Per Tax Lot Acre
EG2	9,184 (87.3%)	938 (8.9%)	295 (2.8%)	103 (1.0%)	10,520	135.3	1,062.4	9.9
IG1	1,971 (88.3%)	169 (7.6%)	49 (2.2%)	43 (1.9%)	2,232	28.0	360.5	6.2
IG2	24,382 (86.6%)	2,688 (9.5%)	792 (2.8%)	303 (1.1%)	28,165	380.8	6,101.9	4.6
IH	14,273 (85.1%)	1,706 (10.2%)	538 (3.2%)	262 (1.6%)	16,779	255.1	4,658	3.6
All Tax Lots	49,810 (86.3%)	5,501 (9.5%)	1,674 (2.9%)	711 (1.2%)	57,696	799.2	12,182.8	4.7

* Needleleaf: $DBH = 0.7595 * CD$, Broadleaf: $DBH = 0.4816 * \mathrm{CD}$

Model Accuracy Statistics: measured DBH – Predicted DBH, where total industrial and EG2 model outputs intersect park and street tree inventory data

Residuals: mean = 0.2 inches, median = -0.4 inches, standard deviation = 7.9 inches, standard error = 0.1073 inches

Model Correlation: $R^2 = 0.4036$

Tree Segments Intersecting Tax Lots (minus problematic tax lots)[1]

Table 3: DBH Categories by Power Function*

Zone	<20"	20" to 27.9"	28" to 35.9"	≥36"	Total Trees	Total Canopy Acres	Tax Lot Acres	Average Trees Per Tax Lot Acre
EG2	9,491 (90.2%)	663 (6.3%)	244 (2.3%)	122 (1.2%)	10,520	135.3	1,062.4	9.9
IG1	2,029 (90.1%)	115 (5.2%)	42 (1.9%)	46 (2.1%)	2,232	28.0	360.5	6.2
IG2 *(omitted problem lots)*	25,078 (89.7%)	1,890 (6.8%)	628 (2.2%)	359 (1.3%)	27,955	374.1	6,084.7	4.6
IH *(omitted problem lots)*	13,814 (89%)	1,060 (6.8%)	365 (2.4%)	274 (1.8%)	15,513	224.8	4,450.3	3.5
All Tax Lots	50,412 (89.6%)	3,728 (6.6%)	1,279 (2.3%)	801 (1.4%)	56,220	762.2	11,957.9	4.7

* Needleleaf: $\boldsymbol{DBH = 0.3286 * CD^{1.2225}}$, Broadleaf: $\boldsymbol{DBH = 0.1802 * CD^{1.2397}}$

Model Accuracy Statistics: measured DBH – Predicted DBH, where total industrial and EG2 model outputs intersect park and street tree inventory data

Residuals: mean = 1.9 inches, median = 1.6 inches, standard deviation = 8.2 inches, standard error = 0.1113 inches

Model Correlation: $R^2 = 0.4022$

Table 4: DBH Categories by Linear Function*

Zone	<20"	20" to 27.9"	28" to 35.9"	≥36"	Total Trees	Total Canopy Acres	Tax Lot Acres	Average Trees Per Tax Lot Acre
EG2	9,184 (87.3%)	938 (8.9%)	295 (2.8%)	103 (1.0%)	10,520	135.3	1,062.4	9.9
IG1	1,971 (88.3%)	169 (7.6%)	49 (2.2%)	43 (1.9%)	2,232	28.0	360.5	6.2
IG2 *(omitted problem lots)*	24,262 (89.8%)	2,640 (9.4%)	762 (2.7%)	291 (1%)	27,955	374.1	6,084.7	4.6
IH *(omitted problem lots)*	13,359 (86.1%)	1,469 (9.5%)	457 (2.9%)	228 (1.5%)	15,513	224.8	4,450.3	3.5
All Tax Lots	48,776 (86.7%)	5,216 (9.3%)	1,563 (2.8%)	665 (1.2%)	56,220	762.2	11,957.9	4.7

* Needleleaf: $\boldsymbol{DBH = 0.7595 * CD}$, Broadleaf: $\boldsymbol{DBH = 0.4816 * CD}$

Model Accuracy Statistics: measured DBH – Predicted DBH, where total industrial and EG2 model outputs intersect park and street tree inventory data

Residuals: mean = 0.2 inches, median = -0.4 inches, standard deviation = 7.9 inches, standard error = 0.1073 inches

Model Correlation: $R^2 = 0.4036$

[1] Two lots zoned as IG2: Property IDs R171715 and R237851 (17.2 acres); seven lots zoned as IH: Property IDs R239681, R256362, R325506, R323385, R256223, R323445, and R256242 (207.7 acres)

EXPLANATION OF RESULTS

Regression equations to estimate DBH as a function of crown width were derived from the totality of the park trees inventory, binned by general structure (needleleaf-conifers and broadleaf). A linear and power trendline was fitted to these datasets in Microsoft Excel (see *Park_trees_BROAD.xlsx* and *Park_trees_CON.xlsx*) and the results of these equations and the root-mean-square errors (RMSE) for each demonstrated a moderate to strong correlation between crown width (CD) and DBH.

- **Needleleaf**: Linear trendline equation: $DBH = 0.7595 * CD$, $R^2 = 0.6181$ and power trendline equation: $DBH = 0.3286 * CD^{1.2225}$, $R^2 = 0.7649$.
- **Broadleaf**: Linear trendline equation: $DBH = 0.4816 * \mathrm{CD}$, $R^2 = 0.789$ and power trendline equation: Broadleaf: $DBH = 0.1802 * CD^{1.2397}$, $R^2 = 0.8411$.

Crown diameter estimates for ITCs were derived with a circle of best fit to the tree segment outputs generated by the R, ForestTools tree segmentation tool. Modeled crown widths were compared to coincident park tree inventory point allometry and the residuals of the actual versus estimated crown width yielded a mean of 2.0 feet, a median of 3.0 feet, and a standard deviation of 15.9 feet. These positive values demonstrate a tendency in the model to underestimate crown width.

Analysis of Errors, Model Limitations, and Further Refinement

A number of limitations, sources of potential error, and areas of possible refinement (as a part of future study) were identified during this study, including the following.

The CHM's 9-square feet resolution is derived from normalized LiDAR point-cloud data during leaf-on conditions, by subtracting the last hit (ground) from the first hit (tree crown or upper canopy). Therefore, the model is incapable of detecting trees that are over-topped by dominant or co-dominant trees. Using a higher resolution CHMs with leaf-on and leaf-off conditions could yield more accurate representations of the canopy characteristics present in the study area.

The LiDAR dataset used to develop the CHM is now nearly 6 years old and is asynchronous with many of the inventory dates in the park and street tree datasets, leading to potential underestimation of height, crown width, and DBH due to growth. Additionally, losses due to death or removal since the base data were acquired are beyond the scope of this analysis.

As a result of the way the segmentation routine works, hard breaks are created between tree crowns. In areas where crowns overlap or are co-mingled, the model invariably underestimates the crown widths of these ITCs, and then propagates this as an underestimation error for the DBH values of these ITCs. Certain tree species are also resistant to being accurately modeled; dense stands of black cottonwood encountered during site sampling were universally narrowly spaced, very tall, had heavily co-mingled crowns, and contained many trees under the dominant tree that are not visible in LiDAR acquired under leaf-on conditions. The model in these instances usually failed to capture ITCs, tending to noticeably commit errors of omission (undercounting the number of individual trees) and errors of commission (lumping multiple tree crowns together into a single segment) and because of this lumping, overestimates DBH values for the trees delineated in the marker-controlled segmentation.

There are temporal discrepancies in the data used in the analysis. Measurements taken during February 2020 fieldwork and the values recorded in the City of Portland Park and Street Trees Inventories between 2017 and 2019 vary from 3 to 6 years from the 2014 CHM that forms the basis of this analysis. This

inevitably leads to an underestimation of allometry for certain trees due to growth, as well as changes to canopy coverage characteristics due to death, removal, or modification of trees. The extent of this variation is unknown.

Identifying individual trees by species would allow for more precise estimates of DBH values, by allowing the use of species-specific functions for modelling crown-width to DBH relationships, developed by the Urban Tree Database and Allometric Equations, developed by the U.S. Forest Service. Such a classification exercise would likely require proprietary, high-resolution hyperspectral imagery and specialized classification tools, and likely a piecewise approach (iteratively processing small geographic study areas) backed up by extensive sampling and ground truthing. Thus, this approach would likely require significant processing time and the costs associated with this alternate approach and the proprietary tools and imagery required are unknown and beyond the scope of this analysis.

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Plowright, Andrew. 2018. Canopy analysis in R using Forest Tools. Available at: https://cran.r-project.org/web/packages/ForestTools/vignettes/treetopAnalysis.html. Accessed February 25, 2020.

Popescu, S. C., and R. H. Wynne. 2004. Seeing the Trees in the Forest. *Photogrammetric Engineering & Remote Sensing* 70(5):589–604.

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APPENDIX A

Data Sources

2014 Metro Canopy Height Model
http://rlisdiscovery.oregonmetro.gov/?action=viewDetail&layerID=3552

2014 Metro Coniferous Deciduous dataset
http://rlisdiscovery.oregonmetro.gov/?action=viewDetail&layerID=3572

City of Portland Park Trees Inventory *(Provided by the City of Portland)*

City of Portland Street Trees Inventory *(Provided by the City of Portland)*

City of Portland zoning dataset *(Provided by the City of Portland)*

City of Portland tax lot data *(Provided by the City of Portland)*

Appendix G: Johnson Economics Analysis

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ANALYSIS OF ANTICIPATED IMPACTS
PROPOSED CHANGES IN TREE ORDINANCE

PREPARED FOR
CITY OF PORTLAND
BUREAU OF PLANNING AND SUSTAINABILITY

JUNE 2020

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Portland, Oregon 97205

JOHNSON
ECONOMICS

TABLE OF CONTENTS

I. Introduction

The City of Portland's Bureau of Planning and Sustainability is evaluating changes to the Tree Code as part of the City's Title 11 process. The evaluation includes impacts on the City's future economic growth capacity in industrial and other employment lands, as well as on housing costs in the city. The following are proposed changes under consideration:

- Remove the exemption from the Tree Preservation Standards and Tree Density Standards for private trees in development situations for four zoning designations – IH, IG1, CX, and EX; and
- Reduce the Tree Preservation size threshold that triggers an inch-for-inch mitigation fee for private trees in development in all zones from 36 to 20 inches in diameter at breast height (DBH).

This report evaluates the anticipated marginal impact of the proposed changes on employment and residential development patterns. The focus of the analysis is the expected impact on future development yield of properties impacted by the proposed changes and utilizes a predictive development/redevelopment model to translate policy actions into associated shifts in anticipated development outcomes.

II. Executive Summary

The proposed changes in the Tree Code would be expected to increase the cost of development when applicable. This impact would be the most pronounced on parcels that are currently exempt from tree preservation standards: sites zoned IH, IG1, CX, and EX. All zoning classification would be impacted by the shift in size threshold, which expands coverage of the tree preservation requirements to trees 20 inches DBH and greater, for all zones.

The impacts assumed in the model included a marginal increase in development cost associated with the proposed changes in the ordinance. Each of these types of changes are expected to result in lower supportable land values in the area and a predicted reduction in development activity and carrying capacity of the properties.

The optimal solution to respond to the proposed ordinance would vary on a site by site basis, based on key variables such as the development requirements and location of the trees on the property. The scope of this analysis does not allow for a detailed site by site assessment, and incremental costs assumed that trees would have to be removed.

The general impact of the increased development costs is reflected in a reduction in the indicated residual value of undeveloped land. This would be expected to marginally reduce the likelihood of development or redevelopment of properties, as the yield to new development is lower. The incremental cost of tree removal was calculated using an assumed distribution of trees by size and a mapping of impacted tree canopy. This was based on work completed by SWCA and the Portland Bureau of Planning and Sustainability.

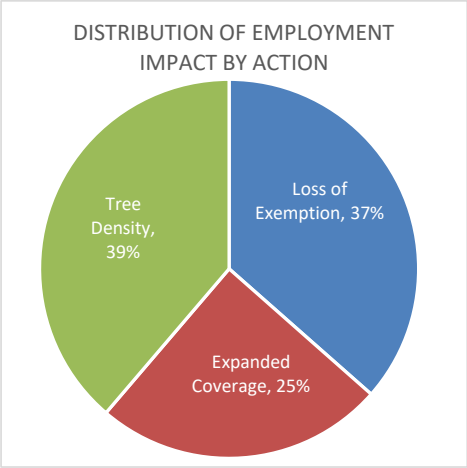
The analysis focused on the marginal impact of the ordinance, and as a result only included parcels identified as having existing tree canopy on site. The model also excluded sites that currently are within an environmental overlay, as the new ordinance would not substantively change development requirements. The model used predicted development yields on these impacted parcels based. Key variables were the estimated cost to mitigate the tree impacts on site development, as well as the underlying value of the property in a development scenario. As a general rule, land uses that support relatively high underlying land values can more easily accommodate the incremental increase in development cost, while the marginal impact will be larger in land uses that have a lower supportable land value (such as industrial in employment lands, and residential sites in lower priced markets).

This analysis evaluates impacts on predicted development outcomes under a range of assumptions and does not assess environmental or other benefits associated with the proposed changes. The analysis only looks at the impacts of regulatory changes on predicted development outcomes and does not represent a full cost/benefit analysis. The regulatory proposals are likely to have significant public benefit that would offset potential costs. While we recognize the existence of public benefits, this analysis does not attempt to quantify these.

FIGURE 2.1: SUMMARY OF PREDICTED DEVELOPMENT YIELDS BY STUDY AREA, 20-YEAR HORIZON

	Predicted Development Yield				Marginal Cost on Impacted Properties		
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Loss of Exemption	Change in Coverage	Tree Density
OVERALL SUMMARY							
BASELINE							
COLUMBIA EAST	$123,938,026	0	31.2	981	$0	$0	$0
HARBOR - AIRPORT	$312,742,428	0	110.6	3,629	$0	$0	$0
HARBOR ACCESS LANDS	$102,402,713	0	46.9	1,500	$0	$0	$0
INNER RESIDENTIAL	$23,408,389,350	62,931	21.0	1,094	$0	$0	$0
MID-RESIDENTIAL	$7,872,409,812	4,294	2.4	123	$0	$0	$0
OUTER RESIDENTIAL	$7,967,427,127	11,772	11.2	588	$0	$0	$0
VARIANCE FROM BASELINE							
COLUMBIA EAST	($784,741)	0	(0.5)	(15)	$0	$153,598	$0
HARBOR - AIRPORT	($19,035,928)	0	(11.7)	(616)	$535,448	$459,901	$199,363
HARBOR ACCESS LANDS	($26,929,491)	0	(15.9)	(506)	$379,823	$133,648	$852,175
INNER RESIDENTIAL	($5,444,872)	(24)	0.00	0	$79,381	$508,748	$582,272
MID-RESIDENTIAL	($1,888,332)	(8)	0.0	0	$30	$477,459	$66
OUTER RESIDENTIAL	($5,013,667)	(22)	(0.0)	(0)	$12,943	$2,166,422	$43,526
TOTAL	($59,097,031)	(54)	(28.1)	(1,137)	$1,007,625	$3,899,775	$1,677,401

Our analysis indicates that the most significant impact on predicted development yields would be for employment lands in the Harbor-Airport study area. Much of this property is currently exempted from tree preservation standards, and the incremental impact would be substantive. In addition, industrial uses support relatively low residual land values, and as a result they are less able to absorb cost increases. The impact on residential yields is less significant as these uses support higher land values, and the marginal change in requirements is lower than for exempted zoning classifications.



For employment areas, the loss of exemption and the tree density standards are the most significant factors influencing the

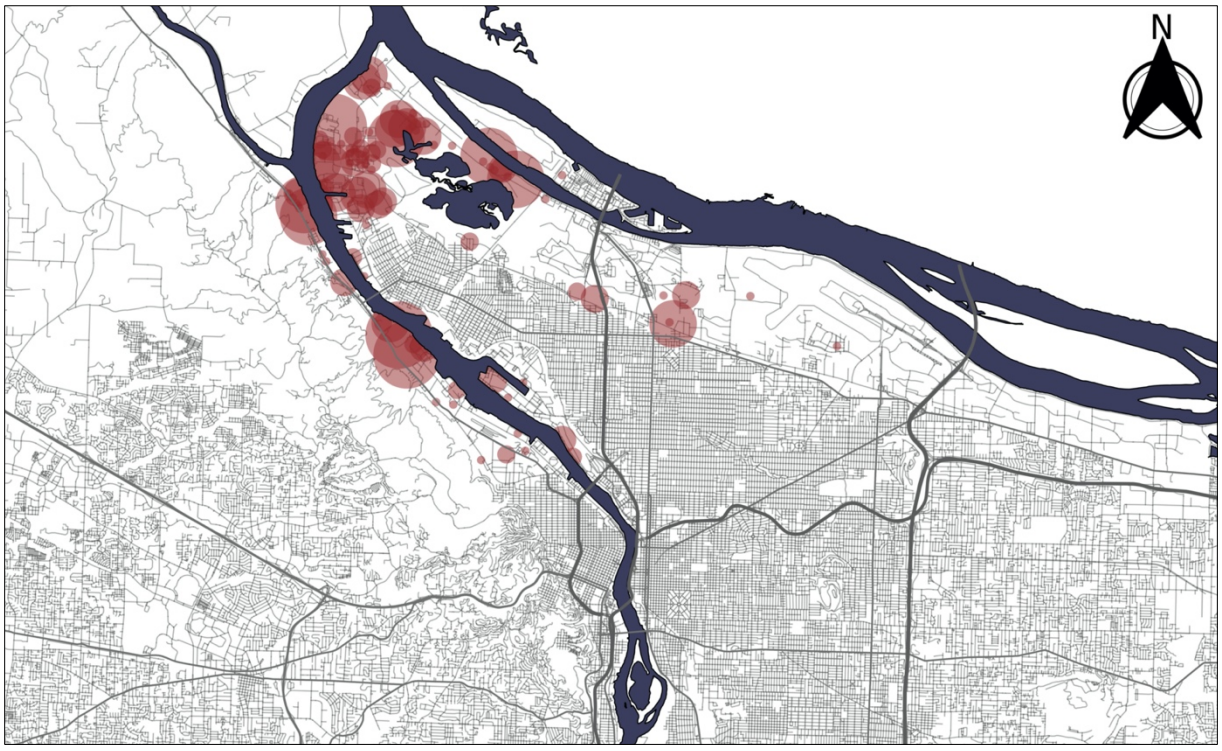
marginal shift in anticipated outcomes. In residential areas, the tree density requirements are most significant in terms of impact. The following table summarizes the predicted change in outcome attributed to individual proposed modifications. This is based on the percentage of cost impact. Impacts in the model reflect an aggregation of cost changes.

FIGURE 2.2: PREDICTED CHANGE IN OUTCOMES ATTRIBUTED TO ORDINANCE CHANGE (20-YEAR HORIZON)

	EMPLOYMENT ACREAGE			RESIDENTIAL UNITS		
	Loss of Exemption	Change in Coverage	Tree Density	Loss of Exemption	Change in Coverage	Tree Density
COLUMBIA EAST	0.00	(0.48)	0.00	0.00	0.00	0.00
HARBOR - AIRPORT	(5.26)	(4.52)	(1.96)	0.00	0.00	0.00
HARBOR ACCESS LANDS	(4.41)	(1.55)	(9.90)	0.00	0.00	0.00
INNER RESIDENTIAL	0.00	0.00	0.00	(1.63)	(10.43)	(11.94)
MID-RESIDENTIAL	0.00	0.00	0.00	(0.00)	(8.00)	(0.00)
OUTER RESIDENTIAL	(0.00)	(0.01)	(0.00)	(0.13)	(21.44)	(0.43)
TOTAL	(9.68)	(6.56)	(11.86)	(1.76)	(39.87)	(12.37)

The distribution of impact for employment lands is concentrated along the Portland Harbor and in North Portland. The following map outlines areas of predicted impact on employment lands.

FIGURE 2.3: IMPACTED EMPLOYMENT LANDS[1]

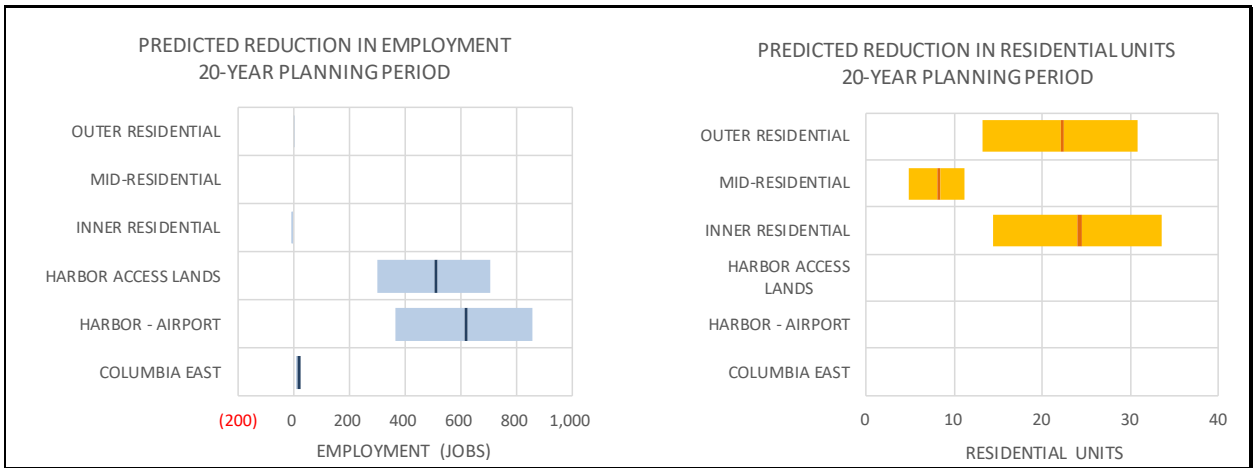


[1] The circles shown represent parcels impacted by tree canopy and are scaled to reflect the amount of area impacted. The map is intended to represent the generalized distribution of impacted parcels and should not be used to identify individual parcels.

The modeling structure's focus is on realized development yield, and the marginal increase in development costs associated with the proposed changes is expected to reduce the predicted yield because of reduced financial viability. The incremental increase in costs translates into a lower supportable land value, reducing the likelihood of development and/or redevelopment. If land values are not reduced at a level necessary to offset the increased costs, development activity would be expected to shift to alternative locations.

The model output is based on the interaction of a multitude of variables and assumptions, not all of which will likely have a normal distribution. While variables such as tree canopy composition are expected to be normally distributed, the model also relies upon assumptions such as property owner disposition which are not normally distributed. As a result, the model outputs do not lend themselves to the calculation of a traditional standard error and confidence bands. We have included a range of anticipated outcomes in the analysis to reflect an inherent degree of uncertainty in the output. The following chart summarizes the generalize range expected outcomes in terms of reduced employment and residential unit yield.

FIGURE 2.4: PREDICTED LIKELY RANGE OF OUTCOMES



The model indicates an expected significant impact on employment capacity for zoning classifications that are currently exempted. The anticipated impact on realized residential density is relatively low in terms of units. For all land use types a marginal increase in development cost is expected to potentially have an inflationary impact on pricing for end users. As development costs increase, that increase will need to be shifted either to the market through higher pricing deducted from land value. Reductions in land value would be expected to reduce the likelihood of development and/or redevelopment.

The model was also run to specifically test the impacts on anticipated levels of development associated with removing the exemptions in the IH and IG1 zones. The analysis indicates that the loss of exemption alone would reduce employment capacity over a twenty-year horizon by 592 jobs, or roughly two thirds of predicted employment capacity lost.

FIGURE 2.4: PREDICTED IMPACT OF LOSS OF CURRENT EXEMPTION ON IH AND IG1 PROPERTIES
TWENTY YEAR HORIZON

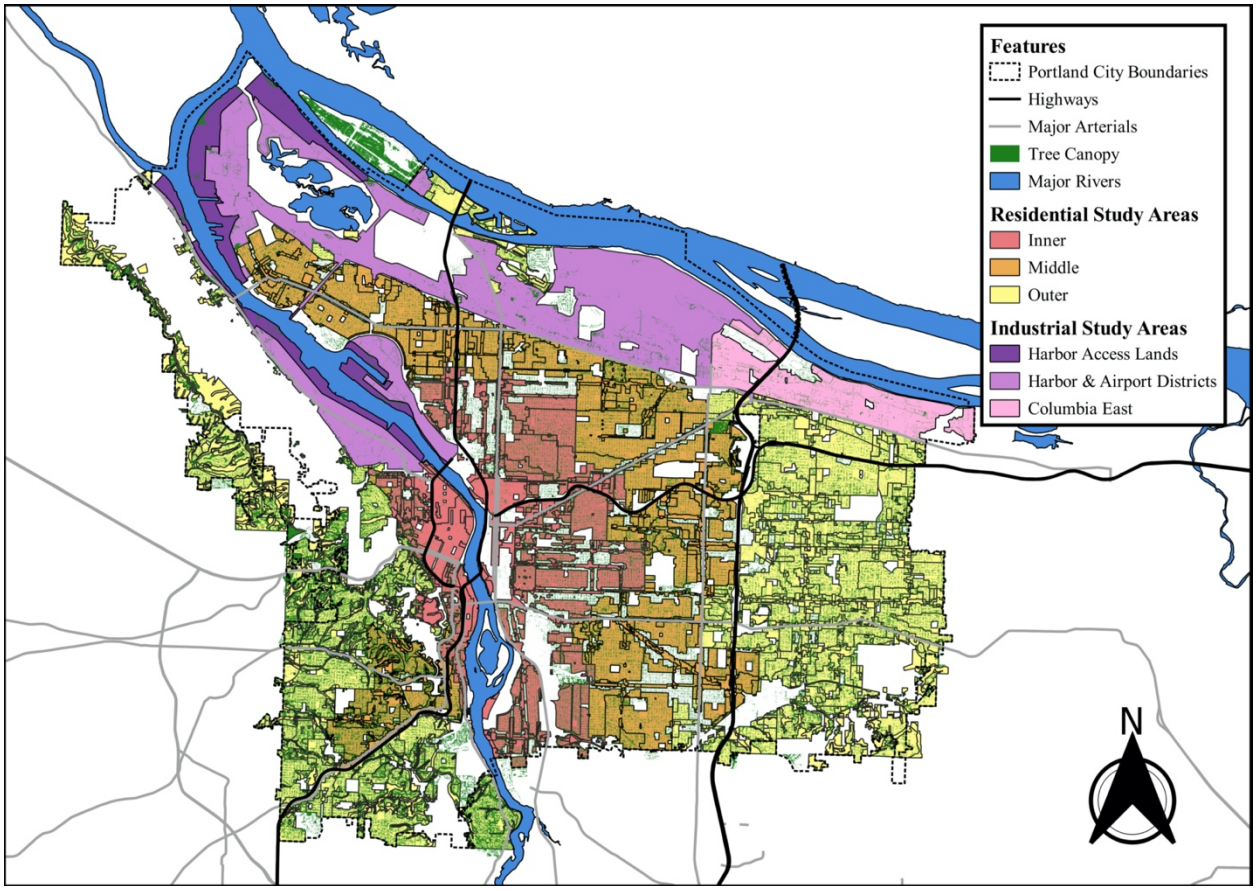
	Predicted Development Yield		
	Construction Investment	Employment Acreage	Employment Capacity
OVERALL SUMMARY			
BASELINE			
HARBOR - AIRPORT	$103,558,035	30.0	945
HARBOR ACCESS LANDS	($12,826,828)	45.6	1,433
CENTRAL CITY	$50,303,262	1.8	632
NON-CENTRAL	$7,467,318	0.2	7
VARIANCE FROM BASELINE			
HARBOR - AIRPORT	($12,826,828)	(7.8)	(349)
HARBOR ACCESS LANDS	($26,003,121)	(15.5)	(488)
CENTRAL CITY	($6,143)	(0.0)	(0)
NON-CENTRAL	($161)	(0.0)	(0)
TOTAL	($38,829,949)	(23.3)	(838)

The impact is largely associated with properties zones IH, as IG1 properties are more concentrated in markets with a greater achievable pricing. The residual land value in these areas is adequate to better allow for developers to address the incremental costs associated with the proposed changes.

III. STUDY AREA DEFINITION

The study area for this project was defined based on properties impacted by tree canopy in five geographic areas. Two primarily employment study areas were defined, the Harbor & Airport Districts and Columbia East. Three primarily residential study areas were also defined based on general price profiles, the inner, middle, and outer residential areas. The current tree canopy was overlaid on the sites.

FIGURE 3.1: SITES EVALUATED BY STUDY AREA



SOURCE: City of Portland and JOHNSON ECONOMICS

Parcel level data was derived from the County Assessor's office while zoning and tree canopy was provided by BPS.

For each tax lot, the total area and percentage of the area of a tax lot and building area identified as tree canopy was calculated. The total vacant and/or redevelopable land area intersecting the tree canopy was calculated based on the City of Portland's BLI layer for employment lands, and the entire site for residential areas.

The impacted properties evaluated included 95,123 sites, representing 21,556.7 acres. The identified tree canopy covered 27.0% of this property, or 5,812.6 acres. The following table summarizes impacted parcels in the delineated submarkets.

SUMMARY OF STUDY AREAS

	# of Parcels	Impacted Acres	Canopy Acres	% Canopy
COLUMBIA EAST	488	302.3	77.0	25.5%
HARBOR - AIRPORT	1,793	849.2	205.3	24.2%
HARBOR ACCESS LANDS	136	278.2	64.4	23.2%
INNER RESIDENTIAL	27,482	4,351.2	971.5	22.3%
MID-RESIDENTIAL	40,756	6,325.7	1,581.6	25.0%
OUTER RESIDENTIAL	24,468	9,450.2	2,912.8	30.8%
TOTAL	95,123	21,556.7	5,812.6	27.0%

SOURCE: City of Portland Bureau of Planning and Sustainability, Johnson Economics

IV. PROPOSED CODE CHANGES

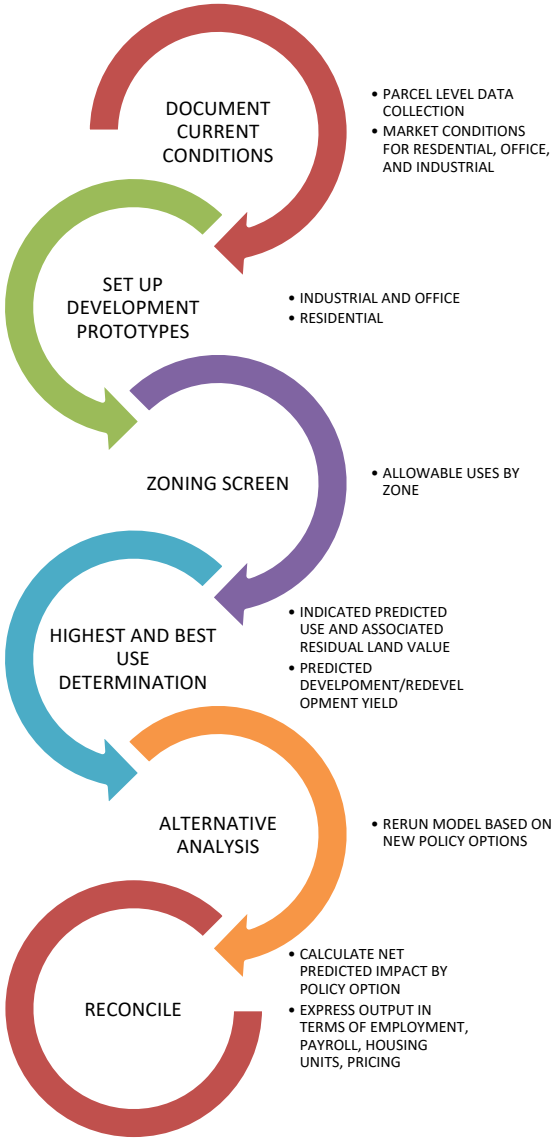
Three proposed code changes were evaluated:

- *Remove the exemption from the Tree Preservation Standards for private trees in development situations for zoning designations – IH, IG1, CX, and EX; and*
- *Reduce the Tree Preservation size threshold that triggers an inch-for-inch mitigation fee for private trees in development in all zones from 36 inches diameter-at-breast height (dbh) to 20 inches dbh for all zones.*
- *Remove the exemption from tree density standards from zoning designations IH, IG1, CX and EX*

Each of these changes are expected to marginally increase the cost to develop affected properties. In addition to impacting costs, the changes are likely to induce marginal changes in development programs to reduce mitigation costs when appropriate.

V. Model Framework

To assess the anticipated magnitude and character of impacts on development outcomes associated with the proposed code changes, we utilized a predictive development modeling framework to forecast development outcomes with and without the proposed changes.



The model is designed to predict the magnitude and form of likely development or redevelopment activity over an assumed time frame. The primary metric used to predict likely development patterns is the relationship between the supportable residual land value for prospective uses and the current value of the property (including land as well as improvements, if any). The underlying assumption is that when the value of a property for new development is high relative to the current value of the property, it will be more likely to see development or redevelopment over a defined time-period.

The model is designed to generate an estimated ratio between the current value of a parcel and the underlying value of the parcel under potential development scenarios. This ratio is used at the primary indicator of the likelihood of development or redevelopment. Within the model, we use Real Market Value (RMV) from the assessors' office as a proxy for the value of the site. While we understand that this is an imperfect measure, it is readily available at the parcel level and any inherent bias is expected to be largely consistent. The residual land value is determined using a series of simplified pro formas that represent potential development forms. The resulting ratio between current and residual value has proven to be a strong predictor of the likelihood of development or redevelopment at the parcel level.

The model solves for a development solution that represents the highest and best use at the parcel level under the assumptions used, as well as outputting an associated residual property value. The highest and best use of each parcel is defined as the allowable land use program that yields the greatest return to the existing property, and the residual property value reflects the maximum acquisition value supported by that program under the assumptions used. For this analysis, the model evaluated a total of 30 prototypical programs which cover the range of residential and employment development forms allowed under the current and proposed code in the study area. An entitlement screen narrows the allowed use types to reflect existing and proposed zoning.

The probability of development/redevelopment activity is predicted by the model at the parcel level based on the ratio generated by dividing the current value (RMV) by the indicated residual land value. A shift in assumptions that increases the value of the property under a new development scenario, such as higher

achievable pricing or less restrictive entitlements, will increase the denominator in this ratio as well as the likeliness of development or redevelopment. Sites with relatively high current values resulting from significant physical improvements will have a relatively high numerator and will be significantly less likely to redevelop.

The model evaluates the likelihood of development at the parcel level, although the results are expressed in aggregated geographies. What the model solves for is probabilities to redevelop as well as anticipated development forms, and the results reflect the expected value of development/redevelopment activity. The model will not indicate that a specific parcel will or will not redevelop, it will change the probability of that occurrence as well as the likely form of development.

In summary, the model uses the relationship between current value of the property and the indicated value of the property under the highest and best use development prototype as the primary predictive measure of the likelihood of development and/or redevelopment.

PROTOTYPES

To test the impact of the proposed changes, Johnson Economics modeled the economic feasibility of a range of prototypical development programs on the impacted sites. This included 11 employment uses (office and industrial), 10 rental-residential, and 9 ownership residential prototypes.

The following series of tables summarizes these program assumptions.

PROTOTYPE OFFICE AND INDUSTRIAL DEVELOPMENT PROGRAMS

	Office high rise	Office mid/ structured	Office mid / ext. structured	Office mid/ surface	Office high rise - CC	Office mid/ structured - CC	Office mid / ext. structure	Office low rise	Manufacturing	Warehouse/ Distribution	Multi-Tenant Flex
Stories	10	5	4	4	10	5	4	1	1	1	1
FAR	7.50	3.75	2.00	0.50	7.50	3.75	2.00	0.30	0.45	0.40	0.33
Parking Ratio/000 SF	1.50	1.50	1.50	1.50	0.50	0.50	0.50	1.50	2.0	1.0	1.0
Structured Parking %	100%	100%	85%	0%	100%	100%	85%	0%	0%	0%	0%

PROTOTYPE RENTAL RESIDENTIAL PROGRAMS

	Rental high rise	Rental high rise – Low Parking	Rental Mid Rise	Rental Mid Rise – Low Parking	Rental 5 over 2	Rental Type V w/podium	Rental Type V w/podium – Low Parking	Rental 3-story wood zero parked	Rental 3-story wood w/surf	Rental Middle Type V
Density/Acre	400	400	225	225	210	170	170	130	35	20
Ave Unit Size	725	725	750	750	750	750	750	750	750	1,000
FAR	7.83	7.83	4.54	4.54	4.24	3.44	3.44	2.63	0.60	0.45
Parking Ratio/Unit	1.00	0.50	1.00	0.50	1.25	1.00	0.25	-	1.50	1.25

PROTOTYPE OWNERSHIP RESIDENTIAL PROGRAMS

	Condo Highrise	Condo Mid Rise	Condo 5 over 2	Condo Type V w/podium	Condo 3-story wood w/surf	Middle Housing Type V	For-Sale Duplexes	Skinny Homes	Single Family
Density/Acre	400	225	210	170	35	25	18	17	9
Ave Unit Size	775	775	775	775	800	1,250	1,250	1,350	1,750
FAR	8.57	4.81	4.48	3.64	0.64	0.56	0.50	0.61	0.35
Parking Ratio/Unit	1.25	1.25	1.25	1.50	1.75	1.50	1.50	1.50	2.00

DEFINITION OF TERMS

This report uses several terms in the tables and text. The following is a brief definition of terms used.

Impacted Acres	The impacted acres in this approach reflect parcels that contain identified tree canopy areas. For employment zones, the vacant and redevelopable acreage within the impacted parcels reflects the City's current BLI estimates. In residential zones, the BLI was not used to limit impacted areas as much of the bulk of residential capacity within the City of Portland is in redevelopment and infill.
Employment Capacity	Employment capacity in the context of this analysis represents the expected number of employees that would be accommodated in the predicted development. This represents the expected marginal increase in realized employment and does not represent the theoretical capacity at full build-out.

Real Market Value (RMV)	RMV is derived from assessor records and represents the assessor opinion as to the current market value of land and improvements on a property.
Prototype	The prototypes represent prototypical development forms that were evaluated. There are innumerable development options for individual sites, but the prototypes represent a series of common development forms that are prevalent in the local market.
Buildable Land Inventory (BLI)	The BLI is a formal inventory maintained by the City as part of their Goal 9 and 10 compliance. The BLI establishes available sites and assumed carrying capacity for employment (Goal 9) and housing (Goal 10). The City's BLI was used to limit the impacted acres for employment uses in this analysis.
Floor Area Ratio (FAR)	FAR refers to a ratio between gross square footage of building area divided by land area. As an example, a 30,000 square foot industrial building on a 100,000 square foot site would have a FAR of 0.30.

VI. Code Changes and Assumed Impacts

The proposed code changes are expected to alter the economics of developing impacted properties. The following summarizes the assumed impact of the proposed code changes.

	ANTICIPATED IMPACTS	
PROPOSED CODE CHANGE	EMPLOYMENT	RESIDENTIAL
Remove exemptions for IH, IG1, CX, and EX zoned parcels	▪ *Increase in development costs for parcels in these zones* ▪ *Tree canopy estimates reduced by 10% in residential/ commercial areas and 15% in industrial area to account for allowed removal of dead, dying, or dangerous trees.*	▪ No marginal impact
Reduce size threshold to 20 inches	▪ Increase in development costs for all impacted parcels	▪ Increase in development costs for all impacted parcels
New Tree Density Standards	▪ Increase in development costs for parcels losing their current exemption.	▪ No marginal impact

The impact of each of these proposed changes will vary significantly on a parcel by parcel basis, and the modeling did not include a detailed site by site assessment. This would be time and cost prohibitive considering the sample site includes over 95,000 sites. In general, the anticipated impacts would be expected to include a combination of increased cost for mitigation as well as some marginal changes in development patterns to avoid incremental costs. Both are expected to reduce the level of realized development in the sample site, through reduced economic returns and/or lower realized densities. Any

increase in cost, decrease in yield, or increase in required rate of investment return is expected to negatively impact likely development outcomes on parcels in the study area.

The following is a summary of the cost calculations used:

Tree Preservation Standards in Currently Exempted Zones

- *Trees 36" or larger, preserve or pay mitigation fee of $450 per inch dbh.*
- *Preserve 1/3 of the 20" to 35.9" trees or pay mitigation fee of $3,600 per tree.*
- *Preserve 1/3 of the 12" to 19.9" trees or pay mitigation fee of $1,800 per tree.*

Expanded Tree Preservation to 20" Trees

- *Preserve 20" and greater or pay mitigation fee-in-lieu of $450 per inch.*
- *Subtract the current requirement to preserve 1/3 of the 12" to 19.9" trees or pay mitigation fee of $1,800 per tree.*

New Tree Density Standards in Currently Exempted Zones

- *Increase in costs associated with an assumed fee in lieu for currently exempted properties.*

VII. SUBAREA ANALYSES

The impact area was broken into six geographic subareas:

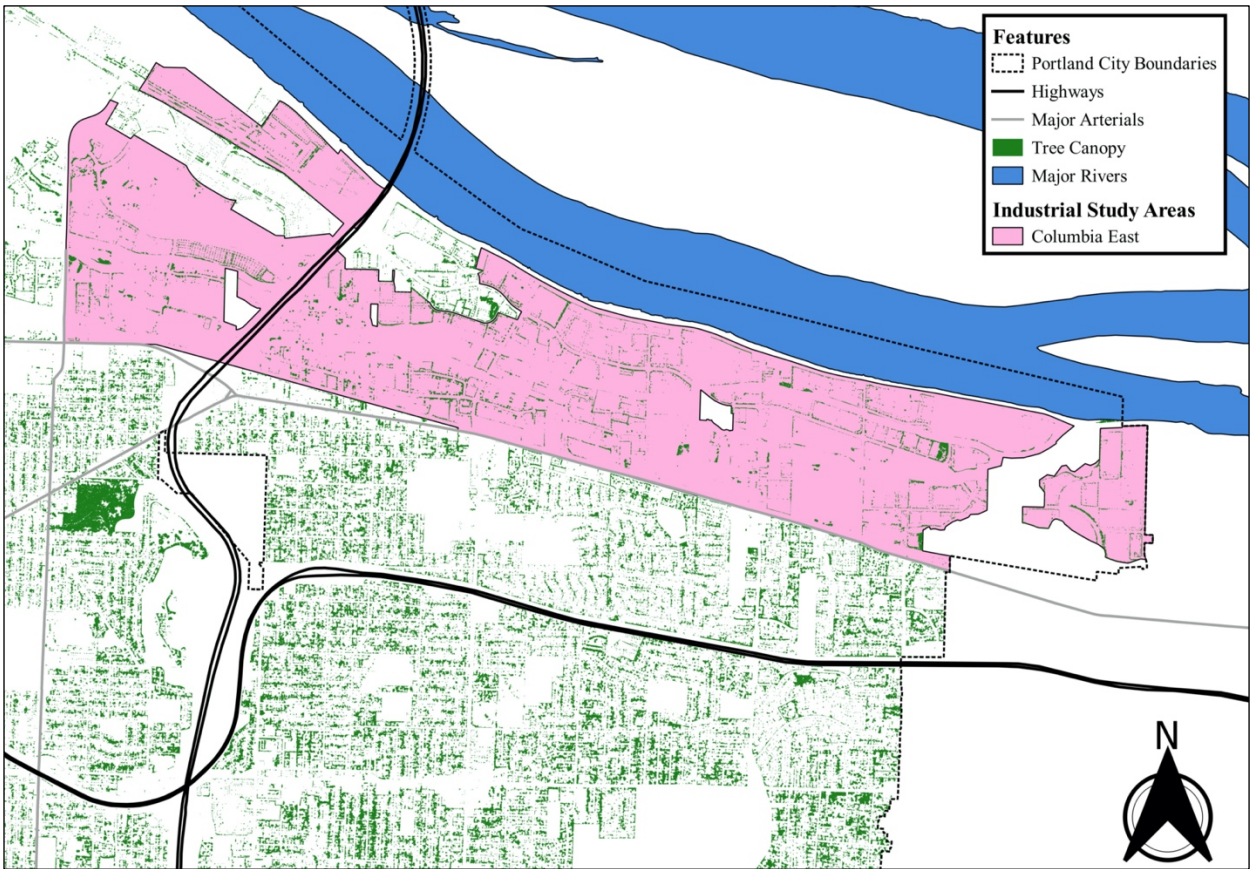
- *Columbia East*
- *Portland Harbor – Airport*
- *Harbor Access Lands*
- *Inner Residential*
- *Middle Residential*
- *Outer Residential*

For each of these areas, our predictive development model was run under the current development code, as well as with adjustments based on the proposed changes to the tree ordinance.

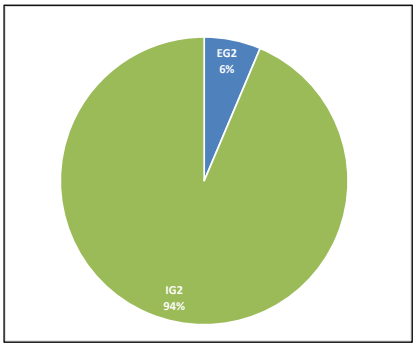
COLUMBIA EAST

The Columbia East study area is located north of Sandy Boulevard and east of the Portland International Airport. The area has been largely developed for employment uses.

MAP OF COLUMBIA EAST STUDY AREA



ACREAGE BY ZONING



A total of 488 site were identified as impacted, representing 302 acres in the BLI. These sites have 77 acres of identified tree canopy, representing 25.5% of the site area. Impacted sites in this study area were largely zoned IG2, with some EG2 as well. As a result, the current zoning did not exempt these sites from tree preservation standards. The impact in IG2 and EG2 was therefore limited to the expansion of the tree preservation requirements to include smaller trees.

MODEL OUTPUT

Our analysis indicates that the proposed changes would have a negligible impact on development and redevelopment in the study area, with a reduction in realized employment capacity over the next twenty years of only 16 jobs. This is largely attributable to the current zoning in the area, which includes no sites that are currently in exempted zoning classifications.

Under baseline scenario, the impacted portions of the subarea would be expected to accommodate an additional 981 additional jobs on impacted sites. This would be predicted to decline to 965 under our assumptions. The impact would be greater over an assumed 100-year horizon, but still quite modest.

SUMMARY OF MODEL RESULTS, COLUMBIA EAST – 20 YEAR HORIZON

	Predicted Development Yield			
LINE	Construction Investment	Residential Units	Employment Acreage	Employment Capacity
COLUMBIA EAST				
BASELINE				
New Construction	$53,837,325	0	31.2	981
Rehab/Renovation	$70,100,701			
Overall Total	$123,938,026			
NEW TREE REPLACEMENT REQUIREMENTS				
New Construction	$53,005,284	0	30.7	965
Rehab/Renovation	$70,148,002			
Overall Total	$123,153,286			

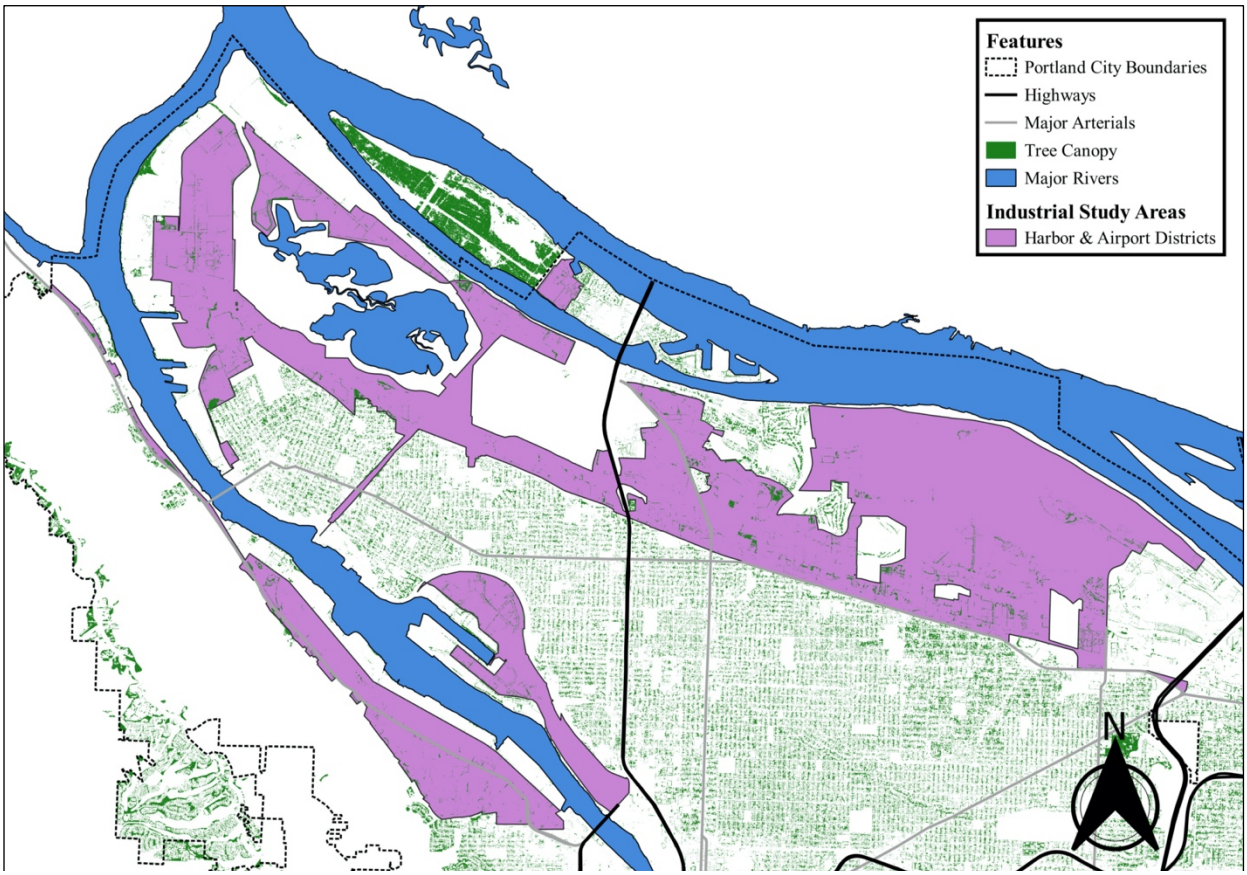
SUMMARY OF MODEL RESULTS, COLUMBIA EAST – 100 YEAR HORIZON

	Predicted Development Yield			
LINE	Construction Investment	Residential Units	Employment Acreage	Employment Capacity
COLUMBIA EAST				
BASELINE				
New Construction	$280,855,626	0	162.6	5,116
Rehab/Renovation	$566,963,489			
Overall Total	$847,819,115			
NEW TREE REPLACEMENT REQUIREMENTS				
New Construction	$278,138,058	0	161.0	5,066
Rehab/Renovation	$568,492,341			
Overall Total	$846,630,399			

HARBOR - AIRPORT

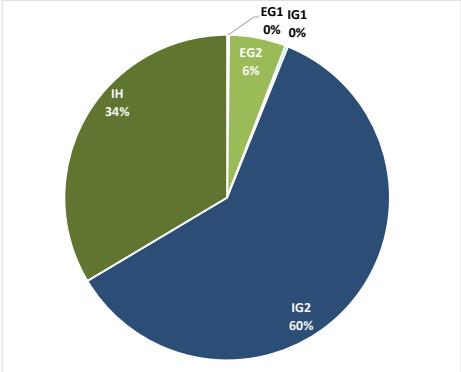
The Harbor-Airport study area includes the Portland International Airport, as well as industrial properties to the west and south along the Willamette River. The area includes Portland Harbor access lands, as well as significant industrial lands north of Columbia Boulevard.

MAP OF IMPACTED PARCELS, HARBOR & AIRPORT STUDY AREA



A total of 1,793 site were identified as impacted, representing 849 acres in the BLI. These sites have 205 acres of identified tree canopy, representing 24.2% of the site area. Impacted sites in this study area were largely zoned IG2(60%) and IH (34%), with some EG2 (6%) as well. Of these, only the IH zoned property is currently exempted from the tree preservation standards. The impact on the IH zoned land is most significant, while the impact on the remaining property is limited to the expansion of the tree preservation requirements to include smaller trees.

ACREAGE BY ZONING



MODEL OUTPUT

Our analysis indicates that the proposed changes would have a much more significant impact on development and redevelopment in the study area than the Columbia East study area. Realized employment capacity is predicted to decline by 616 jobs, reflecting a roughly 17% decrease.

SUMMARY OF MODEL RESULTS, HARBOR-AIRPORT STUDY AREA – 20 YEAR HORIZON

	Predicted Development Yield				
LINE	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
HARBOR - AIRPORT					
BASELINE					
New Construction	$198,806,570	0	110.6	3,629	$370,264
Rehab/Renovation	$113,935,858				
Overall Total	$312,742,428				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$178,699,673	0	98.8	3,014	$346,155
Rehab/Renovation	$115,006,826				
Overall Total	$293,706,499				

If the forecast period is extended to 100 years, the decrease in predicted capacity would be approximately 3,165 jobs.

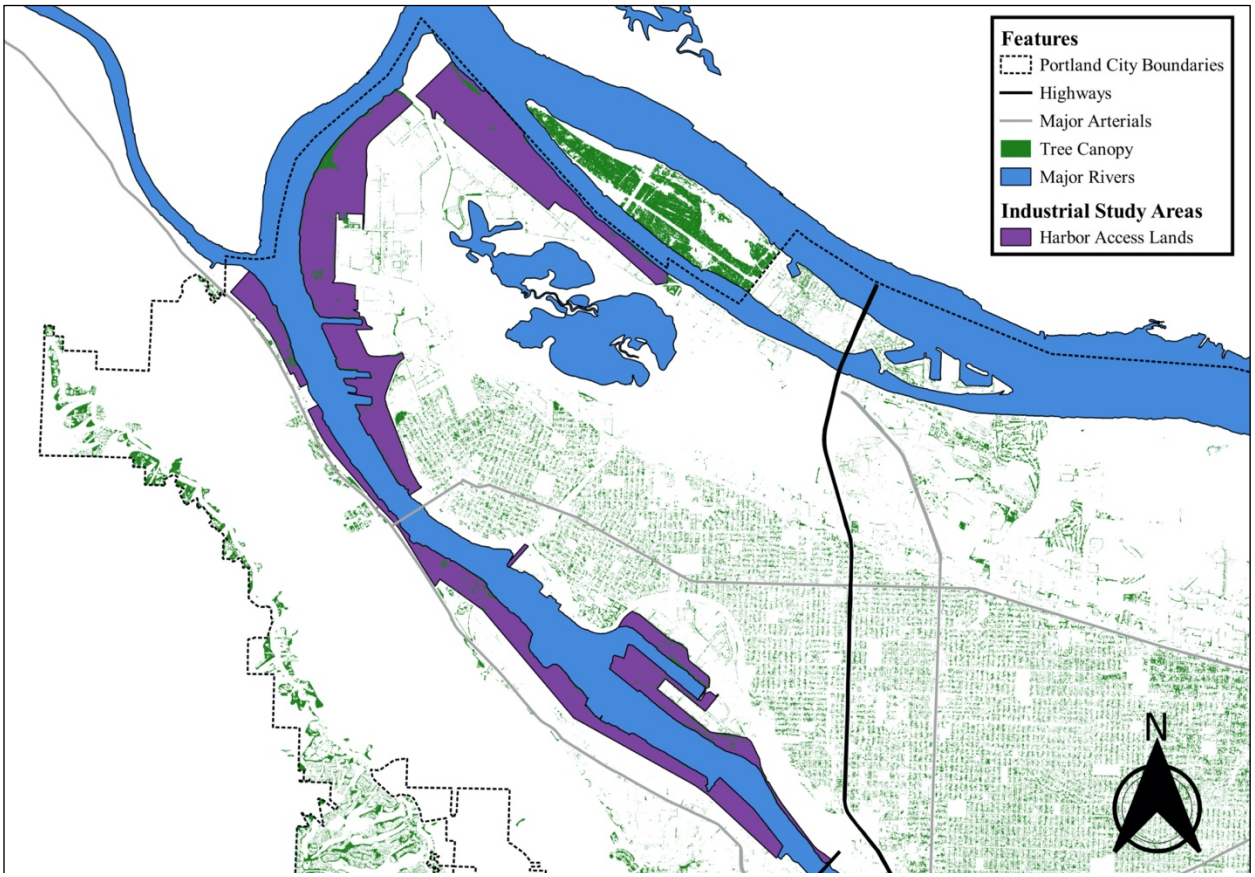
SUMMARY OF MODEL RESULTS, HARBOR-AIRPORT STUDY AREA – 100 YEAR HORIZON

	Predicted Development Yield				
LINE	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
HARBOR - AIRPORT					
BASELINE					
New Construction	$1,034,386,610	0	575.8	18,881	$2,053,289
Rehab/Renovation	$726,866,541				
Overall Total	$1,761,253,151				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$930,777,550	0	515.2	15,717	$1,982,074
Rehab/Renovation	$784,488,519				
Overall Total	$1,715,266,068				

HARBOR ACCESS LANDS

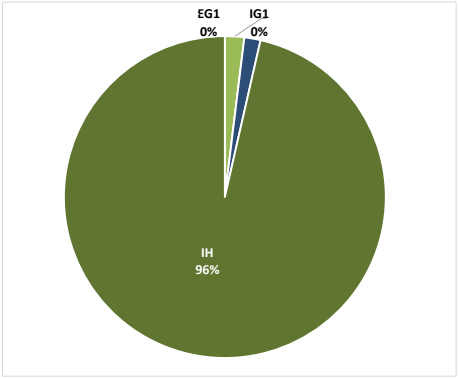
The Harbor Access Lands study area includes properties fronting the Portland Harbor. Harbor access is a limited resource and there is little ability to substitute for these sites. This can allow for higher achievable site pricing for qualified businesses, but not all uses are allowed on sites with marine dependent use restrictions.

MAP OF IMPACTED PARCELS, HARBOR ACCESS LANDS



A total of 136 sites were identified as impacted, representing 278 acres in the BLI. These sites have 64.4 acres of identified tree canopy, representing 23.2% of the site area. Virtually all the impacted sites are zoned IH (96%), which is currently exempted from both the tree preservation and tree density standards. As a result, these parcels are significantly impacted by the proposed changes.

ACREAGE BY ZONING



Model Output

Our analysis indicates that the proposed changes would have a significant impact on development and redevelopment in the study area. Realized employment capacity is predicted to decline by over 506 jobs over a twenty-year period, reflecting a roughly 34% decrease.

Summary of Model Results, Harbor Access Study Area – 20 Year Horizon

	Predicted Development Yield				
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
HARBOR ACCESS LANDS					
BASELINE					
New Construction	$82,278,979	0	46.9	1,500	$127,413
Rehab/Renovation	$20,123,733				
Overall Total	$102,402,713				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$54,537,665	0	31.0	994	$92,817
Rehab/Renovation	$20,935,557				
Overall Total	$75,473,221				

If the forecast period is extended to 100 years, the decrease in predicted capacity would be 2,243 jobs.

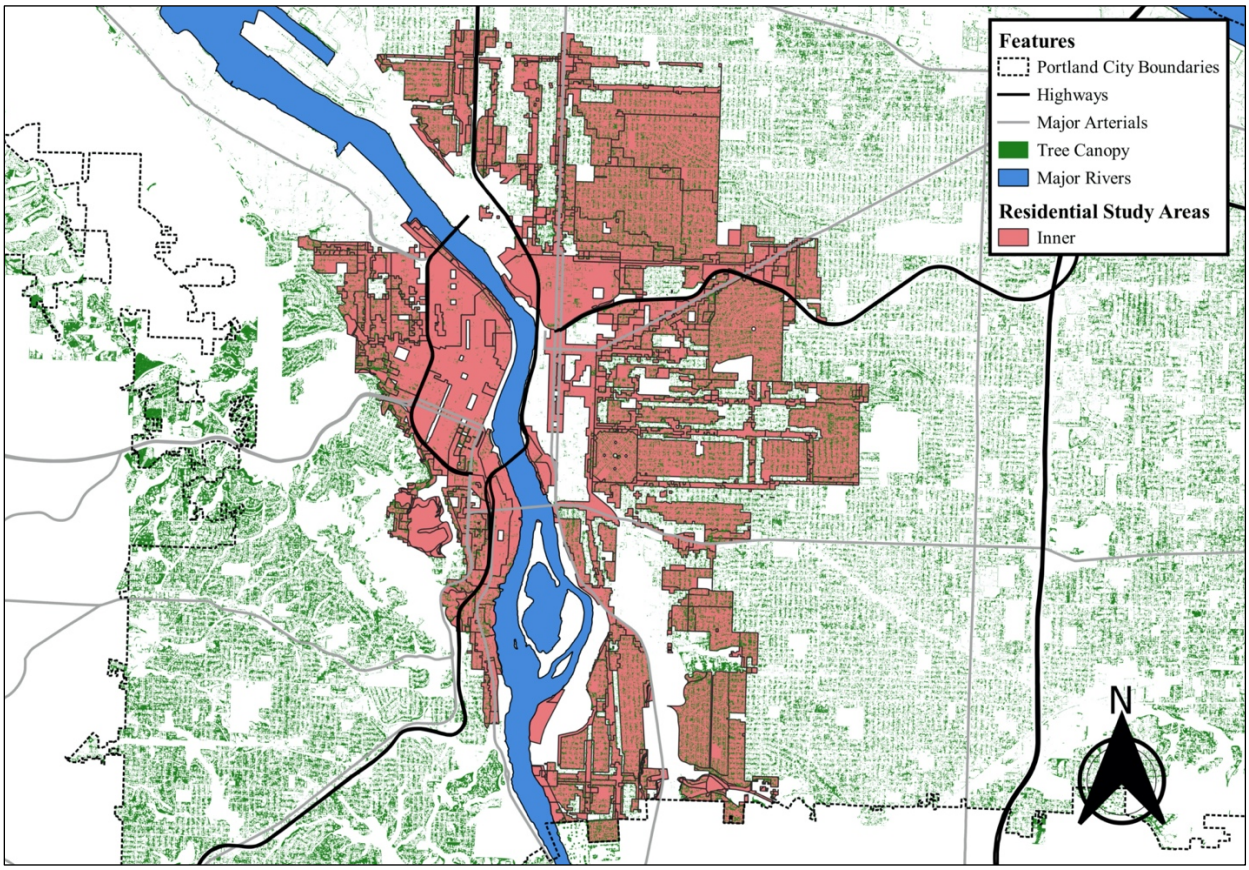
Summary of Model Results, Harbor Access Study Area – 100 Year Horizon

	Predicted Development Yield				
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
HARBOR ACCESS LANDS					
BASELINE					
New Construction	$393,268,464	0	224.3	7,169	$636,221
Rehab/Renovation	$126,443,235				
Overall Total	$519,711,699				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$270,192,060	0	153.8	4,926	$524,833
Rehab/Renovation	$169,779,678				
Overall Total	$439,971,738				

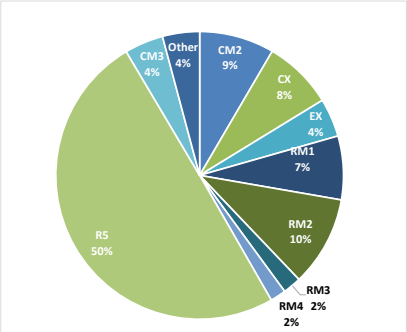
INNER RESIDENTIAL

The Inner Residential study area includes Portland's CBD as well as relatively high-priced neighborhoods in the close-in eastside, north Portland, South Waterfront, Nob Hill, and John's Landing.

MAP OF INNER RESIDENTIAL STUDY AREA



ACREAGE BY ZONING



A total of 27,482 sites were identified as impacted, representing 4,351 acres. These sites have 972 acres of identified tree canopy, representing 22.3% of the site area. Roughly half of the acreage in the study area is zoned R5, with a wide range of other commercial and industrial zoning represented. The study area has some EX zoned property that is currently exempted from the tree preservation standards. The impact on the remaining property is limited to the expansion of the tree preservation requirements to include smaller trees. This will add to the cost of development and redevelopment on impacted sites.

The expected impact of the proposed code changes would be on residential yield in this study area. Under baseline scenario, the impacted portions of the subarea would be expected to accommodate an additional 62,931 residential units over a twenty-year time horizon. The predicted residential unit yield under the new tree ordinance would decline by only 24 units. This reflects relatively high underlying land values in this

market, which allows the cost of the tree ordinance requirements to be addressed through a modest reduction in residual land value.

SUMMARY OF MODEL RESULTS, INNER RESIDENTIAL STUDY AREA – 20 YEAR HORIZON

	Predicted Development Yield				
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
INNER RESIDENTIAL					
BASELINE					
New Construction	$14,271,362,156	62,931	21.0	1,094	$27,258,710
Rehab/Renovation	$9,137,027,195				
Overall Total	$23,408,389,350				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$14,265,390,475	62,907	21.0	1,094	$27,252,150
Rehab/Renovation	$9,137,554,004				
Overall Total	$23,402,944,478				

If the forecast period is extended to 100 years, the decrease in predicted capacity would be close to 150 residential units.

SUMMARY OF MODEL RESULTS, INNER RESIDENTIAL STUDY AREA – 100 YEAR HORIZON

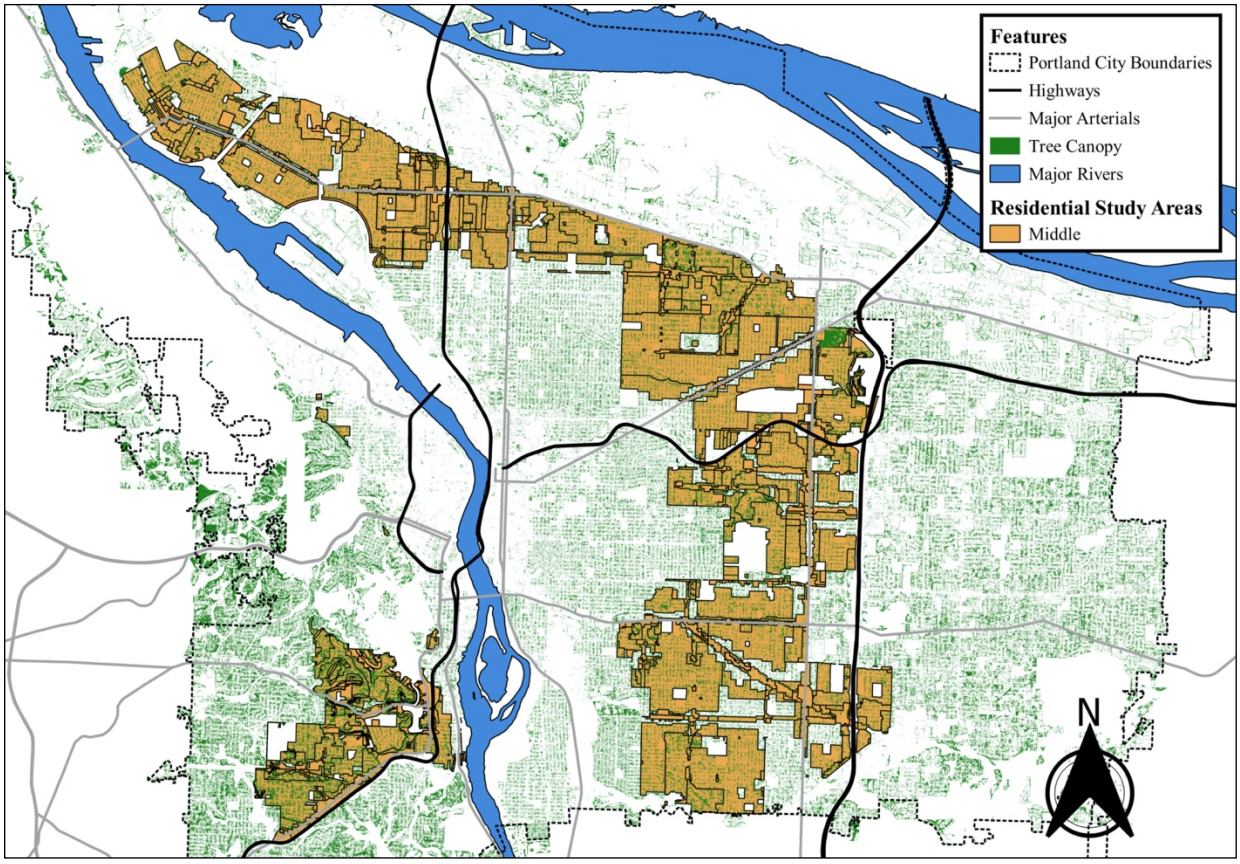
	Predicted Development Yield				
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
INNER RESIDENTIAL					
BASELINE					
New Construction	$77,860,517,107	341,875	101.4	5,284	$166,522,680
Rehab/Renovation	$68,236,571,563				
Overall Total	$146,097,088,669				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$77,824,602,765	341,725	101.4	5,284	$166,500,067
Rehab/Renovation	$68,256,534,532				
Overall Total	$146,081,137,296				

It is important to recognize that a marginal reduction in the price that new development is able to pay for land (residual land value) may lead to some short-term reductions in development activity as the market comes to terms with the new supportable pricing.

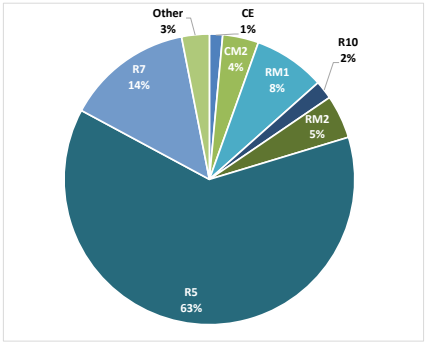
MIDDLE RESIDENTIAL

The Middle Residential study area includes largely residential areas surrounding the Inner Residential study area. Price points for residential product are somewhat lower than in the more central markets. Neighborhoods in this area include Saint Johns, Concordia, Rose City, Montavilla, Mount Tabor, Foster/Powell, Lents, Brentwood/Darlington, Hillsdale, and Multnomah Village.

MAP OF MIDDLE RESIDENTIAL STUDY AREA



ACREAGE BY ZONING



A total of 40,756 sites were identified as impacted, representing 6,327 acres. These sites have 1,582 acres of identified tree canopy, representing 25.0% of the site area. Land zoned R5 represents 63% of the impacted acreage in the study area, followed by R7 (14%) and RM1 (8%). The study area contains no impacted property that is currently exempted from the tree preservation standards.

As with the Inner Residential study area, the anticipated reduction in capacity associated with the proposed regulatory changes in this submarket is negligible. Under the baseline scenario the impacted area is expected to realize an incremental gain of 4,294 residential units. This decreases by only 8 units over a twenty-year planning period.

SUMMARY OF MODEL RESULTS, MIDDLE RESIDENTIAL STUDY AREA – 20 YEAR HORIZON

	Predicted Development Yield				
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
MID-RESIDENTIAL					
BASELINE					
New Construction	$1,077,937,045	4,294	2.4	123	$8,139,729
Rehab/Renovation	$6,794,472,767				
Overall Total	$7,872,409,812				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$1,075,727,503	4,286	2.4	123	$8,137,497
Rehab/Renovation	$6,794,793,977				
Overall Total	$7,870,521,480				

If the forecast period is extended to 100 years, the decrease in predicted capacity would be close to 50 units.

SUMMARY OF MODEL RESULTS, MIDDLE RESIDENTIAL STUDY AREA – 100 YEAR HORIZON

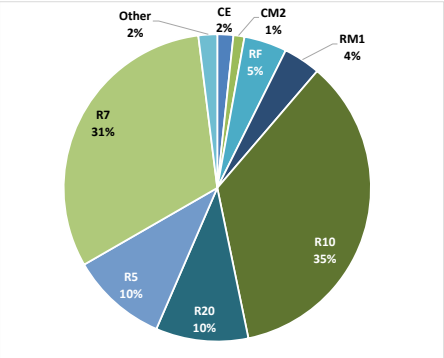
	Predicted Development Yield				
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
MID-RESIDENTIAL					
BASELINE					
New Construction	$5,606,780,884	22,375	12.1	622	$68,988,721
Rehab/Renovation	$62,041,690,509				
Overall Total	$67,648,471,393				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$5,594,713,262	22,326	12.1	622	$68,992,825
Rehab/Renovation	$62,059,587,026				
Overall Total	$67,654,300,287				

OUTER RESIDENTIAL STUDY AREA

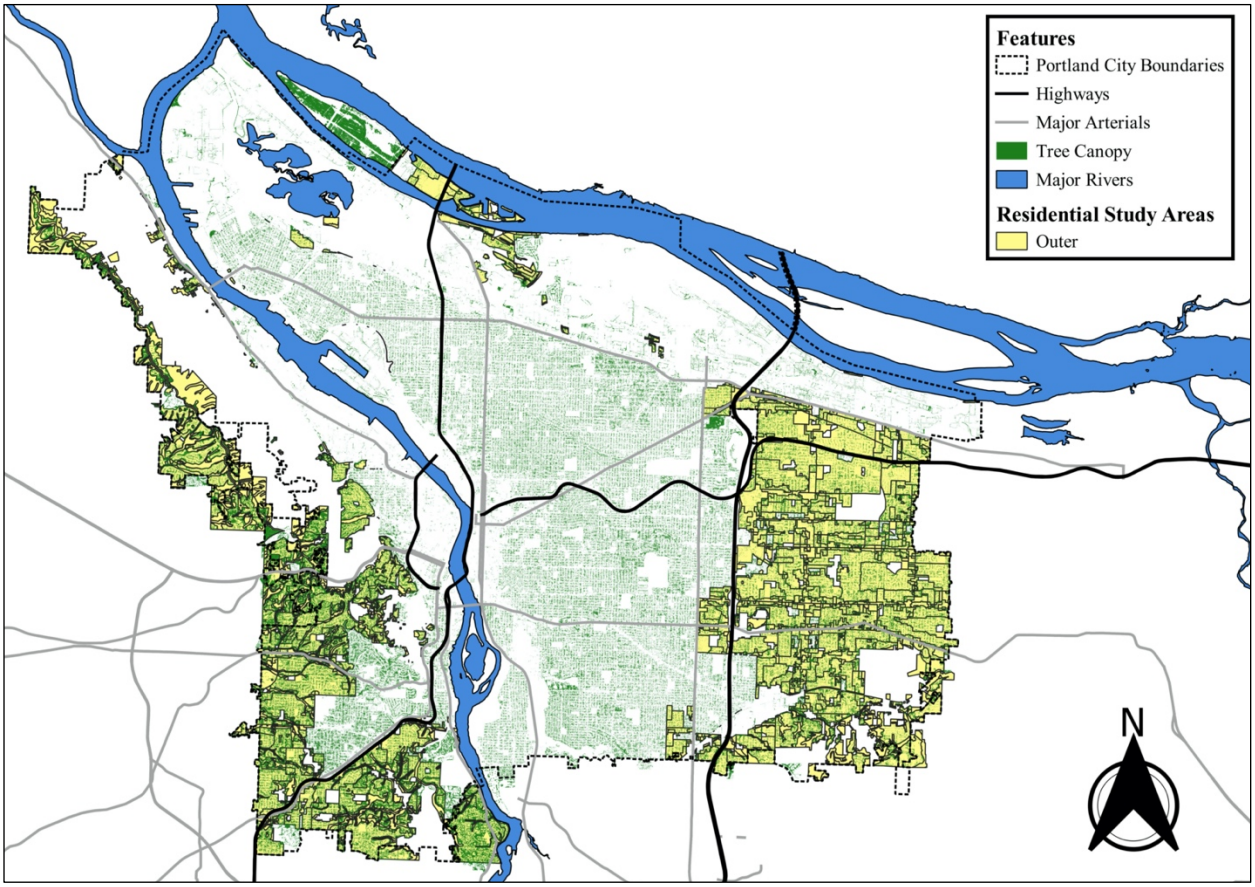
The Outer Residential Study Area includes a diverse mix of neighborhoods. To the east of I-205 are neighborhoods such as Parkrose, Hazelwood, Powellhurst/Gilbert, and Centennial. To the west are neighborhoods that can support relatively higher residential pricing, including Northwest Heights, Bridlemile, Sylvan, and Maplewood. The study area also includes portions of Hayden Island and areas west of Forest Park.

A total of 24,468 sites were identified as impacted, representing 9,450 acres. These sites have 2,913 acres of identified tree canopy, representing 30.8% of the site area. The zoned density in this study area is significantly lower, with 35% of the land zoned R10 and 31% zoned R7. Both R5 and R20 represent 10% of the total impacted land area.

ACREAGE BY ZONING



MAP OF OUTER RESIDENTIAL STUDY AREA



Under baseline scenario, the impacted portions of the subarea would be expected to accommodate an additional 11,722 residential units and 588 jobs. The impact of the new tree ordinance is projected to reduce residential yield by only 22 units in the study area over a twenty-year horizon.

SUMMARY OF MODEL RESULTS, OUTER RESIDENTIAL STUDY AREA – 20 YEAR HORIZON

	Predicted Development Yield				
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
OUTER RESIDENTIAL					
BASELINE					
New Construction	$2,792,161,692	11,772	11.2	588	$8,873,932
Rehab/Renovation	$5,175,265,435				
Overall Total	$7,967,427,127				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$2,786,675,315	11,750	11.2	587	$8,867,772
Rehab/Renovation	$5,175,738,144				
Overall Total	$7,962,413,460				

If the forecast period is extended to 100 years, the decrease in predicted capacity would be 119 residential units.

SUMMARY OF MODEL RESULTS, OUTER RESIDENTIAL STUDY AREA – 100 YEAR HORIZON

	Predicted Development Yield				
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Net Change in RMV (000s)
OUTER RESIDENTIAL					
BASELINE					
New Construction	$14,080,891,789	59,501	56.2	2,936	$64,232,846
Rehab/Renovation	$45,677,171,423				
Overall Total	$59,758,063,212				
NEW TREE REPLACEMENT REQUIREMENTS					
New Construction	$14,052,161,073	59,382	56.1	2,933	$64,224,317
Rehab/Renovation	$45,702,980,836				
Overall Total	$59,755,141,908				

VIII. RESIDENTIAL PRICING IMPACT

While the model does not predict substantive changes in residential carrying capacity associated with the changes in the tree ordinance, the incremental increase in development costs is expected to influence the residential market and potentially have an inflationary impact on housing prices. The proposed changes are expected to increase residential construction costs by over $20 million over the next twenty years, but this represents only 0.11% of overall predicted residential investment in the City (new construction). As a result, the proposed changes are not expected to substantively impact affordability.

SUMMARY OF IMPACTS OF PROPOSED CHANGES ON RESIDENTIAL CONSTRUCTION

Subarea	Residential Units	Unit Change	Cost of Changes	% of Total Construction
INNER RESIDENTIAL	62,907	(24)	$8,403,860	0.06%
MID-RESIDENTIAL	4,286	(8)	$4,566,430	0.42%
OUTER RESIDENTIAL	11,750	(22)	$7,532,151	0.27%
TOTAL	78,943	(54)	$20,502,441	0.11%

One of the reasons that cost of the proposed changes is relatively low for residential development is that the modelling structure tends to avoid development on parcels with relatively high costs. This is reflective of the market, and sites that are more negatively impacted are less likely to develop. While the marginal cost to those that do develop is low in the model, avoidance behavior will likely reduce and/or alter the nature of new development in the study area. This may less directly influence market pricing through a partial constraint on supply.

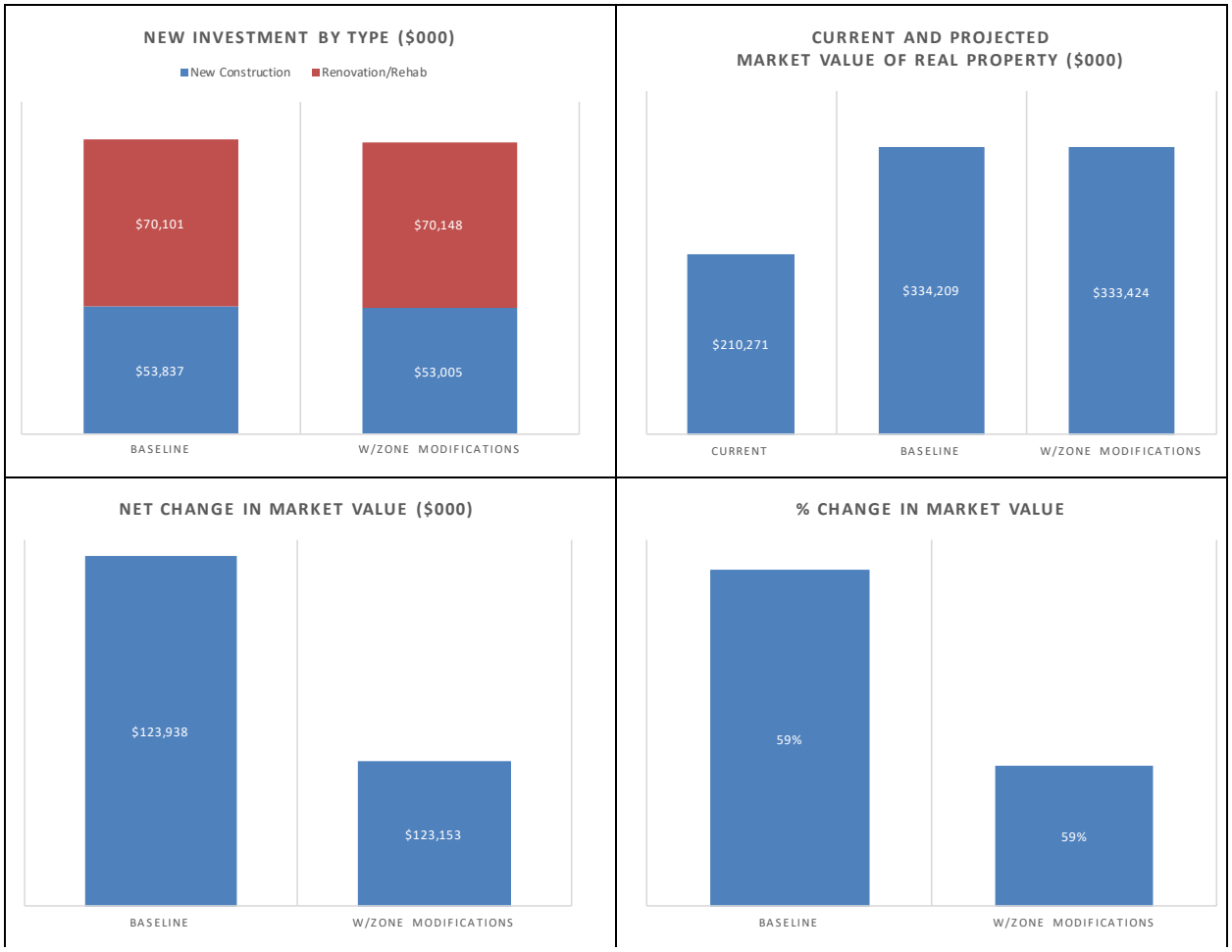
Calculating the actual impact on pricing is a function of the market's ability to shift the increased costs to the end market. In general, over a longer-term horizon increases in cost will be shifted towards the market (increased prices) and/or reflected in lower residual land values for development sites. In the short term, it is likely that some property owners and/or developers could be more negatively by an unanticipated change in the regulatory environment.

APPENDIX: DETAILED MODEL OUTPUT

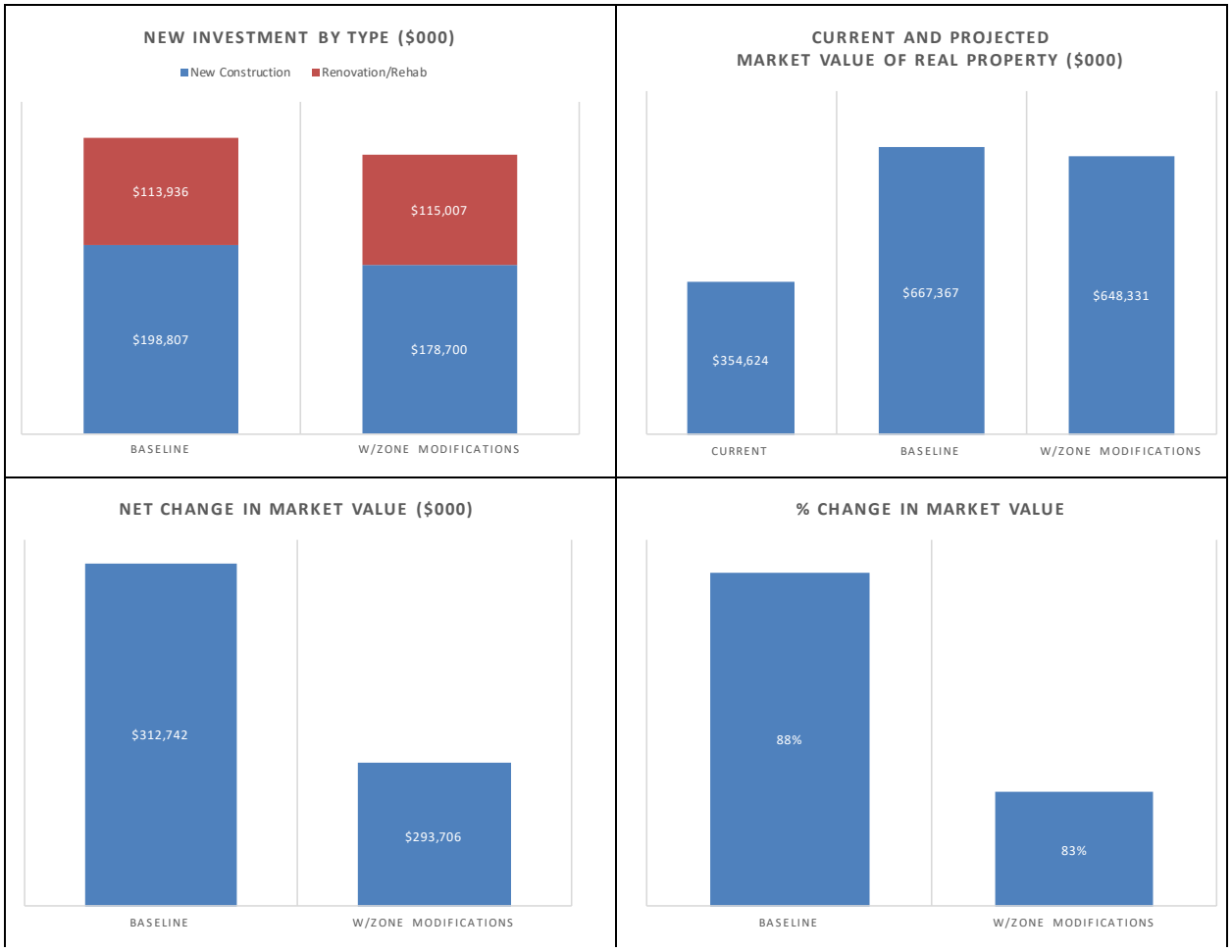
SUMMARY OF PREDICTED DEVELOPMENT ACTIVITY OVER STUDY PERIOD
WITH PROPOSED MODIFICATIONS IN TREE ORDINANCE
20 Year Study Period , No Pricing Changes

	Predicted Development Yield				Marginal Cost on Impacted Properties		
LINE	Construction Investment	Residential Units	Employment Acreage	Employment Capacity	Loss of Exemption	Change in Coverage	Tree Density
COLUMBIA EAST							
BASELINE							
New Construction	$53,837,325	0	31.2	981			
Rehab/Renovation	$70,100,701						
Overall Total	$123,938,026						
NEW TREE REPLACEMENT REQUIREMENTS							
New Construction	$53,005,284	0	30.7	965	$0	$153,598	$0
Rehab/Renovation	$70,148,002						
Overall Total	$123,153,286						
HARBOR - AIRPORT							
BASELINE							
New Construction	$198,806,570	0	110.6	3,629			
Rehab/Renovation	$113,935,858						
Overall Total	$312,742,428						
NEW TREE REPLACEMENT REQUIREMENTS							
New Construction	$178,699,673	0	98.8	3,014	$535,448	$459,901	$199,363
Rehab/Renovation	$115,006,826						
Overall Total	$293,706,499						
HARBOR ACCESS LANDS							
BASELINE							
New Construction	$82,278,979	0	46.9	1,500			
Rehab/Renovation	$20,123,733						
Overall Total	$102,402,713						
NEW TREE REPLACEMENT REQUIREMENTS							
New Construction	$54,537,665	0	31.0	994	$379,823	$133,648	$852,175
Rehab/Renovation	$20,935,557						
Overall Total	$75,473,221						
INNER RESIDENTIAL							
BASELINE							
New Construction	$14,271,362,156	62,931	21.0	1,094			
Rehab/Renovation	$9,137,027,195						
Overall Total	$23,408,389,350						
NEW TREE REPLACEMENT REQUIREMENTS							
New Construction	$14,265,390,475	62,907	21.0	1,094	$79,381	$508,748	$582,272
Rehab/Renovation	$9,137,554,004						
Overall Total	$23,402,944,478						
MID-RESIDENTIAL							
BASELINE							
New Construction	$1,077,937,045	4,294	2.4	123			
Rehab/Renovation	$6,794,472,767						
Overall Total	$7,872,409,812						
NEW TREE REPLACEMENT REQUIREMENTS							
New Construction	$1,075,727,503	4,286	2.4	123	$30	$477,459	$66
Rehab/Renovation	$6,794,793,977						
Overall Total	$7,870,521,480						
OUTER RESIDENTIAL							
BASELINE							
New Construction	$2,792,161,692	11,772	11.2	588			
Rehab/Renovation	$5,175,265,435						
Overall Total	$7,967,427,127						
NEW TREE REPLACEMENT REQUIREMENTS							
New Construction	$2,786,675,315	11,750	11.2	587	$12,943	$2,166,422	$43,526
Rehab/Renovation	$5,175,738,144						
Overall Total	$7,962,413,460						

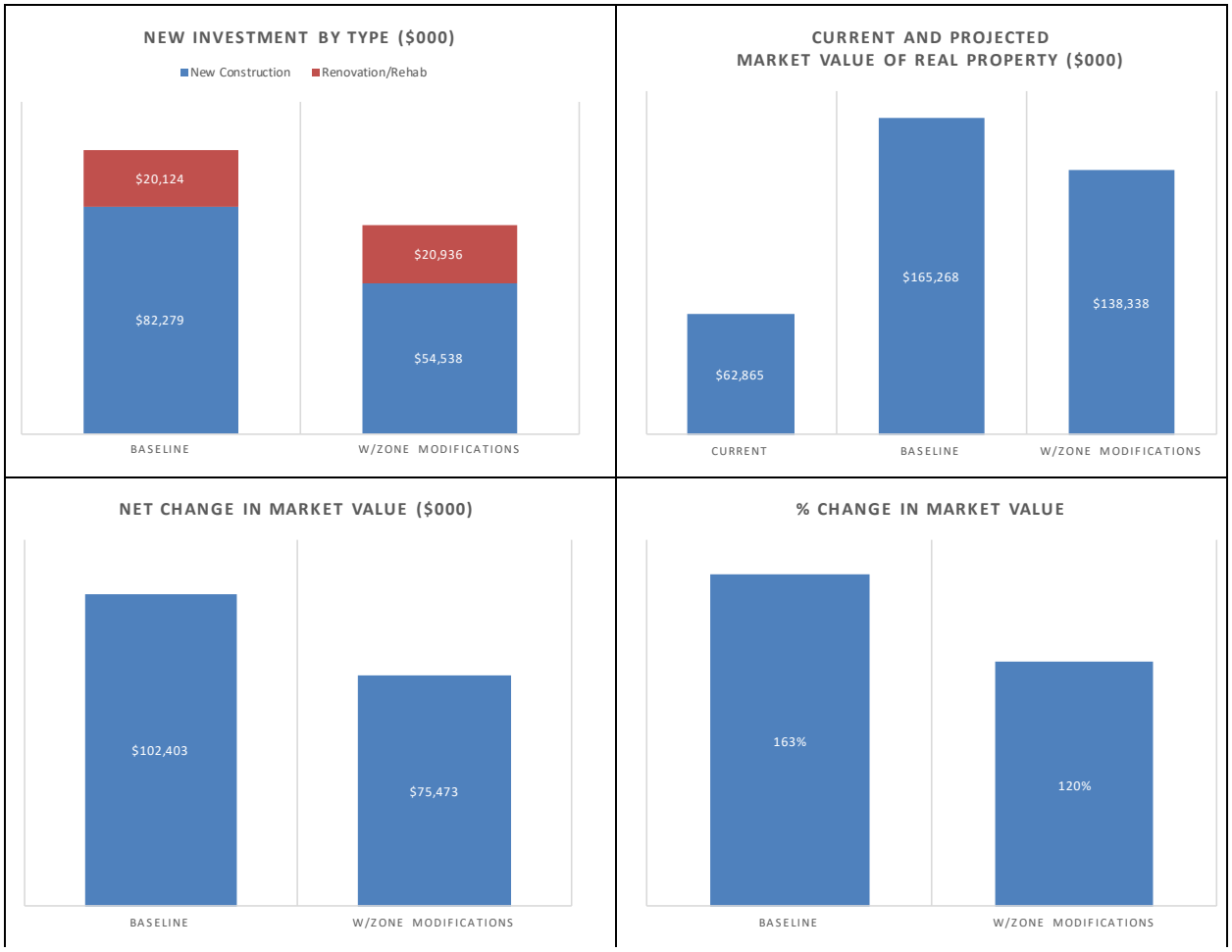
COLUMBIA EAST
SUMMARY OF MODEL OUTPUT
MAGNITUDE OF INVESTMENT AND RESIDUAL PROPERTY VALUES



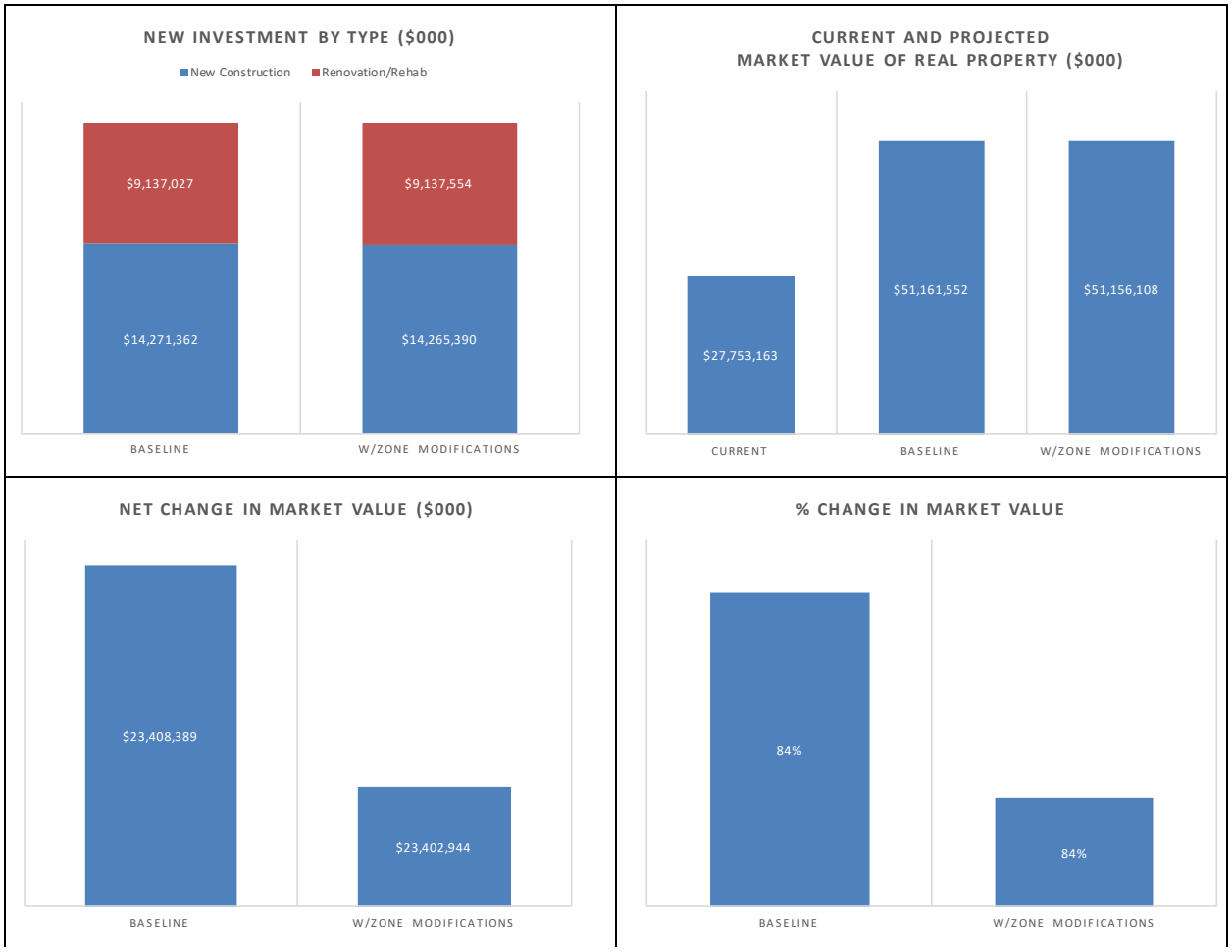
HARBOR - AIRPORT
SUMMARY OF MODEL OUTPUT
MAGNITUDE OF INVESTMENT AND RESIDUAL PROPERTY VALUES



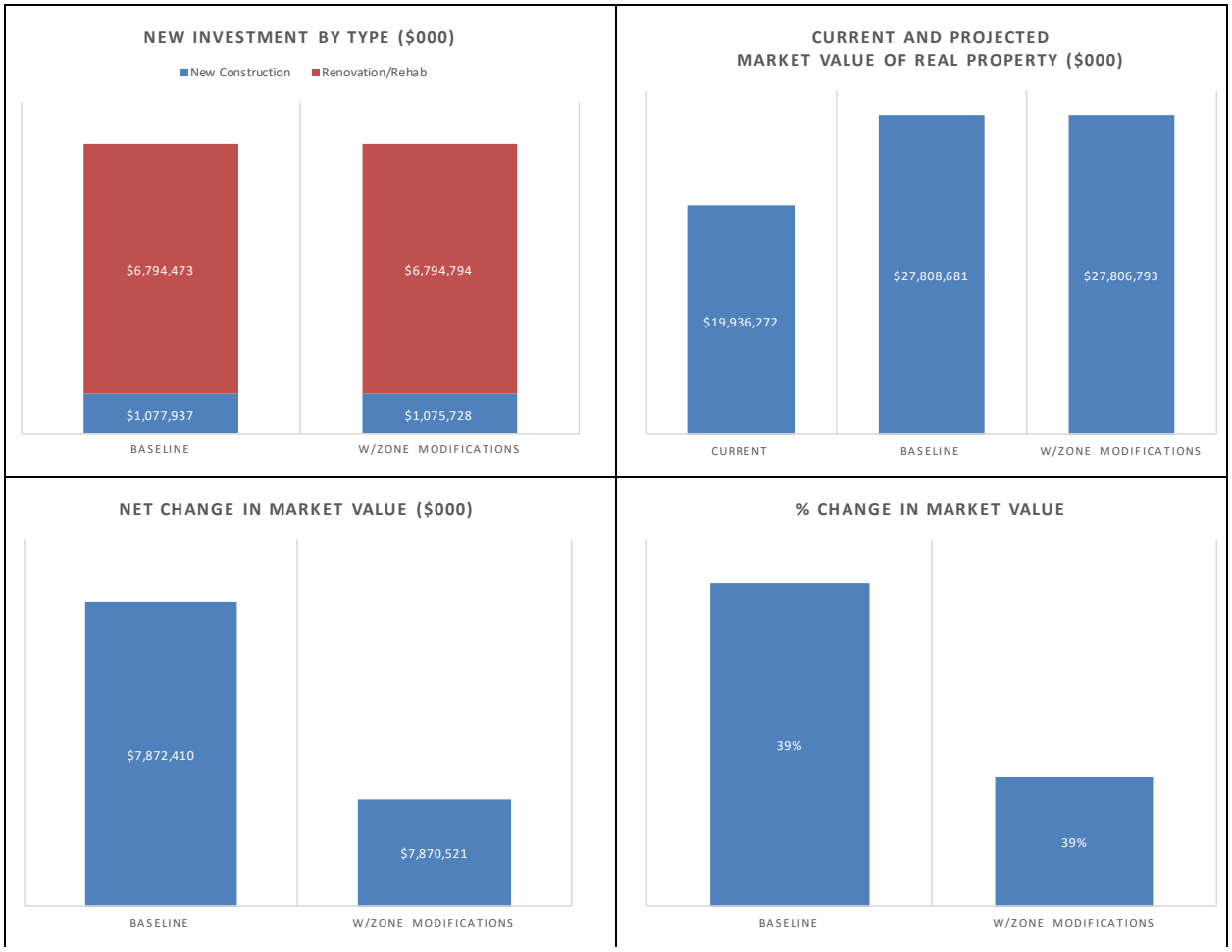
HARBOR ACCESS LANDS
SUMMARY OF MODEL OUTPUT
MAGNITUDE OF INVESTMENT AND RESIDUAL PROPERTY VALUES



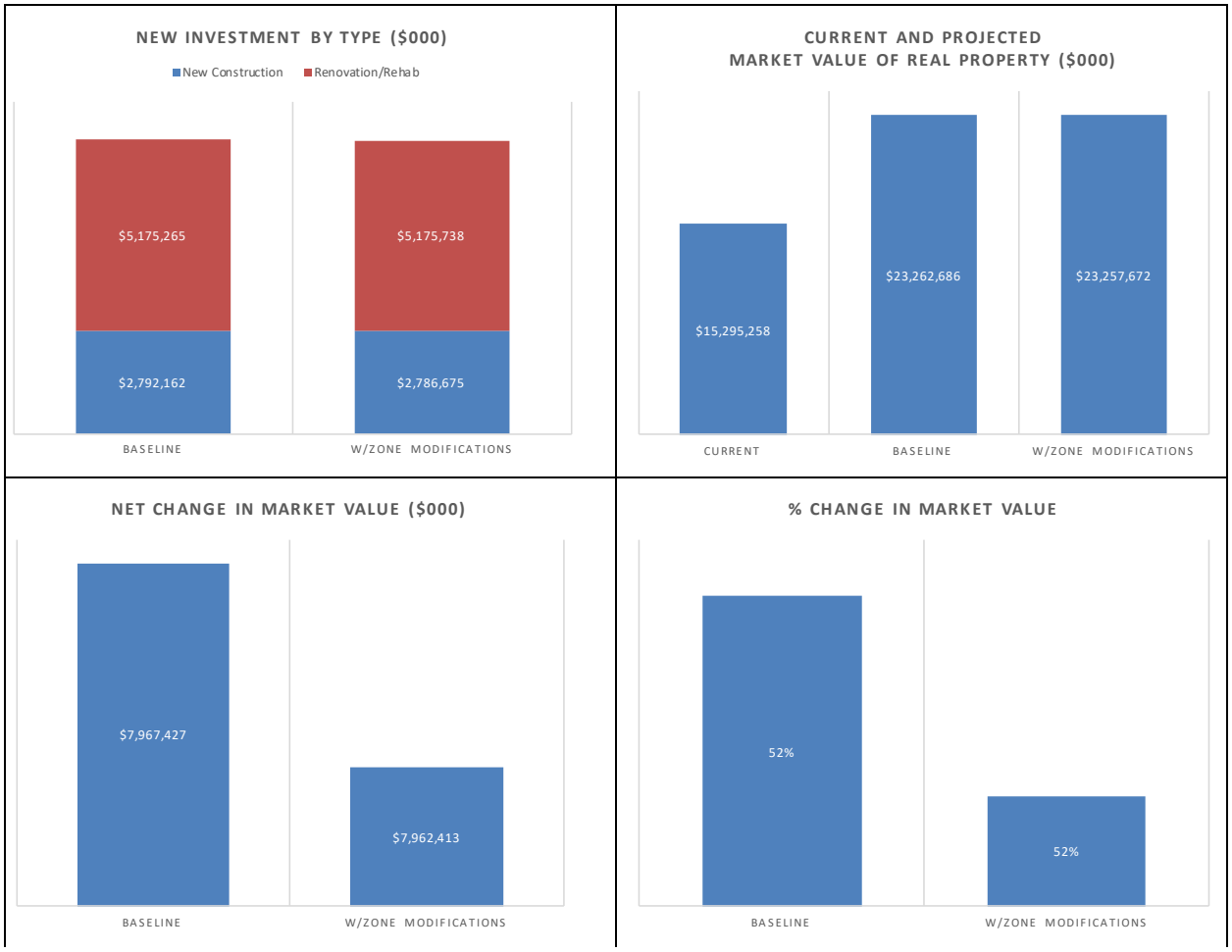
INNER RESIDENTIAL
SUMMARY OF MODEL OUTPUT
MAGNITUDE OF INVESTMENT AND RESIDUAL PROPERTY VALUES



MID-RESIDENTIAL
SUMMARY OF MODEL OUTPUT
MAGNITUDE OF INVESTMENT AND RESIDUAL PROPERTY VALUES



OUTER RESIDENTIAL
SUMMARY OF MODEL OUTPUT
MAGNITUDE OF INVESTMENT AND RESIDUAL PROPERTY VALUES



SUMMARY OF PREDICTED DEVELOPMENT ACTIVITY OVER STUDY PERIOD
WITH PROPOSED MODIFICATIONS IN TREE ORDINANCE - IH ZONED PROPERTY
20 Year Study Period , No Pricing Changes

LINE	Predicted Development Yield Construction Investment	Employment Acreage	Employment Capacity
HARBOR - AIRPORT			
BASELINE			
New Construction	$70,024,954	40.5	1,276
Rehab/Renovation	$27,176,003		
Overall Total	$97,200,957		
PROPOSED CODE CHANGES			
New Construction	$56,505,364	32.7	926
Rehab/Renovation	$27,868,765		
Overall Total	$84,374,129		
HARBOR ACCESS LANDS			
BASELINE			
New Construction	$78,697,976	45.6	1,433
Rehab/Renovation	$19,006,167		
Overall Total	$97,704,143		
PROPOSED CODE CHANGES			
New Construction	$51,891,688	30.0	945
Rehab/Renovation	$19,809,334		
Overall Total	$71,701,022		

SUMMARY OF PREDICTED DEVELOPMENT ACTIVITY OVER STUDY PERIOD
WITH PROPOSED MODIFICATIONS IN TREE ORDINANCE - IG1 ZONED PROPERTY
20 Year Study Period , No Pricing Changes

LINE	Predicted Development Yield			
	Construction Investment	Residential Units	Employment Acreage	Employment Capacity
HARBOR - AIRPORT				
BASELINE				
New Construction	$45,344	0	0.0	1
Rehab/Renovation	$6,311,734			
Overall Total	$6,357,078			
PROPOSED CODE CHANGES				
New Construction	$45,344	0	0.0	1
Rehab/Renovation	$6,311,734			
Overall Total	$6,357,078			
HARBOR ACCESS LANDS				
BASELINE				
New Construction	$0	0	0.0	0
Rehab/Renovation	$0			
Overall Total	$0			
PROPOSED CODE CHANGES				
New Construction	$0	0	0.0	0
Rehab/Renovation	$0			
Overall Total	$0			
CENTRAL CITY				
BASELINE				
New Construction	$44,448,669	0	1.8	632
Rehab/Renovation	$5,854,593			
Overall Total	$50,303,262			
PROPOSED CODE CHANGES				
New Construction	$44,442,282	0	1.8	632
Rehab/Renovation	$5,854,838			
Overall Total	$50,297,120			
NON-CENTRAL				
BASELINE				
New Construction	$386,866	0	0.2	7
Rehab/Renovation	$7,080,451			
Overall Total	$7,467,318			
PROPOSED CODE CHANGES				
New Construction	$386,699	0	0.2	7
Rehab/Renovation	$7,080,458			
Overall Total	$7,467,156			