Environmental Quality Commission

REGULAR MEETING MINUTES

Date: 9/18/2019
Time: 6:00 p.m.
City Hall – "Downtown" Conference Room
701 Laurel St., Menlo Park, CA 94025

Environmental Quality Commissioner Deb Martin participated by phone from:
350 Rocky Run Pkwy
Wilmington, DE 19803

A. Call To Order

Chair Price called the meeting to order at 6:06 p.m.

B. Roll Call

Present: Gaillard, Kabat, Martin, Payne, Price, Turley
Absent: London
Staff: Sustainability Specialist Joanna Chen and Sustainability Manager Rebecca Lucky

C. Public Comment

- Betsy Nash spoke in support of the reach code options.
- Alexander Van Dyh expressed concerns about the noise generated by gas powered leaf blowers and requested information regarding the ordinance appeal process.

D. Regular Business

D1. Recommend proposed changes to the heritage tree ordinance to the City Council

Sustainability Manager Rebecca Lucky made a presentation (Attachment).

- Catherine Martineau spoke in support of the ordinance but expressed concern on the need to have a community dialogue around the appropriateness of redwood trees in an urban canopy, the tree disparity across Menlo Park and advocated that the next step for the city is to develop an urban forest master plan.
- Peter Edmonds expressed concerns about the city arborist's responsibilities, staff report 19-011-EQC, Planning Commission draft minutes from August 12, 2019 and tree valuations (Attachment).
- Scott Marshall spoke in support of the ordinance and provided suggestions to bring awareness to the public about the updated ordinance.

ACTION: Motion and second (Gaillard/Turley) to recommend proposed changes to the heritage tree ordinance to the City Council, with the following additions, passed (6-0-1, London absent):

- Ordinance:

    - For tree removals related to development, final occupancy shall not be granted until evidence or inspection of replacement tree(s) has been completed.
- Administrative guidelines:
    - For a permit or an appeal, the permit applicant may be required to pay for additional costs to process the permit/appeal that can include, but is not limited to:
        - Third party peer review of alternatives
        - Third party analysis of further alternatives
    - If an appeal is filed, the schematic design alternatives originally submitted may require additional and complete analysis that will be paid for by the permit applicant.
    - The city reserves the right to hire a third party review of alternatives that will be paid for by the permit applicant.
    - Include a public review/approval of changes to the administrative guidelines, such as an appointed body or City Council.
- Implementation ideas:
    - Include “heritage tree city” on real estate signs to signal to potential buyers that the City has tree values and protections.
    - Open access to when heritage tree permits/appeals are filed on the website.
- General:
    - The Environmental Quality Commission recognizes that the heritage tree ordinance is only one tool for protecting and growing the urban forest, and that there are many other tools and policies that could further enhance the urban canopy. The Commissioners recommend that the City Council consider developing an urban forest master plan after adopting updates to the heritage tree ordinance. In particular, the urban forest master plan can start by focusing on collecting current canopy coverage information for the entire city, address community values around redwood trees and their changing future in this geographic area, address canopy inequities across the community, and understand the impacts of other city policies on the urban forest.

The Environmental Quality Commission took a recess at 8:00 p.m.

The Environmental Quality Commission reconvened at 8:08 p.m.

D2. Review and discuss subcommittee’s climate action plan situation analysis and request for input memorandum

Commissioner Gaillard, Kabat and Payne made a presentation (Attachment).

- Lynne Bramlett expressed support and interest in the climate action plan situation analysis and provided resources to help update the climate action plan (Attachment).

Item D2 continued to October 16.

D3. Discuss the Environmental Quality Commission’s quarterly report to the City Council

Chair Ryann Price made a presentation (Attachment).

ACTION: Motion and second (Gaillard/Kabat) to approve the Environmental Quality Commission’s quarterly report to City Council, passed (6-0-1, London absent).

D4. Approve the September 18, 2019 Environmental Quality Commission meetings minutes

Vice Chair James Payne introduced the item.

ACTION: Motion and second (Gaillard/Turley) to approve September 18, 2019 Environmental Quality Commission meetings minutes, passed (5-1-1, Martin abstained, London absent).

E. Reports and Announcements

E1. Commission reports and announcements

E2. Staff update and announcements

Sustainability Specialist Joanna Chen announced the cancellation of the November and December Environmental Quality Commission meetings and tentatively scheduled a special meeting on December 11.

E3. Future agenda items

None.

F. Adjournment

Chair Price adjourned the meeting at 9:25 p.m.

Joanna Chen, Sustainability Specialist

These minutes were approved at the Environmental Quality Commission meeting of October 16, 2019.

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HERITAGE TREE ORDINANCE UPDATE

Rebecca Lucky, Sustainability Manager

August 12, 2019

THE TEAM AND COMMUNITY

Staff:

- Candise Almendral, Sustainability Project Contractor
- Christian Bonner, City Arborist
- Thomas Rogers, Principal Planner
- Rebecca Lucky, Sustainability Manager
- Cara Silver, Assistant City Attorney
- Darya Barar, HortScience | Bartlett Consulting
- Debbie Schechter, Peninsula Conflict Resolution Center

City Council Appointed Task Force Members:

- Drew Combs (Chair)
- Sally Cole (Vice Chair)
- Jen Judas
- Kimberly LeMieux
- Tom LeMieux
- Scott Marshall (former EQC member)
- Catherine Martineau (Executive Director Canopy)
- Carolyn Ordonez
- Horace Nash
- Sally Sammut Johnson

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BACKGROUND

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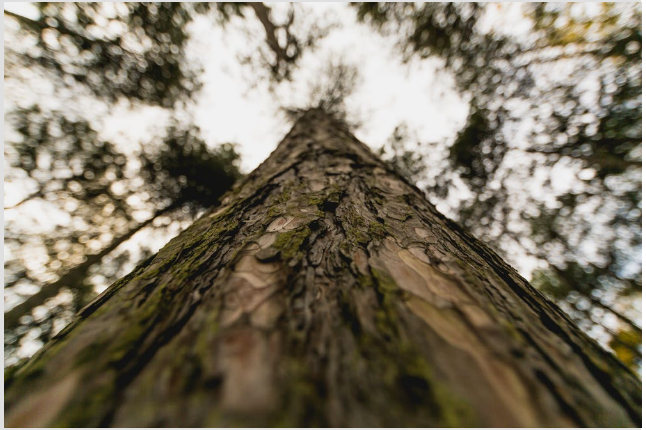
HERITAGE TREE ORDINANCE BACKGROUND

- Purpose of the Heritage Tree Ordinance is to preserve trees by regulating their removal on private property
  - Implemented by requiring a permit to allow pruning or removal of trees of a certain size
  - City Arborists uses specific decision making criteria to determine if removal is necessary
  - Allows for appeals of the City Arborist decision
  - Includes penalties for violations of the ordinance



- Adopted in 1979 and has been revised five times with the latest in 2006

WHY AN UPDATE?

- Over the last several years concerns have been raised regarding development related appeals, unpermitted removals, and inadequate code enforcement

- Environmental Quality Commission provided recommendations to the City Council in 2012

- City Council Work Plan item in 2017, 2018, 2019 (priority No.4)

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TASK FORCE PURPOSE AND EXPERIENCE

- Appointed by City Council in August 2018
- 10 open public meetings from August 2018 to June 2019
- Collaborative community engagement process
- Group agreed to make final recommendations to City Council through a super majority vote (2/3)
- Group diversity = finding middle ground solutions
- Delivered 16 recommendations on time to the City Council

CITY COUNCIL OBJECTIVES

- Desired outcome is to ensure a significant and thriving population of large healthy trees in Menlo Park for public enjoyment and environmental sustainability while balancing property rights/values and implementation efficiency

- Explore options based on evidence and best practices from other communities

POLICY ANALYSIS

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POLICY ANALYSIS PROCESS

- Phase I (August 2018 to February 2019)
  - Collected permit data and surveyed past permit applicants and appellants
    - Major finding: decision making criteria are ambiguous and lack clarity leading to higher instances of conflict between applicants, appellants, and city staff
  - Collected best practice from other communities
  - Identified high level options to explore

POLICY ANALYSIS PROCESS CONTINUED

- Phase II (December 2018 to April 2019)
  - Deeper analysis of identified options
  - Interviewed communities practicing proposed options
  - Evaluated benefits, risks, implementation logistics, savings or costs to applicants, appellants, and the City

- Selecting criteria for determining preferred options
  - Increase clarity (20%)
  - Increase or maintain tree canopy (60%)
  - Improve effectiveness (20%)

RESULTS

- Heritage Tree Ordinance Update Policy Analysis Report
  - 26 options were explored in depth in Phase II
  - 16 emerged as preferred options
- Intent and Purpose drafted by the Heritage Tree Task Force
- Definition of Heritage tree
  - Changes to how multi-stem trees are evaluated

RESULTS: DECISION MAKING CRITERIA

- Provides greater clarity regarding what factors the City Arborist will consider when making a decision for tree removal
- Uses industry standards to define thresholds for removal
- Allows for collecting evidence or alternative tree removals related to development

RESULTS: APPEALS

- Limits ability to appeal when tree risk rating is determined to be moderate or high and there is no feasible option to lower the risk
- Specific standards related to filing appeals for increased efficiency
- Offering conflict/mediation for community member appeals before a formal appeal is processed
- Change the appeal process for tree removal related to Planning Commission project approvals
- Maintain the status quo of the EQC, and add language that allows flexibility to designate another City Council body

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RESULTS CONTINUED

- Mitigation and tree replacements
  - Development related removals
    - Require replacement to be equal to the value of the tree(s) being removed
  - Non-development related removals
    - Replacement matrix

- Expanding use of the Tree Fund
  - Direct violations or other heritage tree related fees to an existing tree fund to plant more trees or assist in implementation of the Heritage Tree Ordinance

RESULTS CONTINUED

- Enforcement of Replacement Trees
  - Two inspections required: one to confirm tree is replaced and another two years later to confirm that tree is thriving

- Violations
  - Increase violations to $10,000
  - Assess punitive or administrative penalties
  - Remove building moratorium penalty

- Notification Requirements
  - Apply existing public noticing requirements required for community development
  - Open access to all heritage tree removal applications, permits, and appeals

COSTS IF UPDATES ARE APPROVED

- $185,000 to $200,000 annually to implement the changes
- Inspection of replacement trees is resource intensive
- Recovered through increasing permit fees and a portion of the proposed tree mitigation requirements
- General Fund may be needed to supplement shortfalls

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COMMUNITY ENGAGEMENT

- 10 public meetings have been held with the Task Force
- Task Force engaged, informed and received feedback from their neighbors or community member to help inform their decisions
- Public comments were received
- Surveyed past permit applicants and appellants

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NEXT STEPS

- Draft ordinance for public review by September 12
- Bring forward to the Planning and Environmental Quality Commission
- Two additional meetings of the Task Force in September and October
- Return to City Council in October for updated ordinance adoption
  - Prepare to include additional costs and cost recovery measures in FY 20-21 budget
  - An implementation and education plan would be developed with an effective date of July 1, 2020.

PLANNING COMMISSION ACTION

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RECOMMENDATION

- Recommend the above proposed recommendations by staff and the Task Force to the City Council.
  - Based on the policy analysis and Task Force findings, the proposed recommendations will increase clarity of the ordinance, increase/maintain the urban forest canopy, and increase the effectiveness of the ordinance.

- Provide additional feedback to the City Council that may be considered before final changes are adopted in October.
  - This may require additional analysis and budget to examine the impacts to City operations and permit applicants for more informed decision making.

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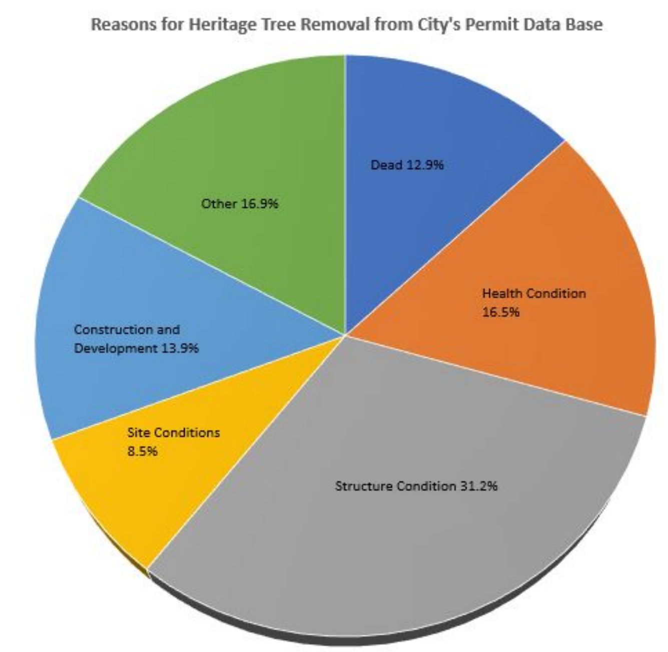
THANK YOU

TREE REMOVAL DATA

- Over the last nine years, the City has processed 6,673 heritage tree removal permits, and 1.3% of these permits have been denied, meaning the tree was not allowed to be removed on the property. The pie chart below provides a breakdown on the decision making criteria used for approving a heritage tree removal by the City.



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Tree compensation rates: Compensating for the loss of future tree values

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ABSTRACT

When healthy trees are removed, common methods of compensation are either monetary or replanting new trees. Accurate monetary compensation for large healthy trees is difficult to ascertain and often uses formulas based on tree attributes such as species, size, location and condition. Compensation based on leaf area is more direct as most tree values are related to healthy leaf area. Using leaf area, a tree compensation rate can be determined (how many new trees are needed to compensate for the removal of a healthy tree). However, compensation also needs to consider the future benefits provided by both the removed tree and newly planted trees. This paper provides a new method of tree compensation based on comparing the net present value of leaf area between a removed tree and planted replacement trees. This proposed method is not intended to replace existing methods, but rather facilitate discussion and science to improve estimating tree values and compensation. Using this new approach with a three-percent discount rate and a four- percent annual mortality rate, maximum compensation rates using comparable trees reached 13.7 trees for large trees and 3.3 trees for small trees. An overall maximum compensation of 41.1 trees was reached when large trees with a one-percent mortality rate were replaced with small trees with a four-percent mortality rate. Compensation rates vary with tree size, estimated life span remaining (mortality rate), discount rates, and type of replacement tree used (large vs. small trees). Compensation for tree loss can either be through planting of replacement trees or the conversion of replacement trees to a monetary value based on local planting costs.

1. Introduction

When a healthy tree is removed without permit or permission, one common question is: how should the tree owner or manager be compensated for the loss? Replacement costs are a direct means of compensation, but work best for small trees that can directly be replaced with the same size and species. For larger trees, formulas are often used to estimate replacement cost. Various formula methods exist, including: a) Council of Tree and Landscape Appraisers (CTLA) (CTLA, 2000), b) Standard Tree Evaluation Method (STEM) (Flook, 1996), c) Helliwell (2000), d) Norma Granada (Asociacion Española de Parques y Jardines Publicos, 1999), e) Burnley (Moore, 1991) and f) CAVAT (Doick et al., 2018).

These methods all use a measure of tree size (e.g., dbh or crown volume), condition and location to determine a tree value. Some methods (Helliwell and STEM) use a point system that is multiplied by a cost per point. The other methods use a cost per size (e.g., $/in^2 of dbh) with discounts (0–1 multipliers) for items such as life span, condition and location. With the Norma Granada method, some multipliers, such as condition, life expectancy and aesthetic value can increase the base value. Some methods, such as STEM, have specific criteria for tree functions such as pollution removal and temperature modification. While these approaches are conceptually similar, they can lead to vastly different estimates of compensation. In a study by Watson (2002), the average compensation among these approaches (excluding CAVAT) varied from $7,322 (Helliwell), $8,367 (CTLA), $45,624 (STEM), $57,343 (Burnley) to $77,971 (Norma Granada) for assessing the same trees (a 10.6 fold difference from lowest to highest). These valuation procedures provide a means to estimate the value of the trees based on its physical structure, but many procedures do not provide a means to estimate the value provided by tree functions (e.g., pollution removal, temperature modification, reduced building energy use, etc.) or the loss of future benefits.

Structural value is based on the physical dimensions of the asset (e.g., timber value), while the functional value is an annual value based on the functions of the particular structure. To understand the difference between structural and functional values consider a factory (with a replacement cost of $1 million) that produces 10,000 widgets per year with a net profit of $100,000/year. The value of the physical structure of the factory is based on the cost to rebuild or replace the factory with

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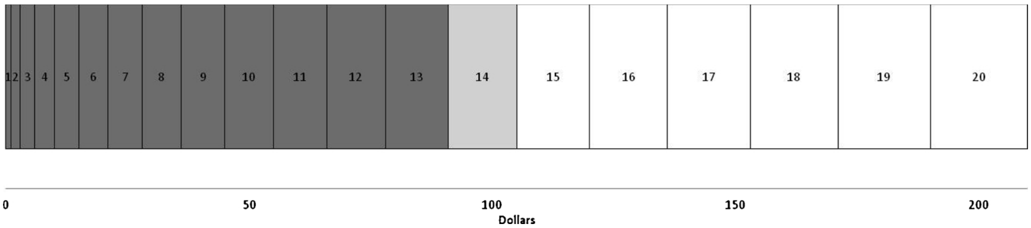

Fig. 1. Annual payments of \$1 in year one, \$2 in year two, \$3 in year three and so forth for 20 years. Dark gray area is amount paid through 13 years; light gray area is amount paid in year 14 (current year); white areas indicate future payments.

a similar structure. The factory also has an additional value based on the potential or actual profits or losses of the factory outputs. The value of the factory structure (\$1 million) is comparable to the structural value of the tree. The net profit (\$100,000/year) is analogous to the functional value of the tree (Nowak et al., 2002a). Trees can have negative functional values (similar to monetary losses in factories) when the wrong tree is put in the wrong site (e.g., trees can increase annual building energy use in certain locations, tree pollen can create allergic reactions) (e.g., Heisler, 1986; Cariñanosa et al., 2014).

Annual functional values are critical for determining adequate tree compensation, as these functions (e.g., air temperature cooling, pollution removal) produce benefits that improve human health and well-being. The combination of multiple positive and negative functions (Dwyer et al., 1992; Nowak and Dwyer, 2007) provides a net annual functional value for a tree. The difficulty in ascribing an annual functional value to trees derives from limited quantification of these multiple benefits. As most of the functional benefits cannot be quantified and the ones that can be quantified often use estimated values (e.g., social costs, externality values, health care costs) to ascribe a monetary value, the means to determine the true monetary value of compensation is lacking or limited at best. If functional values cannot be adequately quantified and structural values are estimated in monetary terms based on formulas and replacement values, how can compensation for tree loss be ascribed that includes both structural and functional values of trees?

A solution to this problem lies in not trying to convert these values to monetary units, but in keeping the values in units that are directly related to the tree itself. The attribute that is most dominant in determining both the structural and functional value of trees is total leaf area (i.e., healthy canopy size). Large healthy trees provide abundant leaf area that remove air pollution, sequester carbon, intercept water, shade surfaces, cool the air, absorb ultraviolet radiation, provide food for wildlife, provide aesthetics and deliver multiple other benefits or costs to society (Nowak and Dwyer, 2007). In addition, large healthy trees also have the highest structural value due to their tree size, which is maintained through increased leaf area. As the value of the tree is most directly related to leaf surface area, then leaf area can be used to compensate for tree loss by directly compensating owners, not in monetary terms, but in terms of leaf area. That is, the number of small healthy trees can be calculated to provide a replacement for a large healthy tree by estimating compensation in terms of similar leaf area.

However, even if leaf area is used as a means of compensation, time must be considered in determining compensation rates. For example, if a large tree has 1500 m^2 of leaf area and a replacement tree has 30 m^2 leaf area, a compensation rate that does not consider time would be 50 replacement trees (1500/30). However, both the removed and replacement trees will live into the future, providing future benefits and values. The larger tree would likely have a shorter life span left, but more leaf area at the start relative to the smaller replacement trees; the replacement trees have a greater potential for future services as they grow through time. The replacement ratio of 50 trees would likely over compensate for the one removed tree due to the future potential of the smaller replacement trees. Thus, compensation based on leaf area should not only consider the amount of leaves from the removed tree and the replacement trees, but also tree growth (changes in leaf area through time), expected life span of the trees and the net present value of the future leaf area.

Existing estimates of compensation based on current tree diameter (tree size) are less appropriate as it compensates for past benefits already received or at best only current annual benefits. As trees age, they accumulate biomass, which increases tree diameter and leaf area (Nowak, 1994). Thus the biomass accumulated through time is an indication of the amount of past leaves and benefits received from the tree through its life to date. It is also an indication of current benefits, assuming that the tree is healthy, but it does not necessarily account for future benefits. For example, consider a person who promises to pay you \$1 in year 1, \$2 in year 2, \$3 in year 3, and so forth for 20 years. At the end of 20 years, you would have received \$210. If after 13 years the payments stop, you would have received \$91, but would have lost current and future payments of \$119. In Fig. 1, the dark gray areas of past payments are comparable to past benefits received by a tree (illustrated through cumulative tree growth to date). The light gray area in year 14 is comparable to current tree leaf area, which will increase tree diameter in year 14. The white areas indicate potential future leaf area and tree services. If a tree is removed in year 14, tree compensation should be based on current and future leaf area (light gray and white areas), not based on past growth as displayed by the tree diameter (dark gray areas), as these services have already been rendered (society has already received those benefits). Compensation based directly on tree diameter or crown size is compensating either for past services received (dark gray areas) or current services (light gray area).

What is critical in compensation is not what has been received in the past, but rather what will be received in the current and future years from the trees (light gray and white areas in Fig. 1). However, to compensate for lost future benefits, a reasonable remaining life span for a tree needs to be estimated for both the removed tree and the replacement trees. If a large tree only had one year remaining in its life, its compensation rate would be much lower than for a tree that has an estimated 50 years remaining. Likewise, compensation is reduced for replacement trees that have a long-life span vs. replacement trees that will have a short-life span.

The purpose of this paper is to determine compensation rates for the loss of healthy trees in terms of the number of replacement trees. This new approach is not intended to be a replacement to existing methods, but rather to provide a new means of quantifying compensatory value using lost future values. It is hoped that this new conceptual approach could be integrated within existing methods to improve tree valuation. This analysis uses varying tree sizes, mortality rates and discount rates to estimate the average number of replacement trees needed to compensate for the loss of healthy trees of varying size. The impact of tree size, life span and discounting rate are discussed, as is the conversion of replacement trees to monetary value.

2. Methods

The basis for compensation is the number of trees needed to provide the same amount of healthy leaf surface area of the removed tree, given that both removed and newly planted trees are expected to have healthy leaf area into the future. The compensation considers the discounted value of future leaf area as well as probabilities of future tree loss. The compensation rate is the number of newly planted trees needed to equal the net present value of leaf area for the removed tree.

To calculate this rate, the net present value (NPV) of leaf area of the newly planted trees and removed trees need to be calculated.

To determine the NPV of leaf area for a tree, four factors need to be considered: 1) leaf area, 2) life span, 3) growth rates, and 4) discount rate for future services. For this analysis, two types of tree sizes were assessed: 1) a large tree (represented by a London planetree; *Platanus × hispanica* Mill. ex Münchh.) and 2) a small tree (represented by crapemyrtle; *Lagerstroemia indica* L.).

2.1. Estimating annual leaf area

Leaf area of these trees was estimated based on leaf area formulas derived from tree crown parameters (Nowak, 1996; Nowak et al., 2008). The formula for estimating the leaf area of a tree was:

$$\ln Y = -4.3309 + 0.2942H + 0.7312D + 5.7217S + -0.0148C$$

where Y is leaf area (m^2), H is crown height (m), D is average crown diameter (m), S is the average shading factor for the individual species (percent light intensity intercepted by foliated tree crowns) and C is based on the outer surface area of the tree crown ($\pi D(H + D)/2$). To correct for logarithmic bias in the regression equations, a correction factor of one-half of the estimated variance was added to the untransformed value ($y = e^{x + var(x)/2}$) (Nowak, 1996).

An average shading coefficient (0.83) was used for both species as this modeling exercise was not trying to estimate the leaf area of a London planetree or crapemyrtle specifically, but rather an average for a large or small tree that used the crown dimensions of the planetree or crapemyrtle.

To estimate how leaf area changes with changing tree diameter at breast height (dbh – diameter at 1.37 m) or age, the relationship between crown dimensions and dbh needs to be estimated. To estimate crown height and crown width for these two species, allometric equations were developed from tree measurements from several U.S. cities. The equations used to estimate crown height were:

$$\text{Crown height (planetree, ft)} = e^{(1.6125 + (\ln(dbh) * 0.6897))}$$

$$\text{Crown height (crapemyrtle, ft): ht} = 4.8082 + (dbh * 1.6692)$$

The equations used to estimate crown width were:

$$\text{Crown width (planetree, ft)} = 3.9088 + 2.6747*dbh - 0.0329*dbh^2$$

$$\text{Crown width (crapemyrtle, ft)} = e^{(1.9526 + (\ln(dbh) * 0.3644))}$$

where dbh is in inches. As trees increased in dbh annually, crown dimensions and leaf area would increase based on these formulas. From the leaf area equation, an average leaf area index (LAI: ft^2 leaves (one-sided) /ft^2 projected crown ground area) was calculated based on the crown height to crown width ratio (Table 1). This LAI was multiplied by the estimated ground projected crown area (Πr^2 of crown) to calculate total leaf area.

2.2. Estimating life span

To estimate the life span remaining for the removed and replanted trees, a population projection model was used (Nowak et al., 2004). Four average annual mortality rates were modeled: 1, 2, 3, and 4 percent. For each of these projections, the annual mortality rates were varied by diameter class (Nowak, 1994), such that the average mortality rate for an urban forest population would equal the desired mortality rates (Table 2). That is, given an average dbh distribution, the mortality rate for each dbh class was adjusted so that the total mortality rate for the population was either 1, 2, 3, or 4 percent. The average dbh distribution for urban forests (Fig. 2) was based on field samples from 32 U.S. urban areas (cities or states). Mortality rates varied between dbh classes with higher mortality rates when small (young) and large (old).

Table 1
Estimated leaf area index based on crown height to width ratio and shading coefficient of 0.83 (Nowak, 1996).

Height to width ratio	LAI
2.0	7.6
1.9	7.1
1.8	6.6
1.7	6.1
1.6	5.7
1.5	5.3
1.4	4.9
1.3	4.5
1.2	4.1
1.1	3.8
1.0	3.5
0.9	3.2
0.8	3.0
0.7	2.8
0.6	2.7
0.5	2.6

Table 2
Annual mortality rates by dbh class for various life span classes.

	Average annual mortality			
dbh class (in/cm)	1 percent	2 percent	3 percent	4 percent
< 3 / < 7.62	1.2	2.3	3.5	4.7
3.01-6 / 7.63-15.24	0.9	1.8	2.7	3.5
6.01-12 / 15.25-30.48	0.8	1.7	2.5	3.4
12.01-18 / 30.49-45.72	0.8	1.7	2.5	3.4
18.01-24 / 45.73-60.96	1.2	2.3	3.5	4.7
24.01-30 / 60.97-76.2	1.2	2.4	3.6	4.8
> 30 / > 76.2	2.2	4.4	6.5	8.7

Using the population projection model, the average life span remaining for trees, based on current dbh, were modeled based on the input mortality rates by dbh class. Thus as trees grow through time, the probability of mortality would change. Based on the given mortality rates, the model will predict that no trees will remain after a certain dbh. However, in reality, if a large tree exists and is healthy, the probability of mortality in the next year would not be 100%. To limit the effect of an over-prediction of mortality for large trees, all healthy trees that are to be removed were given a minimum length of life span remaining based on mortality class. For 1 percent mortality, the minimum remaining life span for healthy trees was set to 20 years; for 2 percent mortality: 10 years; for 3 percent mortality: 8 years and for 4 percent mortality: 5 years. Based on the mortality rates (Table 2) and a 0.2 inch (0.51 cm) dbh annual growth rate, average annual life span can be estimated for each one-inch (2.54 cm) dbh class by projecting a large population through time using these rates (Fig. 3). Given a remaining life span in years, the annual projected leaf area values can be used to estimate the net present value of leaf area.

2.3. Tree growth rates

To estimate how leaf area will change through time as a tree grows, an annual trunk diameter growth rate of 0.2 in. per year (0.51 cm/yr) was used. This growth rate was selected to represent an average growth rate as temperate tree growth rates (153 day growing season) typically range between 0.15 in. / year (0.38 cm/yr) for forest-grown trees to 0.34 in. / year (0.86 cm/yr) for open-grown trees (Nowak, 1994; Nowak et al., 2002b). To estimate annual leaf area, tree dbh was increased annually by the growth rate and leaf area estimated for each year's tree dbh measurement. As a tree approached its estimated life span, annual growth rates were reduced. After the tree reached 75% of

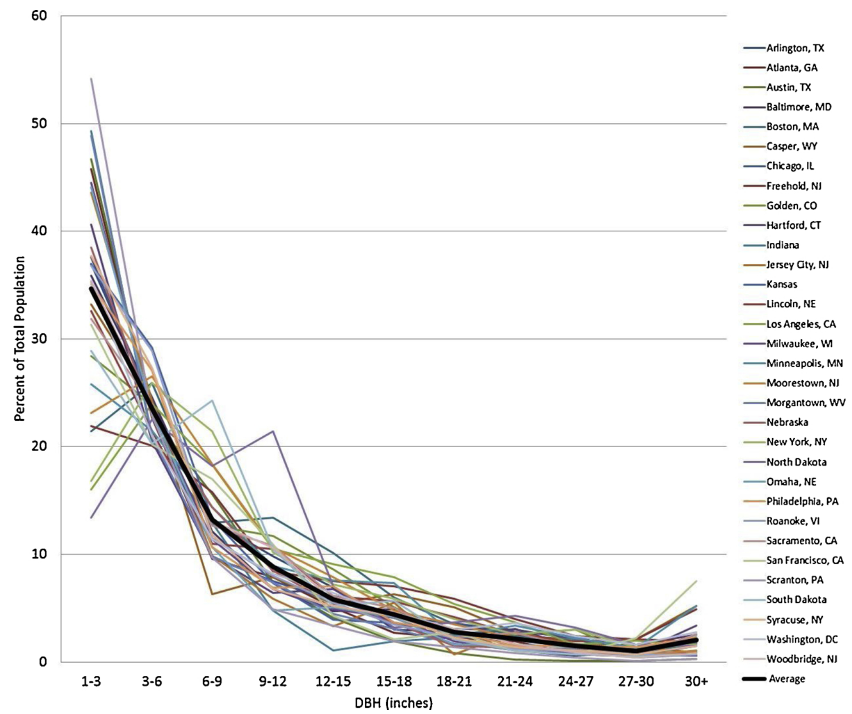

Fig. 2. Average diameter class distribution based on the diameter class distribution from 32 cities or urban areas in U.S. states.

its estimated life span, tree growth was reduced proportionally between 75% and 100%, such that at 75% of estimated life span tree growth was 0.2 in. per year (0.51 cm/yr) and at 100% of estimated life span tree growth rate was reduced to 0 in. per year. In addition, for the small tree, crown and leaf area growth was capped at a maximum dbh of 10 in. (25.4 cm), for the large tree it was capped at 45 in. (114.3 cm) dbh, such that crowns and leaf area did not change after that size, but remained steady.

2.4. Determining net present value of leaf area

The net present value of leaf area (NPV) was calculated as:

$$NPV = \sum_{i=1}^{n} LA_i/(1 + rate)^i$$

Where i = year beyond present year (present year = 1), n = number of future years, LA_i = leaf area in year i and rate = discount rate. To illustrate the impact of varying discount rates on NPV, three discount rates were used: 2, 3 and 4 percent.

2.5. Calculating compensation rates

The compensation rate (i.e., the number of one-inch (2.54 cm) dbh replacement trees needed to compensate for the loss of a healthy tree) was calculated as NPV_r / NPV_p, where NPV_r is the net present value of

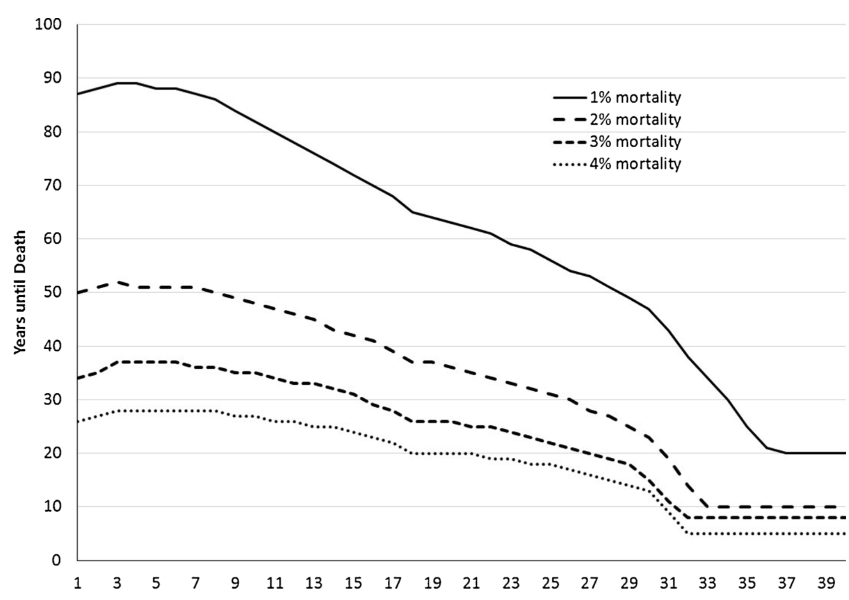

Fig. 3. Average life span remaining based on tree size among differing mortality rates based on a dbh growth rate of 0.2 in. per year (0.51 cm/yr). Remaining life span stabilizes after 30 in. (76.2 cm) dbh as healthy large trees are assumed to live a minimum number of years based on mortality rate.

leaf area of removed tree and NPV_p is the net present value of leaf area of a planted replacement tree. Average compensation rates were determined for each one-inch (2.54 cm) dbh class for differing tree sizes (large vs. small trees), life spans (1, 2, 3 and 4 percent average annual mortality rates) and differing discount rates (2, 3 and 4 percent).

2.6. Average mortality of residential trees

Data on tree mortality from randomly located plots in Baltimore, MD (Nowak et al., 2004) and Syracuse, NY (Nowak et al., 2013) were used to determine annual mortality rates for trees in residential areas. Data on tree change from 1999 to 2001 were used for Baltimore and 1999–2009 were used for Syracuse. The annual mortality rate was calculated as:

$$AMR = 1 - \sqrt[n]{N_n/N_0}$$

Where AMR = annual mortality rate (%), n = number of years between measurements, N_n = number of original trees remaining in remeasurement year n and N_0 = number of trees in original measurement year. Data from residential land uses (Baltimore: high-density residential and low-medium-density residential; Syracuse: residential and multi-family residential) were weighted by original tree population in the residential classes to determine the average mortality rates in the residential land use.

3. Results

Replacement rates vary depending on the remaining life span of the tree, the life span of the replacement trees, tree size and discount rates. The impact of discount rates was relatively minor with replacement values mostly exhibiting a slight increase (+1.1 trees) as discount rates increased from two to four percent. The average increase of replacing trees with similar-sized trees was between 0.1 trees for small trees with 4-percent mortality to 3.4 trees for large trees with one-percent mortality. Due to the minimal effect and the need to simplify the presentation of the remaining results, all results presented use a 3-percent discount rate.

Tree size and life span remaining had substantial impacts on the number of replacement trees. The large and small trees had large differences in projected leaf area through time (Fig. 4). The small tree attained maximum size for the allometric equations after 46 years and leaf area was held at its maximum after that point. This issue of attaining maximum size before 100 years has to do with the dbh cap that prevents small trees from attaining large dbh. The NPV between large and small trees also differ depending on life span remaining (Fig. 5).

When the estimated life span of the removed tree increases, the number of replacement trees increases. However, when the estimated life span of the replacement tree increases, the number of replacement trees decreases. In Supplemental Table 1, compensation rates are given for large trees being replaced by a similar large tree with a four-percent mortality rate. As dbh and life span of the existing tree increase, so does the compensation rate (Fig. 6). Compensation rates vary from zero trees for a one-inch (2.54 cm) tree with one year life span remaining to 43 trees for a 32-inch (81.3 cm) dbh tree with 100 years life span remaining. Similar tables with all tree size, life span and discount rates can be found at www.itreetools.org/research_suite/treecompcalc. This website also contains a calculator where the user can vary tree size, life spans remaining, and growth and discount rates to calculate the number of replacement trees and replacement values based on local planting costs.

Replacement rates also change when tree size classes are changed (Fig. 7). When replacing large trees with small trees, compensation rates increase. When replacing small trees with large trees, compensation rates decrease. When compensating with trees in the same size class, compensation rates for small trees are less than compensation rates for large trees. Maximum compensation rates for large trees replaced with large trees range between 6.6 (one percent mortality) to 13.7 (four-percent mortality); small trees replaced with small trees range between 1.8 (one percent mortality) to 3.3 (four-percent mortality); small trees replaced with large trees range between 0.9 (one percent mortality) to 2.5 (four-percent mortality); and large trees replaced with small trees range between 13.0 (two percent mortality) to 17.9 (four-percent mortality). Peak compensation of 41.1 trees was reached when replacing a large tree with one-percent mortality with a small tree with four-percent mortality (Table 3). Compensation varied with dbh and increases to a peak at 25 in. (63.5 cm) dbh for large trees and 10 in. (25.4 cm) dbh for small trees, and then decreased with larger sized trees.

Residential tree annual mortality rates in Baltimore and Syracuse were 3.6 and 3.8 percent respectively. If the high density and multifamily residential lands are excluded, residential tree mortality drops to 2.2 percent in Baltimore and 3.3 percent in Syracuse. Thus, reasonable

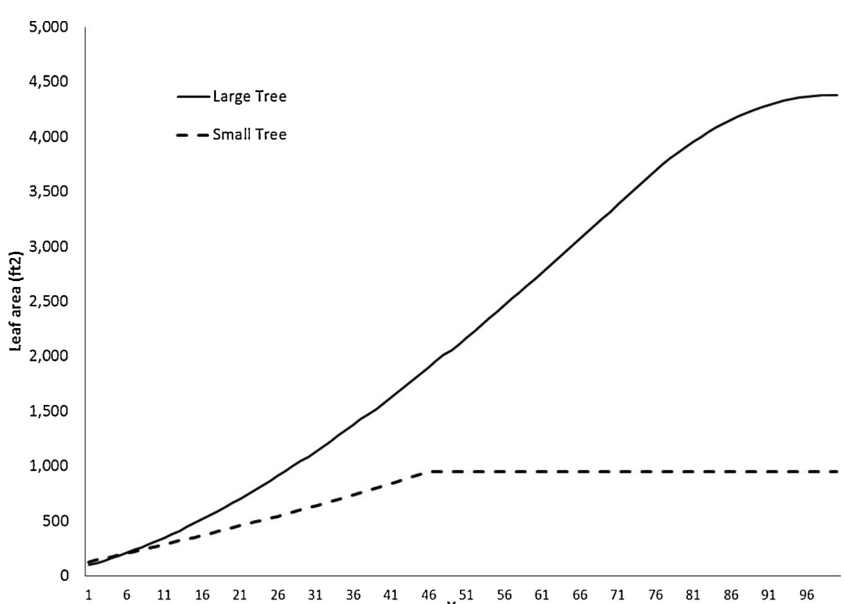

Fig. 4. Projected leaf area for large and small tree over 100 years.

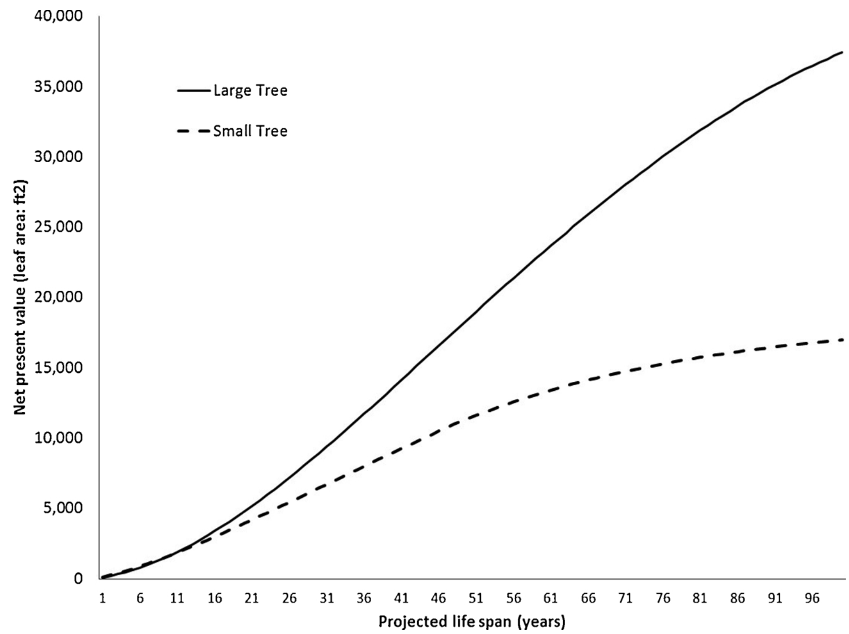

Fig. 5. Net present value of one-inch (2.54 cm) dbh tree (large vs. small) based on projected life span of the one-inch tree.

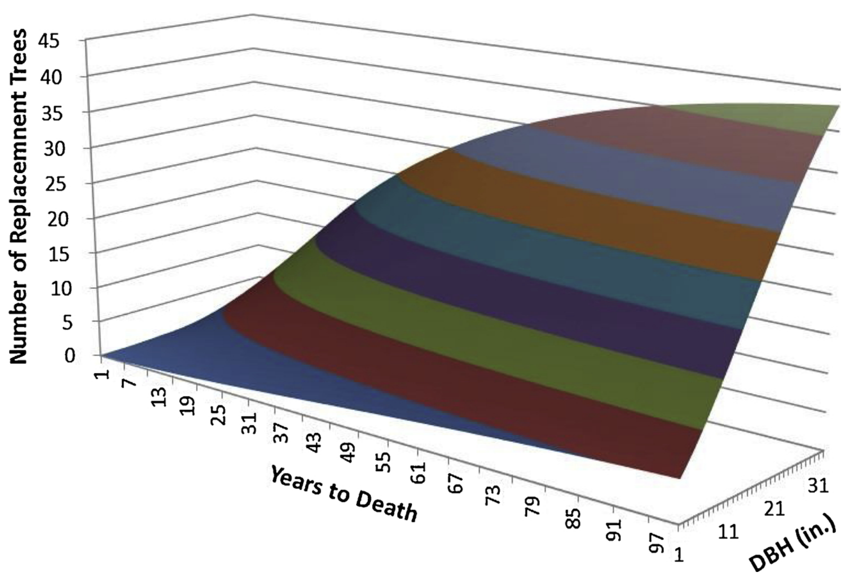

Fig. 6. Number of large one-inch (2.54 cm) dbh replacement trees with a 4 percent mortality rate needed to compensate for large tree loss based on dbh and estimated life span of existing tree. This figure is a graphic representation of data in Supplemental Table 1.

mortality rates for urban residential areas are likely between 2–4 percent annually. Mortality rates will vary among land use classes due to differences in such factors as development, environmental conditions, management/maintenance practices and competition. Using the four percent residential average for a typical mortality rate, general recommendations can be given on tree compensation rates based on tree dbh (Table 4). However, these are just general guidelines on compensation. With better local data and estimates on life span remaining, specific compensation estimates can be derived at www.itreetools.org/research_suite/treecompcalc using the size class tables with specific discount rates (2–4 percent; or 0–7 percent if the calculator is used).

4. Discussion

This paper proposes a new approach to estimating tree compensation for the loss of living trees. This approach bases compensation on the estimated loss of future functions, with compensation given in number of new replacement trees. Numerous other formula-based methods of estimating compensation exist, but this approach is fundamentally different. This new approach is not intended to replace existing methods, but rather set a foundation for improving existing methods.

4.1. Monetary conversion

The number of replacement trees can be converted to monetary units based on local market costs of replacement trees and the costs of planting the replacement trees. For example, a search of various tree nursery web sites finds that a reasonable cost for a one-inch (2.54 cm) dbh, 8–10 foot tall, ball and burlap replacement tree is $200 with replanting costs of $85 (Total = $285). Using this value and a 4% mortality rate (based on average residential mortality rates), the compensation value for large trees would range between $285 and $3,900 when replanting with a similar large species tree. Reducing the

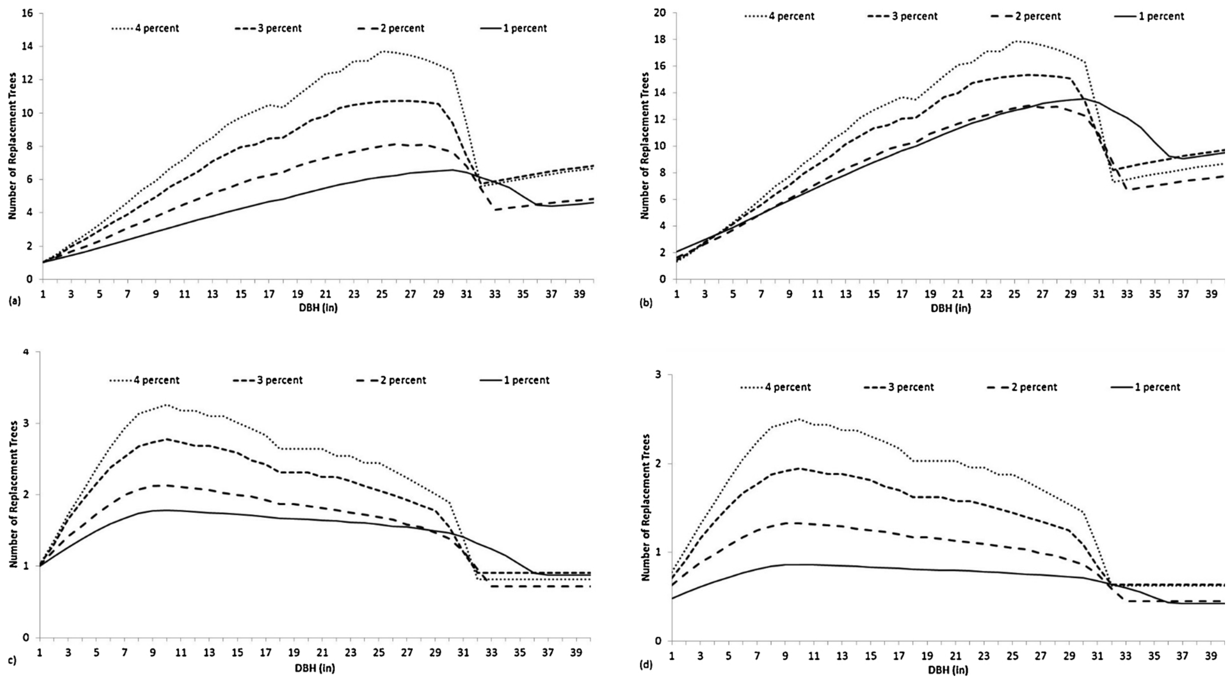

Fig. 7. Tree replacement rates by dbh of removed trees for varying mortality rates. The four percent line illustrates a tree with a four-percent mortality rate replaced with a tree with the same mortality rate and a dbh growth rate of 0.2 in. per year (0.51 cm/yr). Likewise for 3, 2 and 1 percent mortality lines. Figure (a) is a large tree replaced with large tree; (b) large tree replaced with small tree; (c) small tree replaced with small tree; (d) small tree replaced with large tree.

mortality rate would reduce the compensation. Maximum compensation will occur when a large tree with a 1% mortality rate is replanted with a large tree with a 4% mortality rate. In this case, compensation would range up to $9,000 per tree as the removed tree would have a longer expected life span. Valuation can range up to very large amounts depending upon the estimated life spans. For example, if a large 20-inch (50.8 cm) dbh tree with an estimated remaining life span of 100 years is to be replaced by large trees with an estimated life span of 10 years, compensation reaches 129 trees or $36,800. Minimum compensation could be $0 for dead trees.

4.2. NPV vs formula valuation

Compensation rates based on NPV of leaf area differ from the existing formula approach to valuation. As an illustration of differences in these approaches, the NPV approach is compared with the CTLA approach (CTLA 2000 9th Edition), one of the more conservative methods of valuation (Watson, 2002). While both approaches use dbh, the CTLA approach adjusts the replacement cost upward based on an estimated cost per unit trunk area for the trunk area that is greater than the area of the largest transplantable replacement tree. The tree value is multiplied by factors (0–1) for species, condition and location to determine the final value. In both approaches, the cost of tree and stump removal are separate from the compensation estimate.

These two approaches to valuation produce similar results for small trees up to around 10 in. (25.4 cm) in dbh, but can differ substantially for large trees with CTLA producing higher values. As an illustration, CTLA values were compared with the NPV approach for trees with $285 replanting costs, CTLA condition values of 1 (NPV approach also assumed healthy trees for this example) and CTLA species and location ratings of 0.8 and 0.2 (i.e., two estimates were made: one with species and location factors as 0.8, the other with these factors as 0.2) (Fig. 8). As NPV valuation is based on future values, as trees become larger, the compensation stabilizes and then slightly decreases as the large trees approach the estimated end of their life span. Using the CTLA approach the values increase with tree size as the core values are based on tree cross-sectional trunk area. In the CTLA approach, there is a trunk adjustment formula for trees greater than 30 in. (76.2 cm) dbh, so the estimated values in Fig. 8 would continue to rise, but at a diminishing rate.

Table 3
Maximum compensation rates by tree size and mortality rate for 3 percent discount rate. Bordered cells indicate trees within same size and life span class.

		Replacement tree							
		Large				Small			
Existing Tree		1%	2%	3%	4%	1%	2%	3%	4%
Large	1 percent mortality (1%)	6.6	12.2	20.9	31.5	13.6	19.5	29.9	41.1
	2 percent mortality (2%)	4.4	8.1	14.0	21.1	9.1	13.0	20.0	27.5
	3 percent mortality (3%)	3.4	6.2	10.7	16.2	7.0	10.0	15.3	21.1
	4 percent mortality (4%)	2.9	5.3	9.1	13.7	5.9	8.5	13.0	17.9
Small	1 percent mortality (1%)	0.9	1.6	2.8	4.1	1.8	2.6	3.9	5.4
	2 percent mortality (2%)	0.7	1.3	2.3	3.4	1.5	2.1	3.3	4.5
	3 percent mortality (3%)	0.6	1.1	1.9	2.9	1.3	1.8	2.8	3.8
	4 percent mortality (4%)	0.5	1.0	1.7	2.5	1.1	1.5	2.4	3.3

Table 4
Estimated compensation rates (number of one-inch (2.54 cm) dbh replacement trees) based on dbh of removed tree and average mortality for trees. Residential tree mortality in Baltimore and Syracuse averages 4 percent.

DBH	4% mortality				3% mortality				2% mortality			
(in/cm)	L > L	S > S	L > S	S > L	L > L	S > S	L > S	S > L	L > L	S > S	L > S	S > L
1/2.54	1.0	1.0	1.3	0.8	1.0	1.0	1.5	0.7	1.0	1.0	1.6	0.6
2/5.08	1.5	1.4	2.0	1.0	1.4	1.3	2.1	0.9	1.3	1.2	2.1	0.8
3/7.62	2.1	1.7	2.8	1.3	2.0	1.7	2.8	1.2	1.7	1.4	2.7	0.9
4/10.16	2.7	2.0	3.5	1.6	2.4	1.9	3.5	1.3	2.0	1.6	3.2	1.0
5/12.7	3.3	2.4	4.3	1.8	2.9	2.2	4.2	1.5	2.3	1.7	3.7	1.1
6/15.24	4.0	2.7	5.2	2.0	3.5	2.4	4.9	1.7	2.7	1.9	4.3	1.2
7/17.78	4.6	2.9	6.1	2.2	3.9	2.5	5.6	1.8	3.1	2.0	4.9	1.2
8/20.32	5.4	3.1	7.0	2.4	4.5	2.7	6.4	1.9	3.4	2.1	5.5	1.3
9/22.86	5.9	3.2	7.7	2.5	5.0	2.7	7.1	1.9	3.8	2.1	6.1	1.3
10/25.4	6.7	3.3	8.7	2.5	5.6	2.8	7.9	1.9	4.1	2.1	6.6	1.3
11/27.94	7.2	3.2	9.4	2.4	6.0	2.7	8.6	1.9	4.5	2.1	7.2	1.3
12/30.48	8.0	3.2	10.4	2.4	6.5	2.7	9.3	1.9	4.8	2.1	7.8	1.3
13/33.02	8.5	3.1	11.1	2.4	7.1	2.7	10.1	1.9	5.2	2.1	8.3	1.3
14/35.56	9.3	3.1	12.1	2.4	7.5	2.6	10.8	1.8	5.4	2.0	8.7	1.3
15/38.1	9.7	3.0	12.7	2.3	7.9	2.6	11.3	1.8	5.8	2.0	9.2	1.2
16/40.64	10.1	2.9	13.2	2.2	8.1	2.5	11.6	1.7	6.1	2.0	9.7	1.2
17/43.18	10.5	2.8	13.7	2.2	8.5	2.4	12.1	1.7	6.3	1.9	10.0	1.2
18/45.72	10.3	2.6	13.5	2.0	8.5	2.3	12.1	1.6	6.4	1.9	10.3	1.2
19/48.26	11.0	2.6	14.4	2.0	9.0	2.3	12.9	1.6	6.8	1.9	10.9	1.2
20/50.8	11.7	2.6	15.3	2.0	9.6	2.3	13.7	1.6	7.1	1.8	11.3	1.1
21/53.34	12.4	2.6	16.1	2.0	9.8	2.3	14.0	1.6	7.3	1.8	11.7	1.1
22/55.88	12.5	2.5	16.3	2.0	10.3	2.3	14.7	1.6	7.5	1.8	12.0	1.1
23/58.42	13.1	2.5	17.1	2.0	10.5	2.2	15.0	1.5	7.7	1.8	12.3	1.1
24/60.96	13.1	2.4	17.1	1.9	10.6	2.1	15.2	1.5	7.9	1.7	12.6	1.1
25/63.5	13.7	2.4	17.9	1.9	10.7	2.1	15.3	1.4	8.0	1.7	12.8	1.1
26/66.04	13.6	2.3	17.8	1.8	10.7	2.0	15.3	1.4	8.1	1.7	13.0	1.0
27/68.58	13.5	2.2	17.6	1.7	10.7	1.9	15.3	1.3	8.0	1.6	12.9	1.0
28/71.12	13.2	2.1	17.3	1.6	10.7	1.9	15.2	1.3	8.1	1.5	13.0	1.0
29/73.66	12.9	2.0	16.8	1.5	10.6	1.8	15.1	1.2	7.9	1.5	12.7	0.9
30/76.2	12.5	1.9	16.3	1.5	9.4	1.5	13.4	1.1	7.7	1.4	12.3	0.9
> 30/ > 76.2	6.5	0.9	8.5	0.7	6.4	0.9	9.2	0.7	4.9	0.8	7.8	0.5

L > L – large tree replaced with large tree; S > S – small tree replaced with small tree.
S > L – small tree replaced with large tree; L > S – large tree replaced with small tree.

The NPV approach differs from CTLA in how it handles differences among tree species, condition and location. The CTLA approach discounts species (0–1 multiplier) based on the rating of plant characteristics that include aesthetics, functional values, climatic and soil tolerances, resistance to insects and diseases, growth characteristics, maintenance requirements and allergenic properties. The NPV approach uses tree size class (large or small) and projected life remaining to estimate the current value of future services and aesthetics based on future leaf area. Growth characteristics are handled within the growth rate calculations, which can be varied in the calculator (www.itreetools.org/research_suite/treecompcalc). If the tree is replanted with the same species, all the positive and negative aspects of that

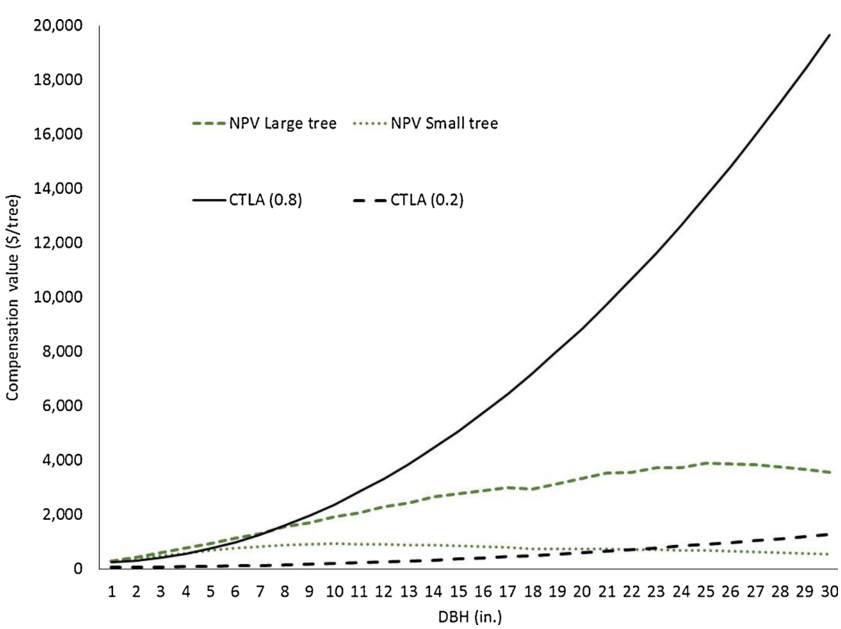

Fig. 8. Comparison of CTLA and NPV estimates for a one-inch (2.54 cm) replacement tree with a replacement cost of $285. CTLA basic price used was $43/in^2 based on U.S. national average values from 2000 adjusted based on the producer price index. The 0.8 adjustment estimates near maximum values from CTLA; the 0.2 adjustment is near the minimum values (minimum value could be $0 for a tree in very poor condition). Large and small tree compensation are based on a 4 percent mortality rate for both the removed and replanted trees, with replanted trees being of the same size class.

species, including maintenance and tolerances, will inherently be included. Thus, in converting to dollar values, the same species should be used as the species value will be directly accounted for in the cost of purchasing and planting of that species. If the same species cannot be purchased, then a close substitute that could be reasonably purchased would need to be found. In some cases, species may be classified as invasive and prohibited from sale or planting in certain regions. In these cases the compensation should be reduced as even though the invasive species would produce environmental benefits associated with leaf area (e.g., air temperature cooling, carbon sequestration), the species was deemed detrimental to the environment due to its invasive tendencies. These types of species adjustments could be done via local stakeholder agreements.

If for some reason the replanted tree needs to be a different-sized species, the number of replacement trees will change. For example, if a small tree is removed, the compensation may be in larger tree species, which would reduce the number of trees to be planted. Large trees replaced with smaller trees would require more trees to be planted. If the entity being compensated agrees to the species change, then changes in costs or values associated with the new trees (e.g., potentially increased maintenance costs) are irrelevant as the species change was agreed upon.

The CTLA approach discounts tree condition (0–1 multiplier) based on the rating of numerous health metrics. The NPV approach addresses condition based on estimated number of years remaining in which the tree would have remained healthy and functional. If the removed tree is dead, the estimated life span would be zero years and compensation would be zero trees. With decreasing vitality of the removed tree, there will be a concomitant reduction in life expectancy and compensation.

The current CTLA approach discounts location (0–1 multiplier) based on the rating of site, contribution and placement factors. The NPV approach does not directly address location, as all locations are treated equally. As far as possible, where site constraints do not preclude otherwise, the trees should be replanted in the same location when compensation is based on the number of trees. When converting the number of trees to monetary values, location could have an impact on the replanting costs. As property value often increases with trees (e.g., Sander et al., 2010; Saphores and Wei, 2012) and these changes in value are related to leaf area (e.g., McPherson, 2007), the NPV compensation should account for property value effects if trees are replanted on the same property. There could be a lag effect where property values may drop immediately after tree removal, but as the replanted trees grow, the property values would increase and may eventually surpass the original property value increase. As the property value change is only realized at the point of sale, on average the tree compensation related to property values should be adequate with some properties losing value and some gaining value depending upon when the property is sold relative to when the tree was removed.

This new approach fits well with the income approach using discounted cash flow analysis as discussed in the latest 10th edition of the CTLA guide for plant appraisal (Clark et al., 2018).

4.3. Limitations

While the NPV approach compensates based on future leaf area, it does not adequately account for future services that are location-specific. A good example of this type of service is tree effects on building energy, which depends upon where the tree is located in relation to the building. If a large tree on the west side of a residence is reducing annual energy use, the loss of that tree will not be adequately compensated as the multiple replacement trees cannot all be planted in the same location, thus not all of the replacement trees will produce the same energy effects. However, a change in compensation for these location-specific values is not likely needed as the additional replacement trees could have energy effects (e.g., shading of building, blocking winds) if planted near the building. In warmer climates, trees near buildings tend to reduce energy use through shade and air temperature cooling. In cooler climates, trees could have either positive or negative effects on energy use depending upon location relative to buildings (Heisler, 1986). Thus targeting the location of replanted trees is important for maximizing future building energy conservation.

With the exception of exotic invasive species removal, the NPV compensation should be considered a minimum compensation. The compensation is based on future leaf area, which is related to various services, values and aesthetics. It does not account for potential historical, social, crop or spiritual values of specific individual trees. These types of values would be tree specific and need to be determined as potential additional value. Examples of these types of values might be sentimental values associated with a tree planted by or in memory of a past family member, or the value of historical or spiritual trees (e.g., the treaty oak in Austin, TX; the survivor tree in New York City; the Major oak in Edwinstowe, England; the Bodhi tree in Bodh Gaya, India) (e.g., Kline, 2016). Pruning efforts used to create specialized tree crowns (e.g., topiary, pollarding, bonsai) would also not be compensated for using the NPV method. Loss of crop production (e.g., fruit and nuts) might be undercompensated due to the time lag in fruit production in newly planted trees. The NPV approach does not apply any type of punitive damage estimates associated with unlawful and willful removal of trees. The NPV approach also does not apply value to dead trees (zero years remaining in life span), yet dead trees can provide value through wildlife habitat, carbon storage and aesthetics. These potential adjustments are often subjective and could be determined locally on a per-tree basis based on local stakeholder agreement.

Another limitation of the NPV approach is the ability to estimate the remaining life span of the removed tree. Although estimates are provided based on estimated mortality rates, life span estimates can be improved through urban forest monitoring. Monitoring data can establish average mortality rates and thus life spans for different species under different environmental and land use conditions. In the United States, the U.S. Forest Service Forest Inventory and Analysis program has started to implement, in partnership with cities, long-term urban forest monitoring. This program measures urban forest data annually to assess urban forest structure, ecosystem services and values, and changes in structure, services and values through time. The first city to have completed a baseline inventory was Austin, TX (Nowak et al., 2016), with 28 cities monitored in 2018 and new cities to be added to the monitoring program in the next few years (US Forest Service, 2018). Though monitoring should provide better data on life span estimates based on species and dbh in the long run, in lieu of monitoring, local expert estimation of life spans could be a reasonable approach even though it is not science-based.

4.4. Factors affecting compensation rates

Based on limited existing urban forest monitoring data, a reasonable mortality rate for residential trees is currently 4 percent. This mortality rate includes not only the natural rate of mortality (removal of dead trees), but also the removal of healthy trees due to various human actions or choices (e.g., site development, people choosing to remove healthy trees for various reasons). Mortality rates will vary among land use types due to differences in mortality causes (e.g., development, plant competition, soil compaction) and tree care. The 4% mortality rate likely overestimates tree mortality due to more natural factors such as old age, insects and diseases and other natural environmental factors. However, these types of mortality factors may increase in the future due to the spread of insects and diseases, changes in climate and/or increased population pressures (e.g., Nowak and Greenfield, 2018). Tree maintenance activities such as watering to enhance young establishment (e.g., Vogt et al., 2015) and pest management strategies to reduce insect-caused tree death (e.g., Liu, 2017) could also help reduce mortality rates.

The 4% mortality rate is comparable to street tree mortality in West

Oakland, California (3.7%; Roman et al., 2013) and other street tree populations (3.5–5.1%; Roman and Scatena, 2011), but less than mortality rates for newly planted residential trees (6.6%; Roman et al., 2014) and newly planted street trees (19%; Nowak et al., 1990). Higher annual mortality rates among newly planted trees are accounted for within the mortality estimates (Table 2). However, if the establishment of new trees is difficult due to site conditions, the life spans of replacement trees should be reduced.

Though desirable, estimating the exact leaf area and life span of an individual tree is not essential for this process. What is essential is a reasonable estimate of leaf area based on tree size classes and estimating the species' average mortality rate. Not every tree species needs to be modeled for leaf area, rather species can be classified into size / crown density classes based on light interception coefficients and a representative tree species from that size class used to estimate leaf area for the class. For example, classes could be large trees with dense crowns (e.g., *Aesculus hippocastanum*), large trees with sparse crowns (e.g., *Gleditsia triacanthos*), small trees with dense crowns (e.g., *Acer ginnala*), etc. For mortality rates, generalized life span tables for a species could be created. Like actuarial tables used for life insurance, the exact life span of an individual does not need to be known, but rather the average life span for a species under various conditions (e.g., street side, parks) can be used to estimate average probable life span.

As the life span for replacement trees decreases (mortality rate increases), the compensation will increase. As the life span for removed trees decreases (mortality rate increases), the compensation will decrease. As large trees are already established, their mortality rate may be relatively low. New replanted trees will likely have a higher mortality rate due to establishment related mortality (e.g., Black, 1978; Nowak et al., 1990). Changing species between the removed and replanted trees may also change the mortality rates (e.g., replacing a long-lived species with a short-lived species). If this is the case, then using the same average mortality rate (e.g., 4 percent) for both the removed and replacement tree might not be sufficient. Increased mortality rates of replanted trees relative to removed trees would increase the compensation rate.

The mortality rate used in the NPV approach assumes an average mortality rate within three or six inch (7.6 or 15.2 cm) dbh size classes, with relatively high rates for smaller and larger trees. As trees shift size classes the rates change. Using the average mortality rates, the expected life spans tend to drop precipitously when the tree reaches the last dbh class (30+ inches (76.2+ cm)). Due to the relative high mortality rates in this last class (8.7 percent when using the 4 percent average mortality rate) and an assumption of a minimum life span remaining for all healthy trees, entering an estimated number of years remaining for trees greater than 30 in. (76.2 cm) is likely a better approach than using the estimated average mortality rate. Small tree species will likely not reach the 30-inch (76.2 cm) dbh class, so mortality of small trees may be underestimated and compensation overestimated using the average mortality data. More research is needed to develop more robust estimates of mortality rates and tree life spans.

Large trees require more compensation than small trees due to their greater leaf area. When replacing large trees with small trees, compensation increases; when replacing small trees with large trees, compensation decreases. Compensation for all trees regardless of size decreases as it reaches the end of its life span.

An average dbh growth rate of 0.2 in. per year (0.51 cm/yr) was used in this analysis. However, growth will affect compensation estimates as increased growth rates will increase leaf area. As growth rates of replanted trees are increased, compensation decreases due to increased leaf area, and vice versa.

If users are not interested in estimating compensation based on future values of leaf area, but would rather base compensation on replacing just current leaf area (i.e., the current leaf area of the replacement trees equals the current leaf area of the removed tree), the users can set the life span estimates in the calculator (www.itreetools.org/research_suite/treecompcalc) to one year for both the removed and replacement trees. In doing so, the current leaf area of the removed and replacement trees will be directly compared to estimate the number of replacement trees. In this case, replacing a large, healthy 30-inch (76.2 cm) dbh tree with a large one-inch (2.54 cm) dbh tree would require 80 replacement trees or $22,800 in compensation based on a planting cost of $285 per tree. Compensation rates will tend to increase without considering life spans and future values of trees, but the estimation process would be made much simpler by not requiring discount rates, and life span and growth rate estimates. This process would be a direct compensation for current leaf area.

As this proposed process is new, more research is needed to improve upon this procedure. There are four variables required to assess NPV: 1) leaf area; 2) growth rates; 3) life span remaining; and 4) discount rates. Leaf area is currently estimated from dbh based on two size classes (small and large trees). More size class evaluations for projecting leaf area would provide better refinements of estimates among species. Leaf area of removed trees can also be reduced downward based on percent crown dieback, as the leaf estimates are based on healthy trees. For example, if the removed tree has 50 percent crown dieback, compensation estimates should be halved, since half of the leaf area is missing. This dieback would also likely increase mortality rates, leading to a further decline in compensation.

Growth rate estimates could be improved with more urban forest monitoring, but current estimates are based on field data measurements and can be reasonably estimated. Discount rates are chosen by the user. Economists calculate that homeowners discount future benefits over 100 years at rates below 2.6% per year (Giglio et al., 2015). However, this rate is lower than the rates used by governments to assess infrastructure projects or by pension funds to evaluate their liabilities (Oxford, 2015). The most important variable to be improved upon is the estimate of life span remaining. This variable is critical. More forest monitoring to provide better estimates of average life span and mortality rates among various conditions (location, land use, etc.) would help improve estimates of compensation with this proposed method.

4.5. Suggested use

To use the NPV calculator or look-up tables, the following steps can be taken:

1) Measure dbh of removed tree and determine if tree is a large or small tree species
2) Determine the discount rate to be used. There are various ways to estimate a discount rate (e.g., judgment on projected rate of returns, current rate for US Treasury bonds). The three percent discount rate was used in this paper as it is the central value discount rate used in estimating the social cost of carbon (Interagency Working Group on Social Cost of Carbon, 2015). The two and four percent estimates are given to illustrate a range in values.
3) Estimate the number of years that the removed tree would have lived as a healthy tree if not removed (based on expert opinion). An option here is to use an average mortality rate (1–4 percent) if the number of years cannot be estimated. For large established trees, the mortality rate is likely lower than 4% for residential trees.
4) Determine size class of replanted tree species (large or small).
5) Estimate the average life span of the replanted tree. This average should be estimated based on the probability of survival. For example, if the replanted tree has a life span of 80 years, but only one in five replanted trees will live past five years due to establishment related mortality, then the average life span would be 20 years ((80 + 5 + 5+5 + 5)/5 = 20). An option here is to use an average mortality rate (1–4 percent) if the number of years cannot be estimated. The 4% mortality rate is currently recommended for residential trees.
6) Enter data into calculator or use look-up tables (www.itreetools.org/

research_suite/treecompcalc)

7) Convert the number of trees to monetary value based on local nursery and planting costs, if so desired.

5. Conclusion

This paper presents a new approach to tree compensation and valuation based on future services of trees. The results should be considered minimum compensation values and tend to be more conservative in the valuation of large trees than other approaches (e.g., CTLA, STEM, Burnley, Norma Granada) as the compensation values stabilize and do not increase with dbh after a certain size. Maximum compensation values tend to cap at $4,000 to $9,000 per tree depending upon the mortality rates used. The difficulty or limitation of this approach is knowing the likely remaining life span. Though estimates of life spans are given based on tree monitoring data and average mortality rates, life span estimation can be improved in the future through urban forest monitoring measurements. The current process uses two tree species to represent a large and small tree. More species equations could be added to represent leaf area projections for multiple tree size classes. This approach can be refined as more data become available and should work globally based on incorporating local costs and species information. The concept of valuation based on future services provides a better approach to valuation as the values are based on contrasting of future benefits rendered by the removed and replacement trees, not the current or past benefits as derived from dbh measurements or other approaches to tree valuation.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ufug.2019.03.014.

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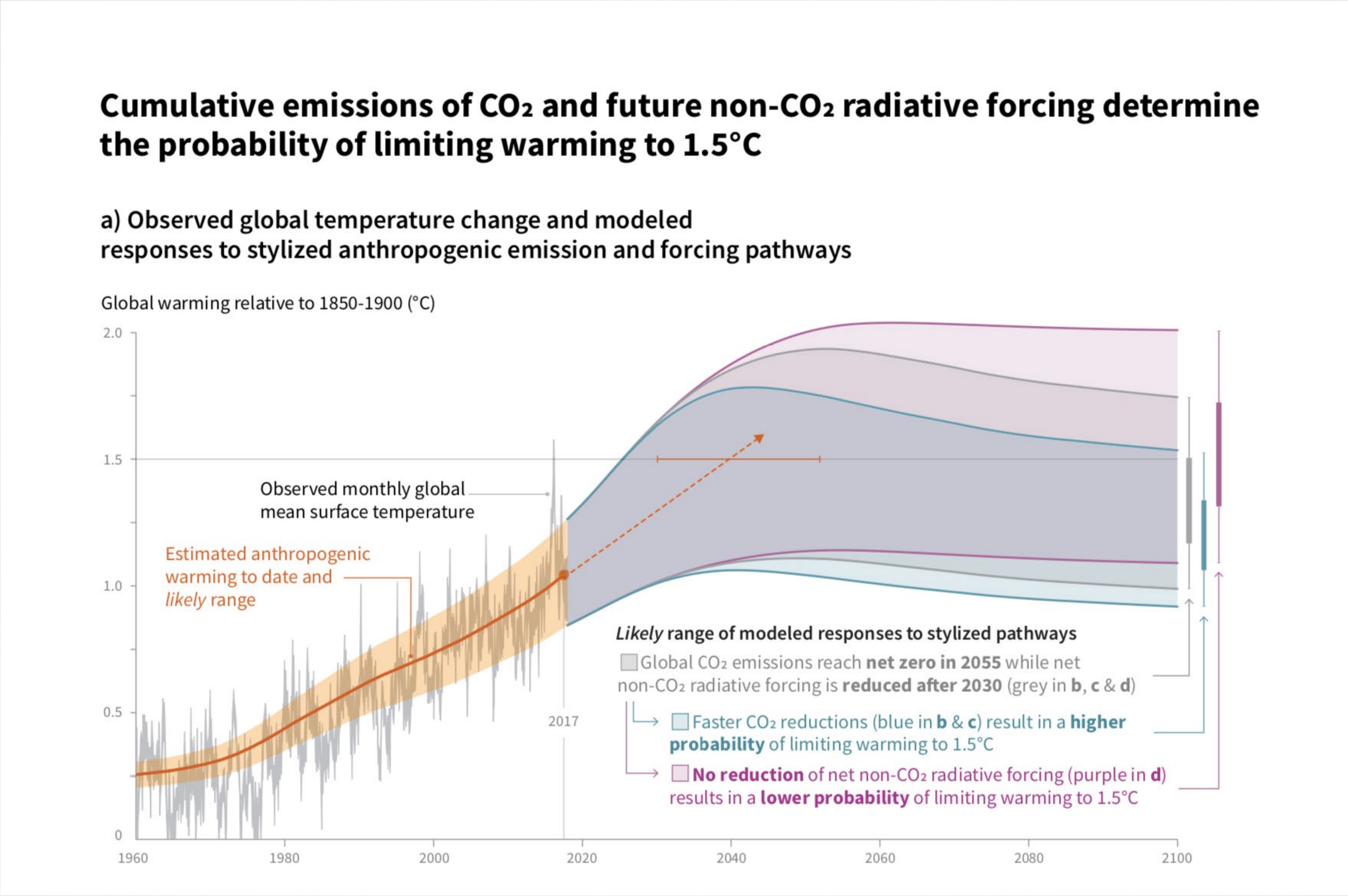
UPDATE: CLIMATE ACTION

Menlo Park Environmental Quality Commission

September 18, 2019

AGENDA

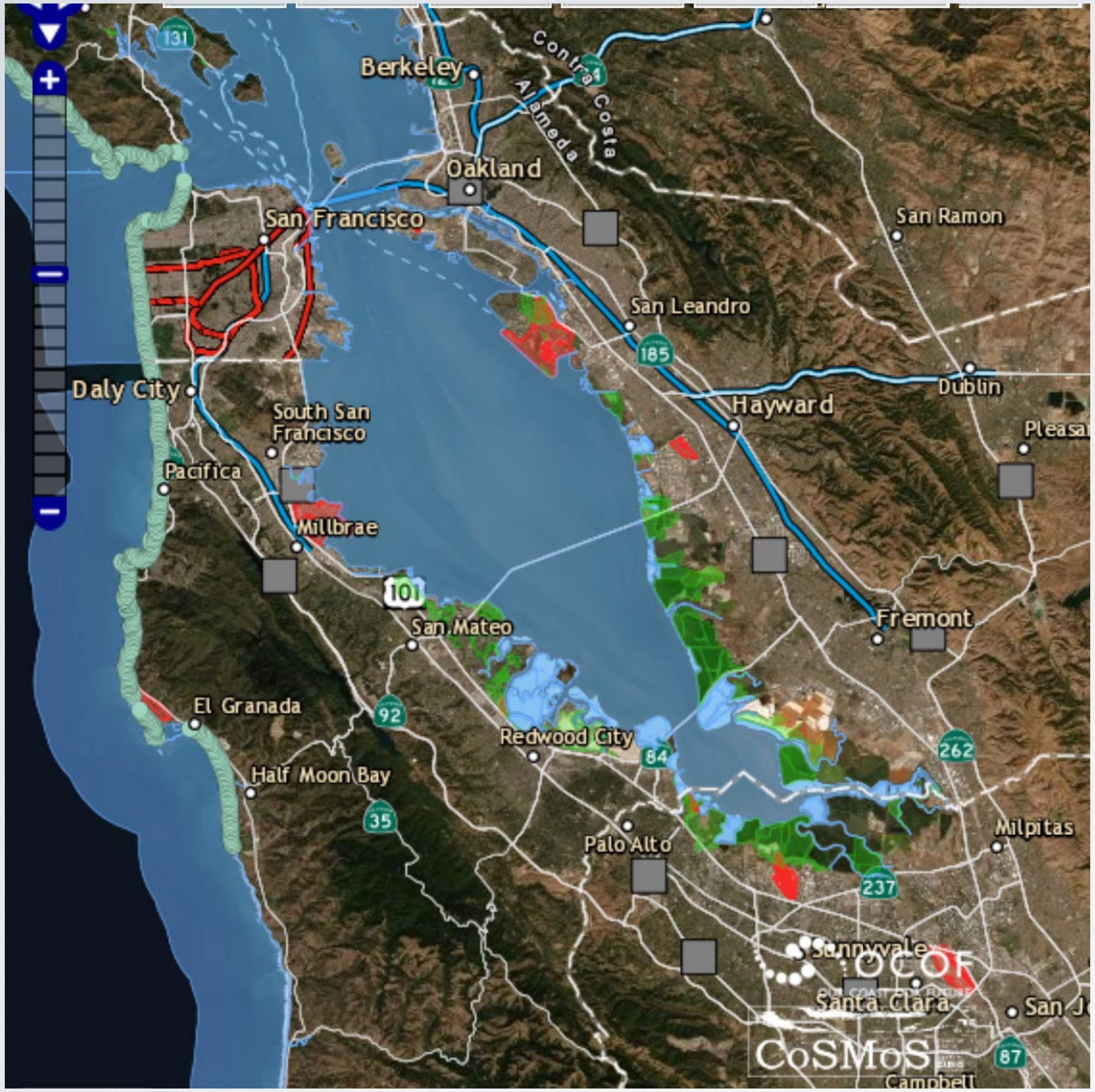
- Latest IPCC projections
- Local impacts of climate change
- Situational analysis
- Input from EQC
  - Preferred pace and timeline for CAP development
  - Desired level of input by full EQC and opportunities for commissioners to lead
  - Options for community engagement
  - Desire to collaborate with other cities, county, CCEs
  - Proposed content framework
    - Proposed final format of CAP recommendations
    - GHG reduction goals, inc. leadership pace
    - Making the case for bold action, inc. financial savings and wealth advantage
    - Sample strategies
    - Sample projects
    - Preferred level of plan detail
- Other advice or requests from EQC



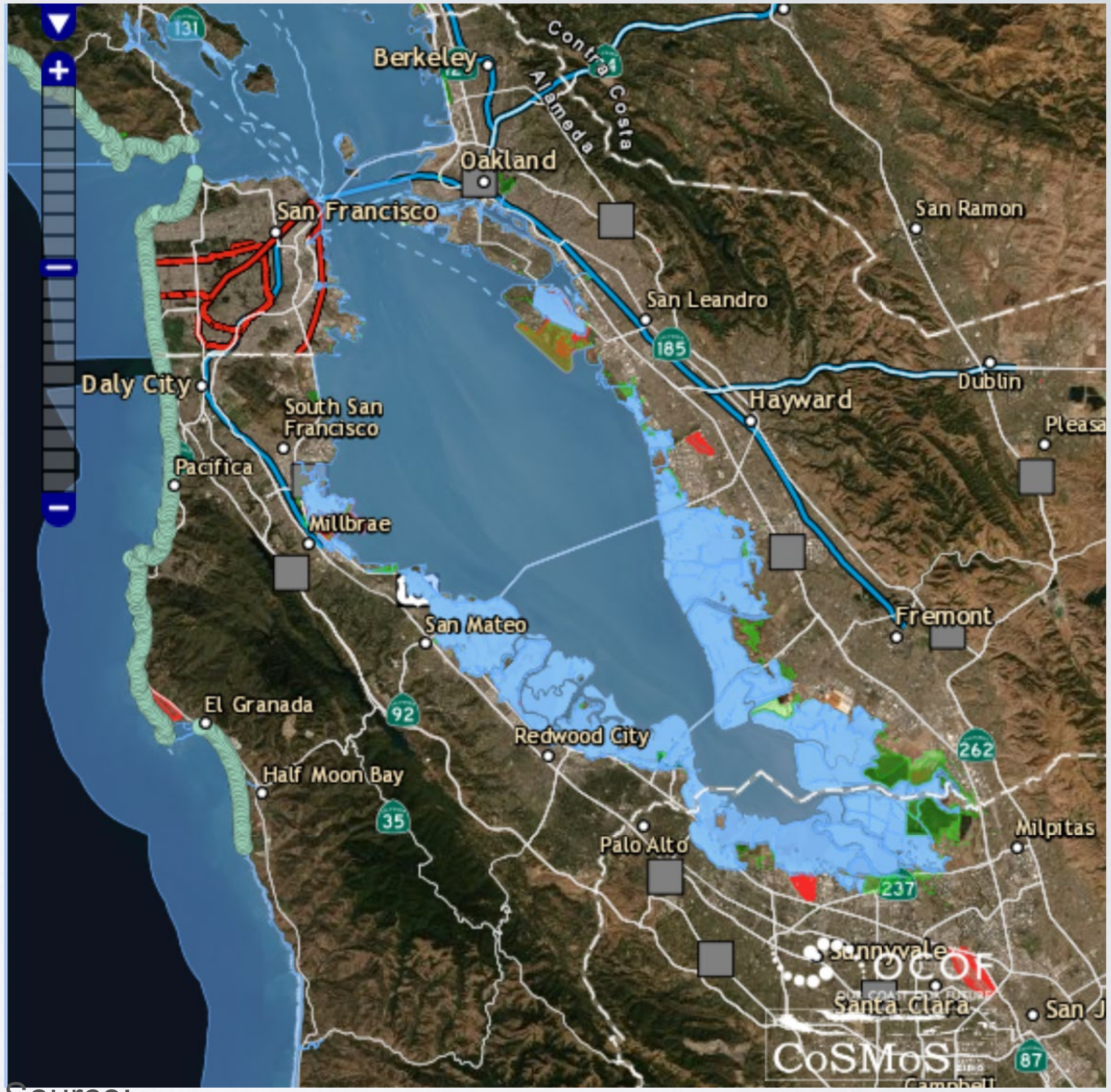
Source: https://www.ipcc.ch/site/assets/uploads/2018/10/SR15_SPM_version_stand_alone_LR.pdf

2018 Report:
Intergovernmental Panel on Climate Change (IPCC)

THE BAY IS RISING



TODAY

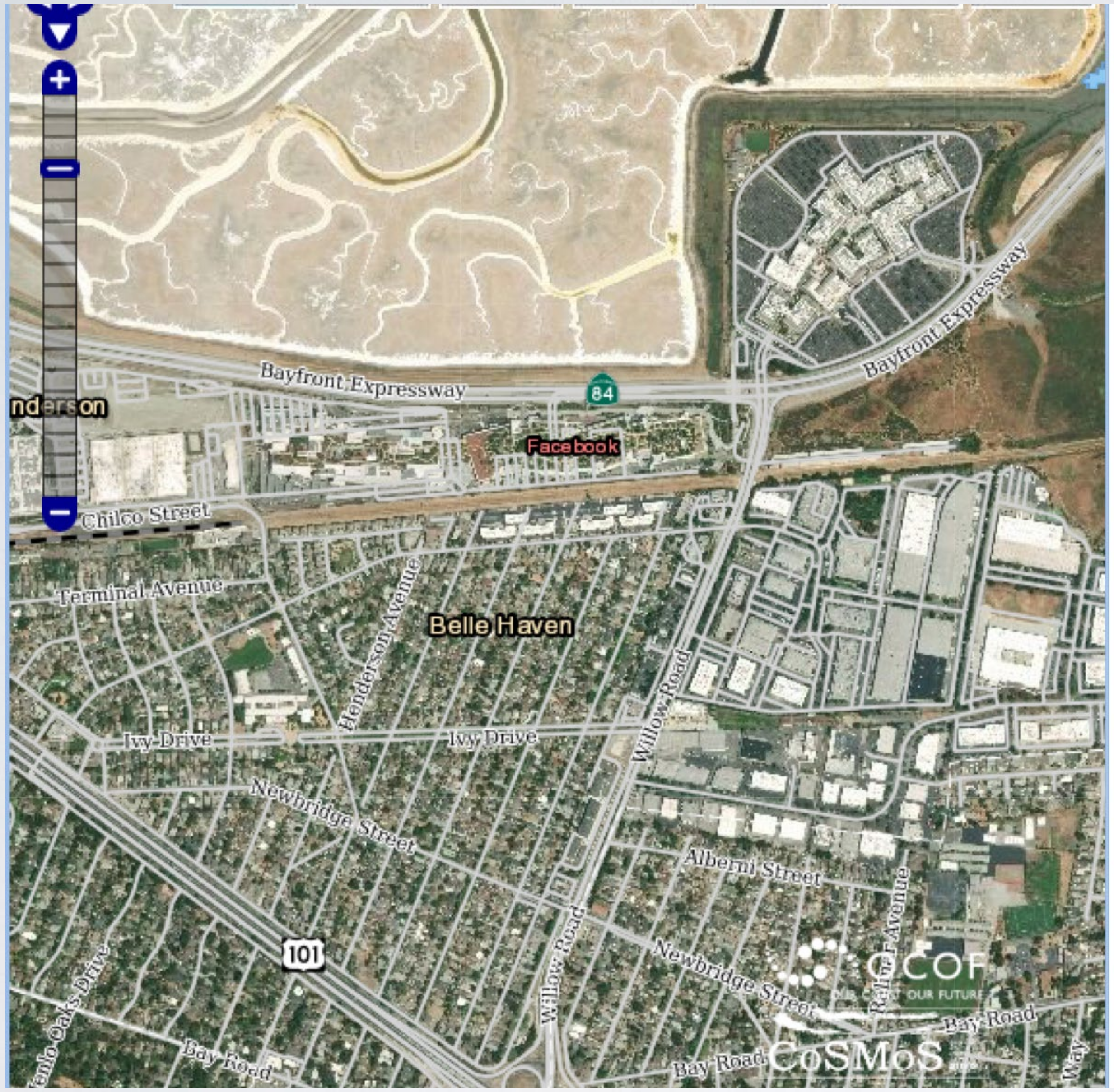


Source:
http://data.pointblue.org/apps/ocof/cms/index.php?page=flood-map

YEAR: 2060-2100

the Bay is projected to rise 3.3 feet

MENLO PARK WILL SUFFER



TODAY

Source: http://data.pointblue.org/apps/ocof/cms/index.php?page=flood-map

YEAR: 2060-2100

the Bay is projected to rise 3.3 feet

REGIONAL MOBILITY WILL SUFFER

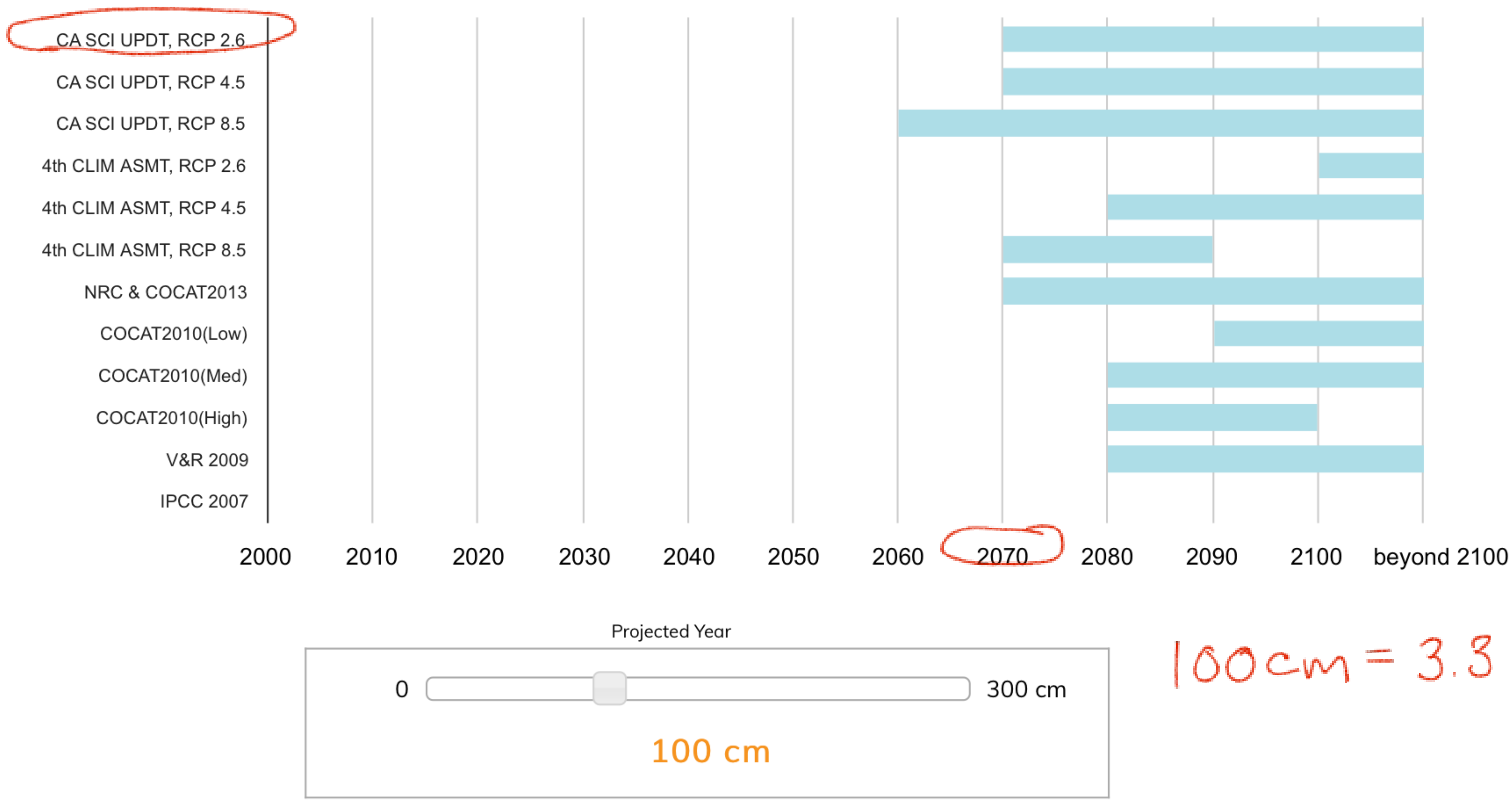
Source: http://data.pointblue.org/apps/ocof/cms/index.php?page=flood-map

YEAR: 2060-2100

route 101 projected to be under water

When is a projection likely to occur?

Move the slider control below the graph left and right to see how different climate experts projections of when sea level rise will occur compare to one another. Hold your mouse over each bar for details.



100cm = 3.3 ft

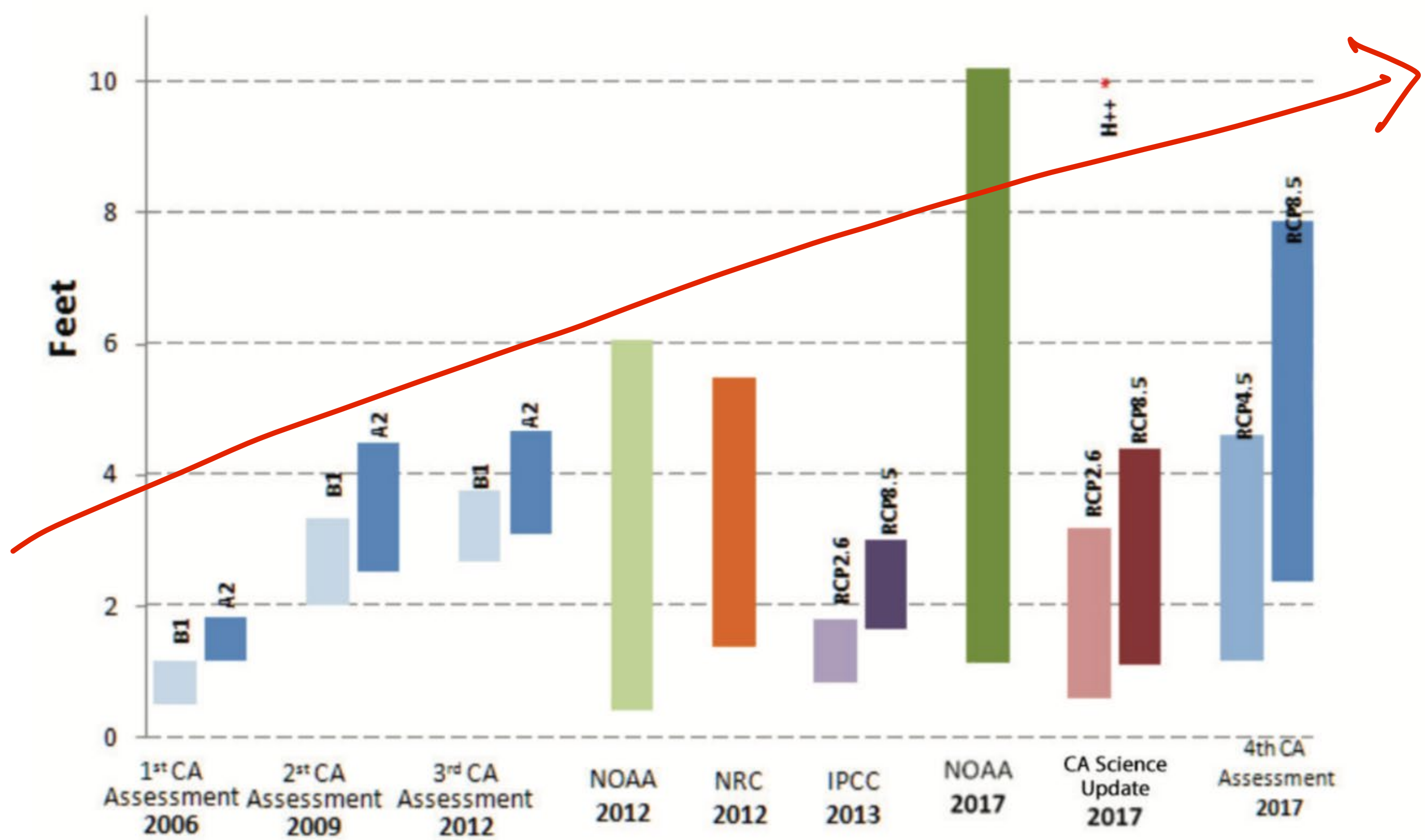
Source: https://data.pointblue.org/apps/ocof/tools/compare/

Best case scenario (RCP* 2.6) predicts 3.3ft rise possible as early as 2070

*RCP=Representative Concentration Pathway

Figure 4. Projections of sea level rise in California and U.S. national reports and assessments of the last decade.

Projections are provided for 2100 according to the approach described in each report. The different approaches reflect the evolution of modeling techniques to project sea-level rise including new approaches to provide greater geographic resolution in projections and probabilistic projections, as well as the different intended purposes of the assessments (i.e., state and national). In brief, the figure depicts: CA 1st, 2nd, 3rd Assessments: range of projections for South Cape Mendocino, NOAA 2012 – range of projections of global mean sea level rise, NRC 2012 – range of projections for South Cape Mendocino, IPCC 2013 – projections of global mean sea-level rise under RCP2.6 and RCP 8.5, NOAA 2017 – range projections for U.S. sea level rise, California 4th Assessment – 5th-95th percentile probabilistic projections for San Francisco under RCP 4.5 and RCP 8.5, California Science Update (this report) – 5th -95th percentile for San Francisco using the Kopp et al., 2014 framework and H++ scenario from NOAA 2017.



Source: Rising Seas in California, an Update on Sea-Level Rise Science, April 2017, p. 35, by California Ocean Protection Council Science Advisory Team, http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf

Sea level projections increase with each report

SCIENTIFIC CONSENSUS

- 97% of climate scientists agree the climate change is happening and that it's primarily caused by humans

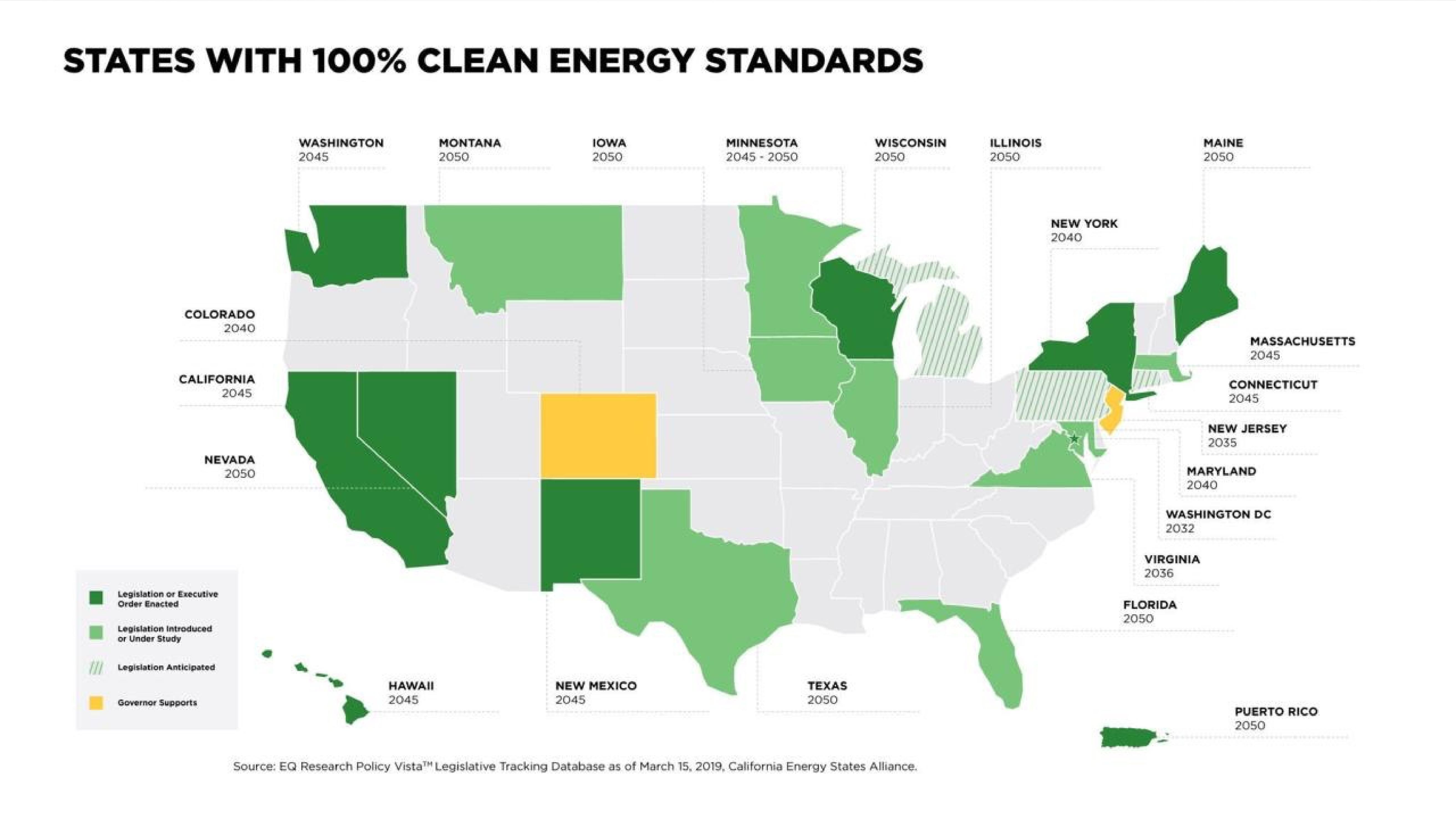
- Joint statement by 18 scientific bodies (inc. the American Meteorological Society and the American Association for the Advancement of Science) reads as follows:

    - "Observations throughout the world make it clear that climate change is occurring, and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver." (2009)

- Recent surveys show that 69% of Americans are at least "somewhat worried" about global warming

BOLD ACTION REQUIRED

- Our community is at risk
- Property at risk = $ billions
- Our response must match the magnitude of the problem in scale and speed
- Goal: reduce greenhouse gas emissions in Menlo Park to zero (or below) as soon as possible, setting targets by year
- Keep the focus simple: eliminate the use of 1) natural gas and 2) gasoline in Menlo Park
- Show leadership and set stage for broader, collective action at state and federal level
- Catalyzing broader action is the only way to link our local actions to successful mitigation of climate threats like sea level rise



Leadership Matters:
California's policies copied by other states

LEADERSHIP MATTERS

"San Jose set to become largest U.S. city to enact natural gas ban

...San Jose joins Berkeley and Menlo Park in enacting natural gas bans."

— Mercury News, September 17, 2019

OUR SOLUTION

Enact a bold update to Menlo Park's Climate Action Plan (CAP) that appropriately addresses the threat of climate change

2009: Menlo Park's first CAP

2015: Update to CAP

2020: New CAP due

CLIMATE ACTION PLAN *SITUATION ANALYSIS* (CAPSA)

- Climate situation is evolving rapidly
- How to plan in a way that makes best use of what's happening around us?
- CAPSA seen as a living document & foundation for strategy development

SCOPE OF PAST CAPs

- Greenhouse Gas (GHG) emissions from:
  - Electricity generation
  - Natural gas usage
  - Gasoline and diesel fuels x combustion VMT
  - Waste collection
  - Marsh Road Landfill emissions

TECHNOLOGY ADVANCING

- Solar costs 1/3 as much as “not-solar”
- Heat pumps are 300-500% efficient (variety is improving, refrigerants are improving)
- EVs are fun and more economic than CVs (combustion vehicles)
- Induction outperforms gas cooking
- E-bikes are increasingly popular
- Ride hailing is improving, so is AV
- Batteries are improving RAPIDLY

FORCES ENCOURAGING ELECTRIFICATION

- Increasing coordination among state agencies: CEC, CPUC, CARB
- Community Choice Energy (CCE) interest in expanding offerings to cut GHGs
- California's new building code providing low cost solar energy and no longer fighting electrification
- Reach Codes encouraging electrification
- EVs showing strong growth
- Advancements in Autonomous Vehicles

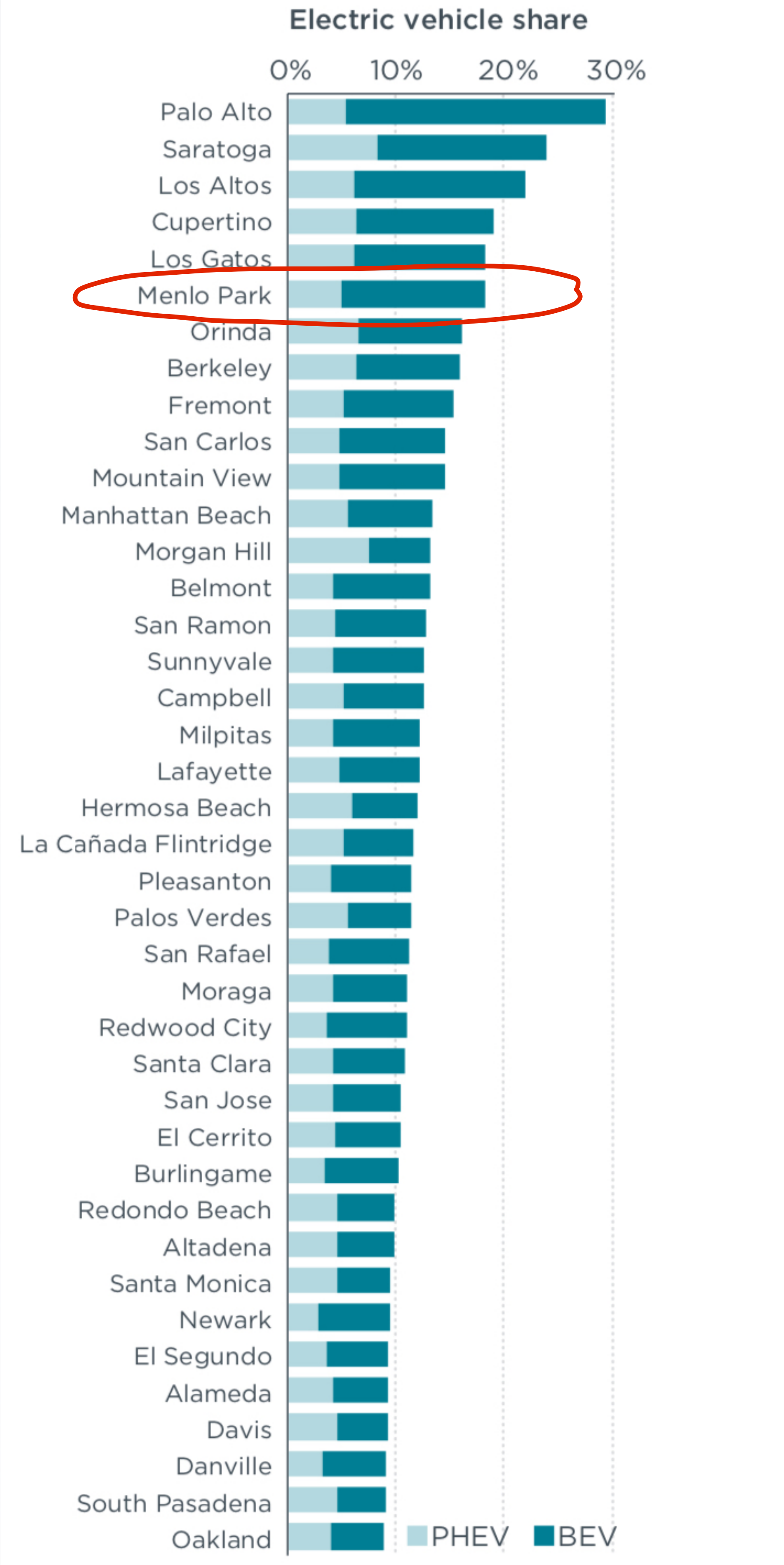


Figure 2. New electric vehicle market share in 2017. *(Vehicle registrations from IHS Automotive)*

INCREASING COLLABORATION

- State agencies adopting climate goals and changing their missions
- Counties getting more serious about cutting GHGs
- Cities expressing interest in joint actions
- Regional groups looking to deliver state programs
- CCEs looking to innovate for GHG reduction
- Reach code help, group buys

EXISTING BUILDING STOCK MUST BE CONVERTED TO 100% ELECTRIC

- Trades not yet motivated to participate
- Workforce must grow to meet anticipated demand
- Competition must improve to bring down labor cost
- Workforce is fragmented (e.g. solar cherries, two trades for HPWH)
- Tools in development (analytical, financial)

TRENDS IN MOBILITY-RELATED EMISSIONS

- Vehicle miles traveled (VMT) is growing as job growth occurs
- Miles per gallon (MPG) is growing as EVs and PHEVs grow
- Active Transportation gets some attention
- Electric bike technology is advancing
- Daytime EV charging reduces emissions and rates

POTENTIAL ROADBLOCKS

- Resistance to change from stakeholders
  - Denial and shame
  - Fear and related feelings of hopelessness
- Misinformation, knowledge gaps
- Cost
- Know-how
- Time and hassle factor related to change

THE CHALLENGE

- How do we maximize greenhouse gas emissions reductions per $ spent?
- How do we meet the scale of the challenge with as little disruption to peoples' lives as possible?
- Information can only get us so far with key stakeholders
  - Emotions run high and can get in the way of reason and facts
  - We must find a way to bridge the gap between 1) awareness that there is an issue and 2) willingness to act at the scale and speed required
  - 95% of our challenge will be addressing psychological barriers to change

EQC INPUT: PACE

- When do we want to have our CAP update done?
- Mayor suggested that now is a good time for bold action
- Our current CAP only extends to 2020, so we are about to enter CAPless territory
- As mentioned before, the more detailed we want our CAP update to be, the longer it will likely take to implement

EQC INPUT:
YOUR INVOLVEMENT

- How involved would full EQC like to be in CAP development details?
- Would EQC like the CAP subcommittee to generate the materials (which Josie will discuss further) independently, and EQC just approves?
- Or would you like EQC to weigh in on specific aspects at specific times?
- There will be opportunities for you to lead

EQC INPUT: COMMUNITY ENGAGEMENT

- Different models:
  - Traditional process: engage community once plan is finalized
  - Start by creating a CAP Advisory board, which includes community stakeholders
  - Engage community early for brainstorming + later for reactions

EQC INPUT: COLLABORATION WITH OTHERS

- Many potential collaborators:
  - Peninsula Clean Energy
  - San Mateo County
  - Community colleges
  - Facebook and other employers
  - Other cities

PROPOSED CONTENT FRAMEWORK

1. GHG inventory
2. GHG reduction targets
3. Proposed strategies
4. Proposed projects with completion dates
5. Proposed timeline for implementation
6. Proposed budget
7. Proposed measures of success

OTHER CITIES' CAPS

- What can we learn?
  - Many different formats
  - Becoming more readable for average citizens
  - Level of detail varies
  - More recent CAPs much bolder
  - Low hanging fruit now gone, next actions require more $
  - Some include: water conservation, adaptation measures

OTHER CITIES' CAPS

- Good examples:
  - Santa Monica
  - Vancouver
  - Salt Lake City
  - San Jose

ACTIONS

A NEW MODEL OF MOBILITY	Carbon Reduction Potential	Cost to City	Community Benefits	Lead	Partners	Status or Timeframe
SM1: Adopt a New Mobility Strategy Develop and adopt policies to govern local mobility services, designate underutilized street space, adapt to technology innovations, implement pricing strategies and foster regional integration.		$		MD		Near Term
SM2: Expand & Diversify Mobility Services & Devices Diversify Breeze fleet to include electric bicycles and offer options for people with different access and functional needs. Partner with operators of dockless devices to expand mobility options that are safe, convenient and affordable, and provide options for people with different needs. Improve shared-mobility services through open marketplace opportunities, permitting systems, dedicated infrastructure and payment platforms that integrate multimodal planning.		$		MD	Business	Near Term
SM3: Expand Mobility Infrastructure Develop strategies and projects to use curb space as mobility hubs that can serve mobility-service providers. Integrate smart-sensing and smart-charging technologies to monitor, inform and enable activities, like congestion pricing. Create tools to maximize street capacity and efficiency for people.		$$$		MD	Business	Near to M Term
SM4: Implement Parking Policies & Pricing Continue to actively review and adjust parking prices citywide as market rates change, and revisit parking management and construction policies to encourage sharing existing resources. Analyze financial impacts and develop alternatives to decreased revenue from parking fees.		$		MD		Near Term
SM5: Sustainable Goods Movement & Delivery Services						

Example: Santa Monica

APPROVED 5-YEAR CAPITAL IMPROVEMENT PROGRAM BUDGETS

CLIMATE ACTION & ADAPTATION SECTOR	SUB-SECTOR	FY 16/18	FY 18/20	TOTAL
Zero Net Carbon Buildings	Municipal Energy	$11,033,075	$108,663,560	$119,696,635
Sustainable Mobility	Bike & Pedestrian Improvements	$15,541,828	$31,131,412	$47,583,240
	Roadway & Transit Improvements	$1,552,247	-	$1,552,247
	Affordable Housing	$10,507,954	-	$10,507,954
	Low Emission Buses	$21,116,000	$432,837,726	$53,953,726
	Electric Vehicles	$186,690	$3,127,300	$3,313,990
Low Carbon Food & Ecosystems	Urban Forest	$2,330,000	$2,250,000	$4,580,000
Water Self-Sufficiency	Local Water Production	$70,858,500	$65,318,436	$136,176,936
Coastal Flooding Preparedness	Pier Hardening	$2,124,000	$3,835,000	$5,959,000
	TOTAL	**$135,160,294**	**$248,163,434**	**$383,323,728**

Example: Santa Monica, population ~100,000 people

CAP BUDGETS

- Survey of other cities’ CAPs reveals that financial commitments have <u>significantly</u> increased in the last 1-2 years, as cities face the dire reality of scientists predictions
- Attitude is: “Low hanging fruit” projects are done...now the hard work begins

GOAL AND TARGETS	INDICATOR	BASELINE	2018	CHANGE FROM BASELINE	IMPROVED OVER BASELINE	2020 TARGET
CLIMATE AND RENEWABLES						
Target: Reduce community-based greenhouse gas emissions by 33% from 2007 levels by 2020.	Total tonnes of community CO_2e emissions from Vancouver	2,765,000 tCO_2e (2007)	2,440,000 tCO_2e	-12%	Yes	1,865,000 tCO_2e
GREEN BUILDINGS						
Target 1: Require all buildings constructed from 2020 onward to be carbon neutral in operations.	Kilograms of CO_2e per square metre of newly built floor area	20.7 kgCO_2e/m^2 (2007)	11.8 kgCO_2e/m^2 (2017)	-43%	Yes	carbon neutral
Target 2: Reduce energy use and GHG emissions in existing buildings by 20% over 2007 levels.	Total tonnes of CO_2e from all community buildings	1,585,000 tCO_2e (2007)	1,415,000 tCO_2e	-11%	Yes	1,270,000 tCO_2e
GREEN TRANSPORTATION						
Target 1: Make the majority of trips (over 50%) by foot, bicycle and public transit.	Per cent mode share by walk, bike and transit	40%[1]	53% of trips	+13%	Yes	50% of trips
Target 2: Reduce average distance driven per resident by 20% from 2007 levels.	Total vehicle km driven per person	5,950 km (2007)	3,690 km	-38%	Yes	4,760 km
ZERO WASTE						
Target: Reduce total solid waste going to the landfill or incinerator by 50% from 2008 levels.	Annual solid waste disposed to landfill or incinerator from Vancouver[2]	480,000 tonnes (2008)	347,000 tonnes (2017)	-28%	Yes	240,000 tonnes
ACCESS TO NATURE						
Target 1: Ensure that every person lives within a five-minute walk of a park, greenway or other green space.[3]	Per cent of city's land base within a five-minute walk to a green space	92.6% (2010)	92.7%	+0.1%	Yes	95%
Target 2: Plant 150,000 additional trees.	Total number of additional trees planted	- - (2010)	122,000 trees	+122,000	Yes	150,000 trees
Target 3: Restore or enhance 25 hectares of natural areas between 2010 and 2020.	Total hectares of natural areas restored or enhanced	- - (2010)	27 hectares	+26	Yes	25 hectares
Target 4: Increase canopy cover to 22% by 2050.	Per cent of city's land area covered by tree-leaf canopies	18% (2013)	Survey results available in 2020	- -	- -	22% (2050)
CLEAN WATER						
Target 1: Meet or beat the most stringent of British Columbian, Canadian and appropriate international drinking water quality standards and guidelines.	Total number of instances of not meeting drinking water quality standards	0 instances (2006)	0 instances	0	Yes	0 instances
Target 2: Reduce per-capita water consumption by 33% from 2006 levels.	Total water consumption per capita	583 L/person/day (2006)	456 L/person/day	-22%	Yes	390 L/person/day
LOCAL FOOD						
Target: Increase city-wide and neighbourhood food assets by a minimum of 50% over 2010 levels.	Total number of neighbourhood food assets[4] in Vancouver	3,344 food assets (2010)	4,960 food assets	+49%	Yes	5,016 food assets
CLEAN AIR						
Target: Meet or beat the most stringent air quality guidelines from Metro Vancouver, BC, Canada, and the World Health Organization.	Total number of instances of not meeting of air quality standards for ozone, particulate matter (PM2.5), nitrogen dioxide and sulphur dioxide from both the Kits and Downtown stations combined[5]	27 instances (2008)	227 instances	+200	No	0 instances

Example: Vancouver

Low-Carbon Growth Milestones

INDICATORS	CARBON REDUCTIONS	ZNE HOMES	ALL-ELECTRIC HOMES	HOUSEHOLD ENERGY USE
METRICS	Emissions reduction from this strategy	Number of ZNE homes	Percentage of homes that are all-electric	Household energy use (gas and electricity)
PROGRESS MILESTONES	Thousands of tons of carbon reduced per year	Number of ZNE homes	Percentage of homes that are all-electric	Household energy consumption (kWhe and kWhth)
TODAY	–	<100	0%	14,988
2030	389	37,975	47%	10,626
2040	663	71,800	95%	6,547
2050	701	90,650	100%	5,704

Example: San Jose

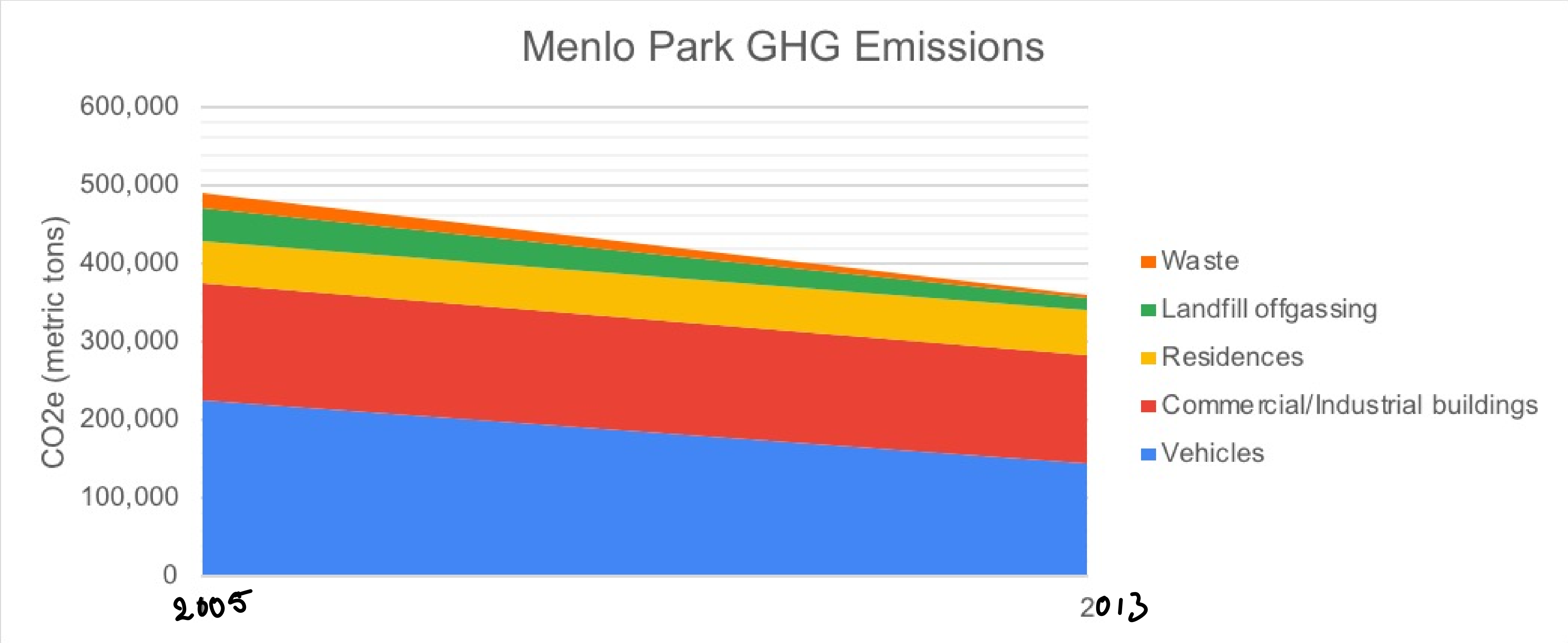
OTHER CITIES' GHG TARGETS

Table 3-2. Summary of Selected GHG Reduction Goals

Target Year	Goal	City
2025	40% below 1990 levels	San Francisco
2030	50% below 2008 levels	Seattle
	80% below 1990 levels	Palo Alto
2040	Net zero GHG emissions	Seattle
2050	80% below 1990 levels	Santa Cruz
	80% below 2000 levels	Berkeley
	83% below 2005 levels	Oakland

PROPOSED GOAL: 90% BY 2030

Menlo Park Community Greenhouse Gas Emissions						
	2005	2013		2018	2030	2050
Vehicles	225,885	144,171	-36%			
Commercial/Industrial buildings	147,316	140,567	-5%			
Residences	54,016	57,668	7%			
Landfill offgassing	44,195	14,417	-67%			
Waste	19,642	3,604	-82%			
Total Emissions (metric tons of CO2e)	491,054	360,427	-27%			



Changing Company Culture Requires a Movement, Not a Mandate

Bryan WalkerSarah A. Soule • June 20, 2017

Culture is like the wind. It is invisible, yet its effect can be seen and felt. When it is blowing in your direction, it makes for smooth sailing. When it is blowing against you, everything is more difficult.

For organizations seeking to become more adaptive and innovative, culture change is often the most challenging part of the transformation. Innovation demands new behaviors from leaders and employees that are often antithetical to corporate cultures, which are historically focused on operational excellence and efficiency.

But culture change can't be achieved through top-down mandate. It lives in the collective hearts and habits of people and their shared perception of "how things are done around here." Someone with authority can demand compliance, but they can't dictate optimism, trust, conviction, or creativity.

At IDEO, we believe that the most significant change often comes through social movements, and that despite the differences between private enterprises and society, leaders can learn from how these initiators engage and mobilize the masses to institutionalize new societal norms.

Dr. Reddy's: A Movement-Minded Case Study

One leader who understands this well is G.V. Prasad, CEO of Dr. Reddy's, a 33-year-old global pharmaceutical company headquartered in India that produces affordable generic medication. With the company's more than seven distinct business units operating in 27 countries and more than 20,000 employees, decision making had grown more convoluted and branches of the organization had become misaligned. Over the years, Dr. Reddy's had built in lots of procedures, and for many good reasons. But those procedures had also slowed the company down.

Prasad sought to evolve Dr. Reddy's culture to be nimble, innovative, and patient-centered. He knew it required a journey to align and galvanize all employees. His leadership team began with a search for purpose. Over the course of several months, the Dr. Reddy's team worked with IDEO to learn about the needs of everyone, from shop floor workers to scientists, external partners, and investors. Together they defined and distilled the purpose of the company, paring it down to four simple words that center on the patient: "Good health can't wait."

But instead of plastering this new slogan on motivational posters and repeating it in all-hands meetings, the leadership team began by quietly using it to start guiding their own decisions. The goal was to *demonstrate* this idea in action, not talk about it. Projects were selected across channels to highlight agility, innovation, and customer centricity. Product packaging was redesigned to be more user-friendly and increase adherence. The role of sales representatives in Russia was recast to act as knowledge hubs for physicians, since better physicians lead to healthier patients. A comprehensive internal data platform was developed to help Dr. Reddy's employees be proactive with their customer requests and solve any problems in an agile way.

At this point it was time to more broadly share the stated purpose — first internally with all employees, and then externally with the world. At the internal launch event, Dr. Reddy's employees learned about their purpose and were invited to be part of realizing it. Everyone was asked to make a personal promise about how they, in their current role, would contribute to "good health can't wait." The following day Dr. Reddy's unveiled a new brand identity and website that publicly stated its purpose. Soon after, the company established two new "innovation studios" in Hyderabad and Mumbai to offer additional structural support to creativity within the company.

Prasad saw a change in the company culture right away:

> After we introduced the idea of "good health can't wait," one of the scientists told me he developed a product in 15 days and broke every rule there was in the company. He was proudly stating that! Normally, just getting the raw materials would take him months, not to mention the rest of the process for making the medication. But he was acting on that urgency. And now he's taking this lesson of being lean and applying it to all our procedures.

What Does a Movement Look Like?

To draw parallels between the journey of Dr. Reddy's and a movement, we need to better understand movements.

We often think of movements as starting with a call to action. But movement research suggests that they actually start with emotion — a diffuse dissatisfaction with the status quo and a broad sense that the current institutions and power structures of the society will not address the problem. This brewing discontent turns into a movement when a voice arises that provides a positive vision and a path forward that's within the power of the crowd.

What's more, social movements typically start small. They begin with a group of passionate enthusiasts who deliver a few modest wins. While these wins are small, they're powerful in demonstrating efficacy to nonparticipants, and they help the movement gain steam. The movement really gathers force and scale once this group successfully co-opts existing networks and influencers. Eventually, in successful movements, leaders leverage their momentum and influence to institutionalize the change in the formal power structures and rules of society.

Practices for Leading a Cultural Movement

Leaders should not be too quick or simplistic in their translation of social movement dynamics into change management plans. That said, leaders can learn a lot from the practices of skillful movement makers.

Frame the issue. Successful leaders of movements are often masters of framing situations in terms that stir emotion and incite action. Framing can also apply social pressure to conform. For example, "Secondhand smoking kills. So shame on you for smoking around others."

In terms of organizational culture change, simply explaining the need for change won't cut it. Creating a sense of urgency is helpful, but can be short-lived. To harness people's full, lasting commitment, they must feel a deep desire, and even responsibility, to change. A leader can do this by framing change within the organization's purpose — the "why we exist" question. A good organizational purpose calls for the pursuit of greatness in service of others. It asks employees to be driven by more than personal gain. It gives meaning to work, conjures individual emotion, and incites collective action. Prasad framed Dr. Reddy's transformation as the pursuit of "good health can't wait."

Demonstrate quick wins. Movement makers are very good at recognizing the power of celebrating small wins. Research has shown that demonstrating efficacy is one way that movements bring in people who are sympathetic but not yet

When it comes to organizational culture change, leaders too often fall into the trap of declaring the culture shifts they hope to see. Instead, they need to spotlight *examples of actions* they hope to see more of within the culture. Sometimes, these examples already exist within the culture, but at a limited scale. Other times, they need to be created. When Prasad and his leadership team launched projects across key divisions, those projects served to demonstrate the efficacy of a nimble, innovative, and customer-centered way of working and of how pursuit of purpose could deliver outcomes the business cared about. Once these projects were far enough along, the Dr. Reddy's leadership used them to help communicate their purpose and culture change ambitions.

Harness networks. Effective movement makers are extremely good at building coalitions, bridging disparate groups to form a larger and more diverse network that shares a common purpose. And effective movement makers know how to activate existing networks for their purposes. This was the case with the leaders of the 1960s civil rights movement, who recruited members through the strong community ties formed in churches. But recruiting new members to a cause is not the only way that movement makers leverage social networks. They also use social networks to spread ideas and broadcast their wins.

Leadership at Dr. Reddy's did not hide in a back room and come up with their purpose. Over the course of several months, people from across the organization were engaged in the process. The approach was built on the belief that people are more apt to support what they have a stake in creating. And during the organization-wide launch event, Prasad invited all employees to make the purpose their own by defining how they personally would help deliver "good health can't wait."

Create safe havens. Movement makers are experts at creating or identifying spaces within which movement members can craft strategy and discuss tactics. Such spaces have included beauty shops in the Southern U.S. during the civil rights movement, Quaker work camps in the 1960s and 1970s, the Seneca Women's Encampment of the 1980s and early 1990s. These are spaces where the rules of engagement and behaviors of activists are different from those of the dominant culture. They're microcosms of what the movement hopes will become the future.

The dominant culture and structure of today's organizations are perfectly designed to produce their current behaviors and outcomes, regardless of whether those outcomes are the ones you want. If your hope is for individuals to act differently, it helps to change their surrounding conditions to be more supportive of the new behaviors, particularly when they are antithetical to the dominant culture. Outposts and labs are often built as new environments that serve as a microcosm for change. Dr. Reddy's established two innovation labs to explore the future of medicine and create a space where it's easier for people to embrace new beliefs and perform new behaviors.

Embrace symbols. Movement makers are experts at constructing and deploying symbols and costumes that simultaneously create a feeling of solidarity and demarcate who they are and what they stand for to the outside world. Symbols and costumes of solidarity help define the boundary between "us" and "them" for movements. These symbols can be as simple as a T-shirt, bumper sticker, or button supporting a general cause, or as elaborate as the giant puppets we often see used in protest events.

Dr. Reddy's linked its change in culture and purpose with a new corporate brand identity. Internally and externally, the act reinforced a message of unity and commitment. The entire company stands together in pursuit of this purpose.

The Challenge to Leadership

Unlike a movement maker, an enterprise leader is often in a position of authority. They can mandate changes to the organization — and at times they should. However, when it comes to culture change, they should do so sparingly. It's easy to overuse one's authority in the hopes of accelerating transformation.

It's also easy for an enterprise leader to shy away from organizational friction. Harmony is generally a preferred state, after all. And the success of an organizational transition is often judged by its seamlessness.

In a movements-based approach to change, a moderate amount of friction is positive. A complete absence of friction probably means that little is actually changing. Look for the places where the movement faces resistance and experiences friction. They often indicate where the dominant organizational design and culture may need to evolve.

And remember that culture change only happens when people *take action*. So start there. While articulating a mission and changing company structures are important, it's often a more successful approach to tackle those sorts of issues after you've been able to show people the change you want to see.

San Francisco Bay: New plan to combat sea level rise

Airports, roads, office buildings, sewage treatment plants at risk

Paul Rogers • May 2, 2019 at 1:37 pm

Waves break over the seawall at Pier 14 along the San Francisco Embarcadero during high tide on Feb. 14, 2011 (Photo: Dave Rauenbuehler, Port of San Francisco)

There's only one San Francisco Bay.

But the Bay Area is made up of nine counties and 101 cities, each with its own politics, local rules and shorelines, differences that can make it complicated to figure out how to protect billions of dollars of highways, airports, sewage treatment plants, homes and offices from the rising seas, surging tides and extreme storms climate change is expected to bring in the years ahead.

A new report released Thursday aims to make that gargantuan challenge a little easier.

The "San Francisco Shoreline Adaptation Atlas" divides San Francisco Bay's 400 miles of shoreline into 30 zones, and recommends a range of options — from building more tidal wetlands to constructing concrete sea walls — for each zone, based on local conditions.

The scientists and planners ,who spent two years writing the 250-page document, hope it will serve as a guide for cities, counties and other agencies to work together from a common plan, rather than randomly building projects individually that could make flooding worse for neighboring areas.

"The problem is that the Bay Area is ground zero for sea level rise in California. We're a bathtub. We're a bowl," said Warner Chabot, executive director of the San Francisco Estuary Institute, a non-profit scientific research group in Richmond that was a co-author on the report.

"Airports, highways and wastewater treatment plants are located right near the shoreline," he said. "Even if you live in the foothills, if you want to flush your toilet, or if you want to get to work, or school, or the hospital, sea level rise is going to affect you."

San Francisco Bay's waters already have risen 8 inches since the mid-1800s. A tide gauge at Fort Point, next to the Golden Gate Bridge, has recorded measurements since 1850.

Recent studies by the U.S. Geological Survey, National Academy of Sciences and other scientific organizations estimate that, depending on the amounts of greenhouse gases released into the atmosphere in the coming years, the Pacific Ocean on the West coast — and in turn, the water in San Francisco Bay — will rise up to two feet by 2050 and up to five feet by 2100.

In recent years, during high tides in storms, waves have crashed over the seawall on San Francisco's Embarcadero, flooding roads.

And the pace is accelerating. The 10 hottest years on Earth since 1880 all have occurred since 1998, according to NASA, NOAA and other federal agencies.

Planning has begun in many Bay Area cities. But as with controversies over where to build new housing or transportation projects, passions and gridlock

Thursday's atlas looks at 27 different options, including building tidal wetlands to absorb wave action, adding new beaches, constructing new levees, changing zoning rules and raising some structures.

"We aren't telling people what to do. We are giving people tools so they can decide what to do," said Laura Tam, sustainable development policy director with SPUR, an urban planning think tank that co-wrote the report.

The most vulnerable areas are places built generations ago on wetlands and parts of the bay that were later filled in. They include San Francisco and Oakland airports, Foster City, San Rafael, Corte Madera, East Oakland, San Leandro, Alviso, East Palo Alto and Redwood Shores, experts say.

"In Superstorm Sandy in New York, no one could imagine that New York City would flood, but the flooding went up to the historical shoreline," said Julie Beagle, an environmental scientist with the San Francisco Estuary Institute. "Everything that flooded was built on fill. It will be the same thing here. The bay is basically taking back areas."

Different places will need different strategies, she noted. Highway 37 in the North Bay, which flooded this spring, may need to be raised up on supports, like the Highway A1A causeway that connects the Florida Keys. Former salt ponds in the South Bay are being converted to tidal marsh, which dulls wave action. Airport runways will need to be built higher, and in some places it will make sense to let the bay waters reclaim undeveloped areas.

Overall, it's cheaper to use natural solutions than to try and wall off huge sections of the shoreline with concrete. And natural solutions preserve birds, fish and other wildlife.

"What are we going to do about it?" Beagle said. "How do we organize ourselves to adapt, and not leave our children a bay that is surrounded by concrete walls? These are hard choices, they are really emotional for people. But sea level rise is not going to stop at our city boundaries. We need to find a way to work together."

In 2012, Superstorm Sandy caused $69 billion in damage on the East Coast. Record storm surges destroyed seaside communities and sent flood waters pouring down the stairs in the New York City subway system, causing blackouts when the water hit electrical equipment. Afterward, former Mayor Michael Bloomberg outlined a $20 billion plan to protect the city.

Around San Francisco Bay, the Bay Conservation and Development Commission, a state agency that regulates construction within 100 feet of the bay shoreline, is working on studies with local communities to address sea-level rise. But the commission hasn't yet made the tough political calls. New rules to limit what can be built where on the shoreline are at least six years away, said Larry Goldzband, executive director of the commission.

"You have cities, counties, scores of special districts that need to work on this plan so it isn't seen as a top-down plan that is the subject of endless litigation," he said. "There has to be a regional agreement."

The final cost to protect the bay's shoreline will almost certainly cost tens of billions of dollars. And apart from Measure AA, a $12-per home annual parcel tax that voters approved in 2016 to raise $500 million for wetland restoration and flood control projects, no one knows where it will come from.

"We're going to have to go from a stroll to a sprint if we are going to stay ahead of the problem," said Chabot. "Unfortunately in most cases it takes a disaster to accelerate the type of planning that is necessary. Hopefully that won't occur here."

CITY OF MENLO PARK

ENVIRONMENTAL QUALITY COMMISSION

Quarterly Update from EQC Chair Ryann Price

AGENDA

- Updates
- Community Concerns
- Seeking guidance
- Next Steps

CITY OF
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UPDATES

CITY OF MENLO PARK

WHAT HAS HAS THE EQC BEEN UP TO?

- Reach Code Recommendation
  - Recommended council direct staff to develop amendments to the building code requiring new construction to be electrically heated for space & water as well as solar production for new nonresidential buildings.
  - Council enhanced the recommendation including additional commercial kitchen and dryer electrification requirements.
  - The estimated result will reduce GHG added to the city through development by 6K tons/year for the next 30-50 years with the development currently planned.
- Heritage tree appeals
  - Three appeals in 2019 to date
- Arbor Day Celebration
  - Tree planting ceremony with Mayor Mueller at the Boys & Girls Club in Bell Haven
- Currently working on Climate Action Plan Update

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COMMUNITY CONCERNS

CITY OF MENLO PARK

PUBLIC CONCERNS VOICED TO EQC

- Gas powered leaf blowers
  - Gas powered leaf blowers impact our climate, however, there are larger sources of impact and this issue is also motivated by noise concerns.
  - What might be the right commission to address the public concerns regarding leaf blowers?
- San Francisquito Creek
  - Recommendation from the joint power authority brought forward concerns regarding habitat preservation and restoration
  - How would you like the EQC to engage?
- PACE
  - There is currently one provider for PACE funding in Menlo Park.
  - There is a concern this creates a monopoly in a market were several options are available and lending regulations have been addressed to make the lending more consumer friendly

CITY OF MENLO PARK

SEEKING GUIDANCE

CITY OF MENLO PARK

SEEKING GUIDANCE

- Earth Day Proclamation
  - What role would you look to the EQC to play?
- The pesticides' ban
  - How might the EQC engage on this topic?
- Workplan
  - Time investment in Heritage Tree Appeals
  - EQC and staff time could be put to greater use on greenhouse gas reduction activities for the city. Projects like the reach code update.

CITY OF MENLO PARK

NEXT STEPS

WHAT DO YOU SEE AS PRIORITIES FOR THE EQC?

- ?

THANK YOU

CITY OF MENLO PARK