

HISTORICAL VEGETATION CHANGE IN OAKLAND AND ITS IMPLICATIONS FOR URBAN FOREST MANAGEMENT

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Abstract. The history of Oakland, California's urban forest was researched to determine events that could influence future urban forests. Vegetation in Oakland has changed drastically from a preurbanized area with approximately 2% tree cover to a present tree cover of 19%. Species composition of trees was previously dominated by coast live oak (*Quercus agrifolia*), California bay (*Umbellularia californica*), and coast redwood (*Sequoia sempervirens*) and is currently dominated by blue gum (*Eucalyptus globulus*), Monterey pine (*Pinus radiata*), and coast live oak. Many forces throughout the history of Oakland have shaped the current urban forest structure. These forces include the gold rush of the 1840's, the San Francisco earthquake of 1906, massive afforestation of the early 1900's, and various fires from 1923 to 1991. These historical forces and the impact they had on Oakland's urban forest are explored. Future forces that can alter any urban forest are presented and discussed.

Events that influenced urban forest structure and management issues in the past will likely occur again and influence urban forests in the future. By understanding what these past forces are, urban foresters can better prepare for present and future events that will influence urban forests for years to come. To understand how past events have influenced an urban forest, the history of Oakland, California's urban forest was researched. This paper presents the history of major events influencing Oakland's urban forest and discusses probable forces that will influence urban forests in the future.

Methods

In researching the history of Oakland's urban forest, black and white aerial photos from 1988 (1:12,000), 1959 (1:9,600), and 1939 (1:20,000) were sampled using a random dot grid to determine historical changes in urban forest and artificial (e.g., roads, buildings) cover (13). Historical documents and photographs were evaluated to analyze Oakland's vegetation before 1939.

Preurbanized species composition, stand areas,

and tree densities were estimated using historical maps and descriptions of vegetation (5, 8, 10, 11, 12). Present day urban forest structure in Oakland was determined by ground sampling 5% of the vegetation on all land uses in 1989 (13). Impacts of the 1991 fire in Oakland were subsequently analyzed using aerial photographs and ground data (14).

The Shannon-Weiner diversity index was used to estimate species diversity (2). This diversity index ranges from zero, for a community with only one species, to values of seven or more in some rich western forests. Eastern deciduous forests range in diversity index values from approximately 1.7 to 3.1 (2).

Historical Changes in Oakland's Vegetation

Vegetation before urbanization in Oakland was dominated by grass, shrub, and marshlands that occupied approximately 98% of the area. Trees in riparian woodlands covered approximately 1.1% of Oakland's preurbanized lands, redwood stand - 0.7%, and coast live oak stand - 0.5% (13). Original forest cover is estimated at 2.3% with an original tree species composition of about 10 species dominated by coast live oak (*Quercus agrifolia*), California bay (*Umbellularia californica*), and coast redwood (*Sequoia sempervirens*); and an estimated Shannon-Weiner diversity index value of 1.9. A panoramic series of photos depicts the early vegetation of northern Oakland (Figure 1).

Many factors throughout the history of Oakland have led to changes in the vegetative structure. A chronology of these factors is given to illustrate how various forces have changed the vegetative structure of Oakland. The first two of these factors occurred before the incorporation of the city in 1854.

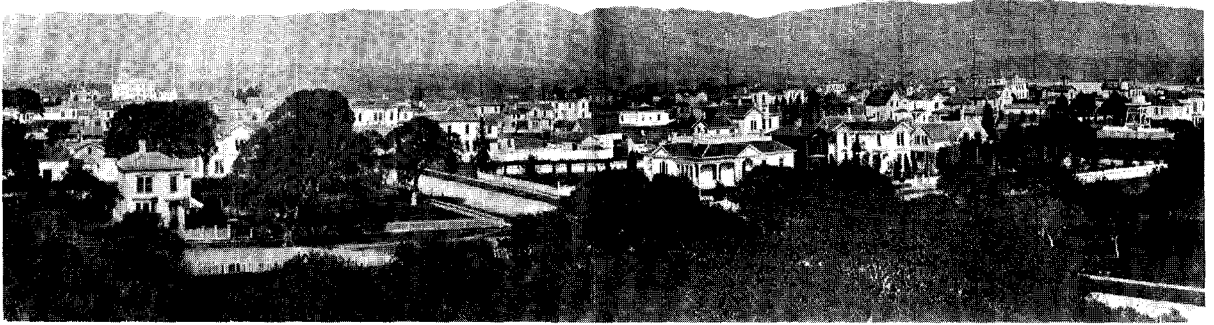


Figure 1. Oakland - 1869. Panorama taken from 14th and Webster Street. Photo courtesy of the Oakland History Room, Oakland Public Library.

1500 B.C. - early 1800s: Costanoan Indians. The Costanoan Indians deliberately manipulated the vegetation of the Oakland area. They altered the native oak stand composition and spread by burning vegetation to facilitate the collection of acorns (6).

1840s: Discovery of Gold in California and Removal of Redwoods. As early as the late-1700s, redwoods were logged from Oakland for use in the church of Mission San Jose (4, 6). Redwood logging in Oakland was recorded in the early to mid-1840s but subsided in 1848 due to the discovery of gold. However, the discovery of gold, which gave the redwood stand a respite from logging, ultimately led to its demise. With the gold rush, came an overwhelming demand for lumber and by 1860 not a single giant redwood was left in Oakland (4). Besides decimating the redwoods, the gold rush also brought a large influx of immigrants, and thus the urbanization of Oakland began.

1850 - 1890s: Early City Development and Destruction of Native Oak Stand. The urbanization of Oakland began in 1850 with the development of a gridded street pattern in a stand of coast live oak. This early urbanization of Oakland gradually destroyed the oak stand, and by the 1890s nearly all of the original oaks were gone. In the 1850s, an ordinance was passed by the city council prohibiting oak removal without council permission. Unfortunately, the council never halted the removal of the trees (9).

1880s through 1920s: Afforestation of Oakland Hills. The grassy hills of Oakland underwent a dramatic transformation in the late 19th and early 20th century. The first major afforestation in the Oakland hills was done by Joaquin Miller. In 1886, Joaquin Miller purchased 69 acres and proceeded to plant his land with pines, cypress, acacia, and eucalyptus (17, 18).

More large-scale plantings were accomplished around the turn of the century for three reasons: 1) "primarily as a measure against the recurring fires that almost every year swept over the hills..." (18); 2) to increase the value of land holdings (18); and 3) to profit from future lumber sales of eucalyptus trees. Between 1910 and 1913, Frank Havens is estimated to have planted between 1 and 8 million trees, mostly eucalyptus, on the hills in and around Oakland (19). Many of the eucalyptus were planted for lumber sale profits, but in 1913, the eucalyptus boom was over as it was discovered that small blue gums could not be made into timber and large trees require special handling (19).

1903: City Involvement in Street Tree Planting. In the early 1900s, the City Beautiful Movement began. During this period, the city became increasingly involved in urban vegetation. In 1903, a citizen committee was organized and persuaded the city to initiate a street tree planting program (16). Subsequent developments during the next 30 years typically included street trees. In 1932, the city began to designate "official trees" for each street to ensure uniform planting.

In 1948, all existing street trees were classified as either: 1) official, 2) interim, or 3) unofficial. Official trees are generally small, long-lived trees planted or approved by the city. Interim trees are considered desirable but their ultimate size is too large. Interim trees are eventually to be replaced by official trees. Unofficial trees consist of trees planted without city approval and are to be removed as soon as possible (16).

1906: San Francisco Earthquake. The 1906 earthquake had an indirect impact on the vegetation of Oakland. After the earthquake, a large influx of people relocated to Oakland. This sudden increase in population prompted a housing boom that directly altered Oakland's vegetation in a relatively short period of time.

1920s: The Start of the Automobile Era. The automobile allowed residents to live farther from places of employment; thereby, expediting housing developments. In 1923 there was a 900% increase in the number of dwellings built compared with the number in the previous five years (1).

Early 1940s: World War II. World War II brought an increase in jobs and consequently increased Oakland's population. The war also facilitated a shift in the socioeconomic makeup of Oakland with a large increase in women and minorities. Changes in socioeconomic status can alter vegetative structure through changes in vegetation preferences and management activities.

Fire and Fire Potential. The last factors that continue to affect vegetation in Oakland are fire and the threat of fire. Past fires in the Oakland area (e.g., 1923 - 625 homes destroyed; 1970 - 37 homes destroyed; 1991 - 3,210 homes and apartments destroyed) have directly altered urban vegetation structure and increased the public concern over fire.

After a freeze in 1972 damaged many eucalyptus trees, large-scale fuelbreaks between wildland and residential areas were constructed (7), and eucalyptus removal in Oakland still continues today as a fire protective measure.

The 1991 fire decreased overall tree cover in Oakland (assuming all trees in the burn area are killed or removed) from 21 to 19% with the greatest impact occurring in wildland and residential areas. The effect of the fire on vegetation in surrounding

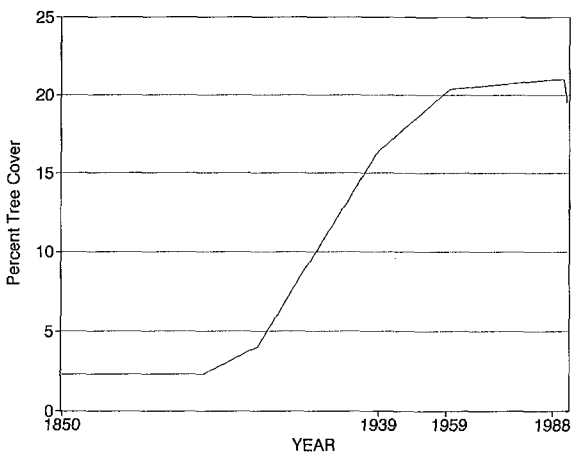


Figure 2. Estimated historical changes in percentage tree cover in Oakland, California, based on data collected from 1850, 1939, 1959, 1988 and 1992. Percentage tree cover probably remained relatively static in the late 1800s because destruction of cover due to removal of oaks and redwoods was offset by tree plantings associated with new developments and orchards. Tree cover increased near the turn of the century due to afforestation of Oakland hills and continuing development in grasslands. Loss of cover in 1991 is associated with the Oakland fire.

non-burned areas remains to be seen as people react to increased awareness of urban forest fire potential.

Present Structure of Oakland's Urban Forest

These past and present factors along with the gradual urbanization of the Oakland area, have and continue to alter vegetation structure. Amount of wildland in Oakland has been continually decreasing as other land uses increased, with 47% of Oakland in wildlands in 1939, 30% in 1959, and 20% in 1988. Overall tree cover in Oakland had been on the rise until the 1991 fire (Figure 2). Amount of impervious surface cover (e.g., buildings, roads) also has been on the rise, increasing from 28.2% in 1939 to 49.1% in 1988. Today, Oakland's urban forest structure is drastically different from that of preurbanized days (Figure 3).

Along with the influx of settlers to Oakland came an influx of new tree species. Tree species diversity, as expressed by the Shannon-Weiner diversity index, increased from approximately 1.9

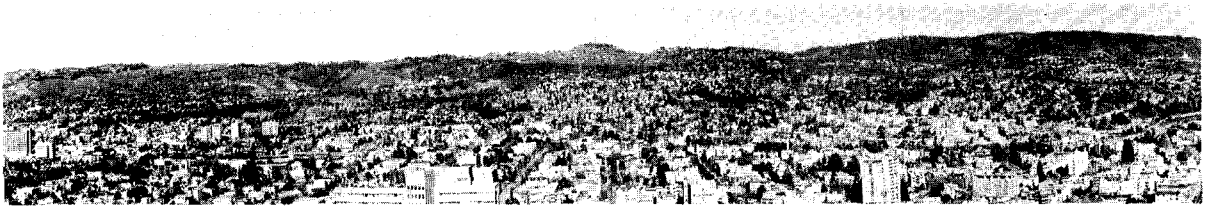


Figure 3. Oakland - 1991. Panorama taken from 1 Kaiser Plaza, March, 1991.

in 1850 to 5.1 in 1988. Oakland's original species composition has increased from approximately 10 tree species to more than 350 (13).

Oakland's urban forest is presently dominated by blue gum (*Eucalyptus globulus*), Monterey pine (*Pinus radiata*), coast live oak (*Quercus agrifolia*), and California bay (*Umbellularia californica*). These four species represent about half of the total cover and half of the total number of trees in Oakland. Today, only 31% of the existing trees are native to Oakland; the plurality of trees (38%) are native to Australia/New Zealand (13).

Forces of Urban Vegetation Change

To sustain a desirable urban forest structure, urban foresters must be cognizant of forces affecting urban vegetation structure and change. Along with recognizing these forces, urban foresters must also be aware of how they can attain a more desirable urban forest structure.

The Oakland landscape has changed drastically over the last 150 years. Various forces in the past have led to significant vegetation changes. In general, these forces have been dictated by economics (e.g., desire for profit associated with early mass plantings or development activities that led to the demise of native stands), but limits to the amount of change can be controlled by nature (e.g., winter temperatures or drought can limit species composition) or planning (e.g., ordinance to potentially limit oak removals). Natural forces also can directly alter vegetation structure (e.g., fire, insect outbreaks), and the associated degree of change in vegetation can be influenced to some extent by planning and economics (i.e., implementation and costs of preventative or control measures).

Future forces that can detrimentally change forest structure must be recognized so that man-

agers can avoid, control, or direct the impact of these forces through planning and management practices. Urban foresters must understand the potential changes to their urban forest based on its natural environment (e.g., temperature and precipitation extremes; potential species composition and pests) and economic/planning environment (political structure and budgetary constraints).

There are four general classes of forces that can alter urban forest structure: 1) anthropogenic direct -- direct human actions (e.g., large-scale planting or removals), 2) anthropogenic indirect -- human actions that indirectly lead to change in vegetation through such factors as changes in demographics (e.g., war, economic depression), 3) natural direct -- direct changes in vegetation due to nature (e.g., fire, storms, insects), and 4) natural indirect -- natural factors that indirectly lead to vegetation changes through changes in human population structure (e.g., large earthquakes). Vegetation managers can do little about many indirect forces (e.g., war, depression), but they can control the influence of the direct forces on urban forest structure through proper planning.

Probable future anthropogenic forces of change that urban forest managers will likely encounter include: 1) species fads -- through education, ordinances, and working with nurseries, managers can control the influx of undesirable fad species; 2) development of wildlands -- planners and the public must make informed decisions on cost and benefits of loss or preservation of city wildlands; and 3) influx of money to plant trees (e.g., Urban and Community Forestry Program) -- managers can use this money to improve the urban environment by planting proper species in correct locations as efficiently as possible before funding sources disappear.

Probable future natural forces include: 1) drought and/or freezing temperatures — planting of more drought tolerant and/or winter hardy species will minimize the impact of drought and cold snaps; 2) storms -- pruning and reduction of easily wind-damaged species can reduce the impact of future storms; 3) natural aging -- managing toward an all-aged forest structure can reduce the potential for major forest change that can occur with even-aged forests as they reach senescence; 4) insect and disease outbreaks — understanding tree population structure and potential pests can aid in preparing for and minimizing future pest problems; and 5) fire — properly manipulating urban forest structure can reduce the potential of wildfire ignition and spread.

Directing Urban Forest Change

Formulating and implementing appropriate plans can lead to desirable urban forest change and structure. Plans or ordinances without effective implementation are like no plans at all as exhibited by Oakland's early oak removal ordinance. The city's failure to prevent oak removals led to the early demise of the native oak stand. The city today has a street tree plan with an official tree list that is updated as more is learned about individual species. The city is also developing a comprehensive master plan for Oakland parks (Acosta, pers. commun., 1992). However, overall vegetation plans that encompass the entire urban forest (i.e., include privately owned trees) are needed because publicly owned vegetation is generally the minority of the urban forest (e.g., street trees in Oakland represent less than 2% of Oakland's 1.6 million urban trees (15)). Privately owned trees not only greatly influence the city's physical environment and vegetation management issues, but also affect the visual quality of the city (20).

Oakland, along with other cities and agencies, has formed a vegetation management consortium to develop a comprehensive vegetation management plan that includes privately owned vegetation for high-risk fire prone areas of the East Bay hills. This plan, funded by local agencies and a Hazard Mitigation Grant from the Federal Emergency Management Agency (FEMA), is designed to alter vegetation structure to reduce the poten-

tial for wildfire ignition and spread (Acosta, pers. commun., 1992). Comprehensive vegetation plans can be focused on specific problems such as fire, but must also consider other attributes or management issues associated with vegetation structure. Because different forest structures are often needed to attain various management goals, management priorities must be set. In the East Bay hills plan, fire safety is the dominant concern, but a fire safe landscape will likely alter wildlife habitat, visual aesthetics, local building energy relations, and so on. These potential conflicts probably are not a great concern in the East Bay hills because of the importance of human safety. However, conflicting management results need to be addressed in management plans so that informed decisions can be made regarding the final plan. Planning and management priorities can aid in achieving an optimal plan.

In developing an overall urban forest plan, urban foresters must consider not only urban forest structure, but also forces of urban forest change. Some of the best ways to minimize possible negative impacts of direct anthropogenic forces are through public education and ordinances. A properly educated public will likely develop a desirable urban forest structure. Ordinances can be used to directly control actions influencing urban forest structure (e.g., 3). Once an optimal urban forest structure is attained, either through education, ordinances, planning and/or direct management, the impact of direct natural forces will be minimized and beneficial forest functions (e.g., building energy conservation, lower city temperatures, air pollution mitigation, etc.) will be enhanced. Conversely, improper structure can exacerbate some direct natural forces (e.g., increase outbreak and spread of insects, diseases, or fire) increasing costs and reducing forest benefits.

Along with striving toward an optimal urban forest structure, urban foresters must consider the likelihood of future forces of change so they can plan for and make rapid and informed decisions on how to direct urban forest development (e.g., fire is an important issue in Oakland, but may not be for other cities). Understanding current urban forest structure (e.g., through street tree invento-

ries, air photo analyses, sampling of non-street vegetation) is the first step in determining the likely forces of urban forest change. Various species or age structures may be more prone to certain insects, diseases, fire, or storm damage. For example, although exotic species increase the diversity of the urban forest and reduce the potential impact of species-specific catastrophic events (e.g., Dutch elm disease), exotic species can lead to devastating insect or disease problems because an imported pest of exotic species often lacks natural controls. A recently introduced pest into California, the eucalyptus long-horned borer (*Phoracantha semipunctata*), may have a major impact on Oakland's urban forest, which is dominated by exotic eucalyptus.

Once current structure and associated possible future forces of change are understood, management plans can be designed to diminish the likelihood of the event occurring. If the event does occur, the plan will aid in a more desirable outcome. In the past, many cities have not responded or have responded too late after a major force of change; thus they had less control of the situation and increased the cost for corrective actions.

Although many of the ideas presented here may seem like luxuries to cities with minimal budgets, the relatively minimal investment for increased education, and developing and implementing ordinances and/or management plans can deliver large benefits through reduction of future problems and costs. Working with other private and public groups to develop and implement these goals can help ensure a successful program for developing optimal urban forest structure.

Conclusions

Many forces in the past have altered urban forest structure, and these same forces will continue to alter urban forest structure in the future. Urban foresters can minimize the undesirable impact of possible future forces by understanding what they might be and planning accordingly. The five main steps to help direct and sustain proper urban forest structure are to: 1) understand current forest structure; 2) consider probability of future events that will influence forest structure; 3) develop a long-term comprehensive management

plan that accounts for probable future events and develops optimal forest structure; 4) determine best methods within city's political, economic, and natural systems to implement proper courses of action; and 5) implement plan.

Proper or optimal urban forest structure is specific to each city and is best inferred from local experience and management goals in conjunction with research findings. Through education, ordinances, planning, and management, proper urban forest structure can be attained and reduce the undesirable impacts of many forces of urban forest change while maintaining associated urban forest benefits. Urban foresters must incorporate urban forest change into urban forest management plans with goals of optimal forest structure on both public and private lands.

Acknowledgment. I thank Joe McBride; Rowan Rowntree; Tony Acosta and the City of Oakland, Office of Parks and Recreation for their help with various aspects of this project. I also thank Tony Acosta; Michael Stankovich and Mary Buchanan for their manuscript review. This research was supported in part by the University of California, Berkeley, and the City of Oakland, Office of Parks and Recreation.

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Résumé. L'historique de la forêt urbaine d'Oakland en Californie fut l'objet d'une recherche afin de déterminer les événements qui pourraient influencer sur le futur des forêts urbaines. La végétation d'Oakland s'est modifiée drastiquement d'une zone préurbanisée avec un couvert d'arbres de 2% à un couvert actuel de 19%. La composition en espèces était, à l'origine, dominée par le chêne vert de Californie (*Quercus agrifolia*), le laurier de Californie (*Umbellularia californica*) et le séquoia toujours-vert (*Sequoia sempervirens*) et l'est aujourd'hui par l'eucalyptus bleu (*Eucalyptus globulus*), le pin de Monterey (*Pinus radiata*) et le chêne vert de Californie. De nombreuses forces tout au cours de l'histoire d'Oakland ont façonné la structure actuelle de la forêt urbaine. Ces événements incluent la ruée vers l'or des années 1840, le tremblement de terre de 1906 à San Francisco, la déforestation massive du début du 20^e siècle et les nombreux feux de forêts de 1923 à 1991. Ces forces historiques et leurs impacts qu'ils eurent sur les arbres d'Oakland sont explorés. Les forces futures qui peuvent altérer une forêt urbaine quelconque sont présentées et discutées.

Zusammenfassung. Die Geschichte von Oakland, Kaliforniens Stadtwald wurde erforscht, um die Ereignisse, die zukünftige Stadtwälder beeinflussen können zu bestimmen. Die Vegetation in Oakland hat sich drastisch verändert von einer vor-urbanisierten Region mit schätzungsweise 2%iger Baumbedeckung zu einer gegenwärtigen Baumbedeckung von 19%. In der Artenzusammensetzung dominierten früher Küsteneiche (*Quercus agrifolia*), Kalifornischer Lorbeer (*Umbellularia californica*), und Küstensequoie (*Sequoia sempervirens*) und gegenwärtig dominieren Eukalyptus (*Eucalyptus globulus*), Monterey-Kiefer (*Pinus radiata*) und die Küsteneiche (*Quercus agrifolia*). Viele Kräfte haben während der Geschichte von Oakland auf die gegenwärtige Struktur eingewirkt, darunter der Goldrausch in den 1840ern, das Erdbeben von San Francisco im Jahre 1906, massive Aufforstung um 1900 und zahlreiche Brände von 1923 bis 1991. Diese historischen Einflüsse und deren Einfluß auf die Bäume in Oakland wurden ergründet, Zukünftige Einflüsse, die auf Stadtwälder wirken können, wurden dargestellt und diskutiert.