The History, Ecology and Future of Eucalyptus Plantations in the Bay Area

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Berkeley, CA
Commonwealth Club, San Francisco
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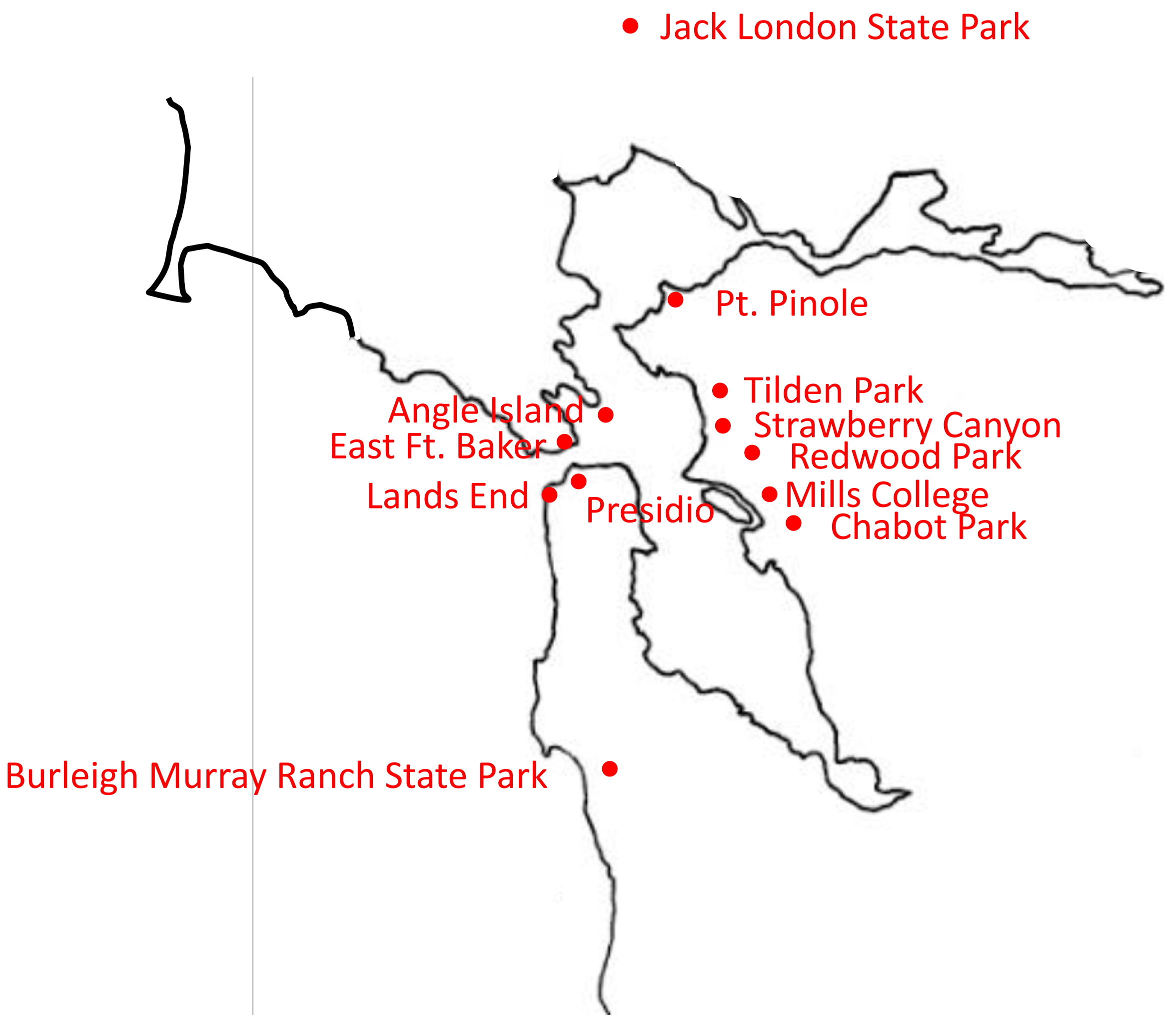
Link to talk on Youtube

"The Eucalyptus seems an indispensable element of this State's landscapes, as indigenously Californian as the redwoods, the poppy fields, the long white coastal beaches, the gleaming granite of the High Sierra." H. Gilliam, 1965

Overview

1. History of eucalyptus in California
2. Characteristics of eucalyptus plantations
3. Modification of site conditions by eucalyptus
4. Eucalyptus forests as habitat for wildlife
5. Future of eucalyptus plantations in California

Location of Eucalyptus Study Sites



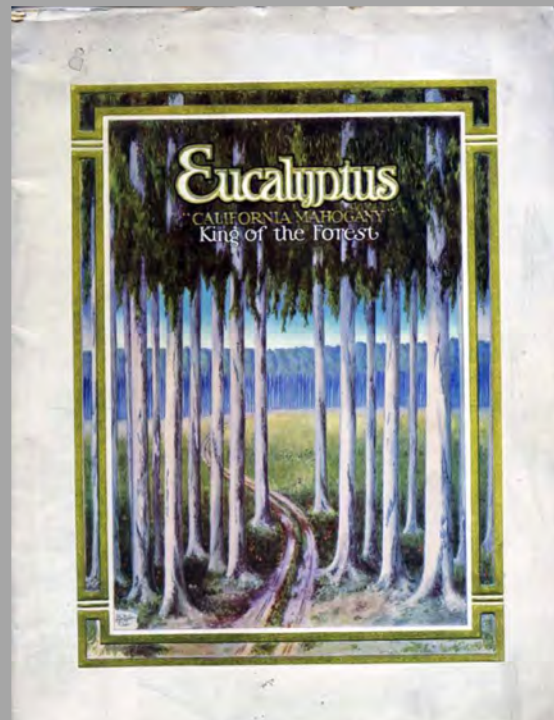
History

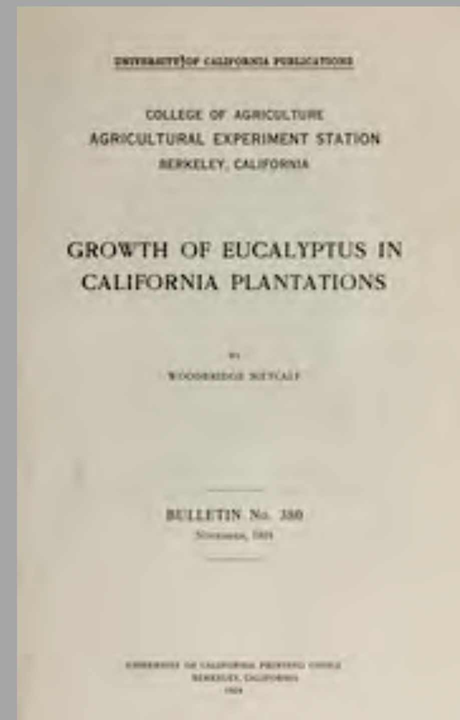
- Initial Introduction
- Planting during the 1870s
- Planting from 1906-1913
- Planting in the latter half of the 20th century

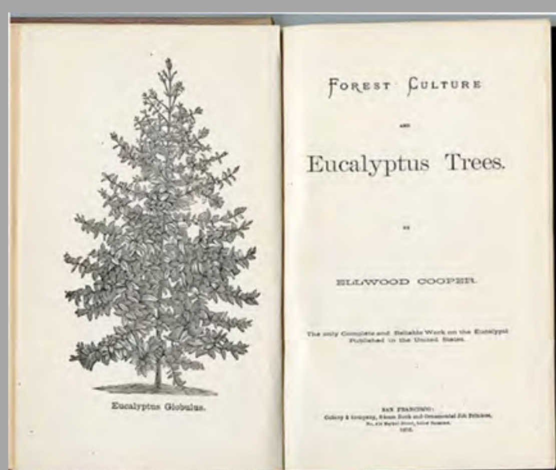
Initial Introduction of Eucalyptus to California

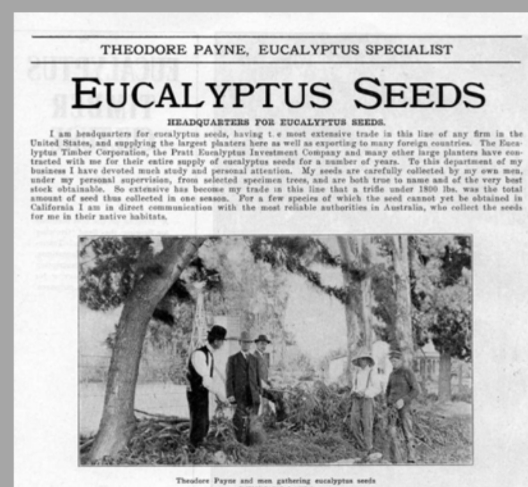
Eucalyptus Planting in the 1870s

Eucalyptus Planting 1906 -1912









Latter Half of the 20th Century

Propagating fast-growing eucalypts for energy crops

High rooting success has been achieved from seedling cuttings

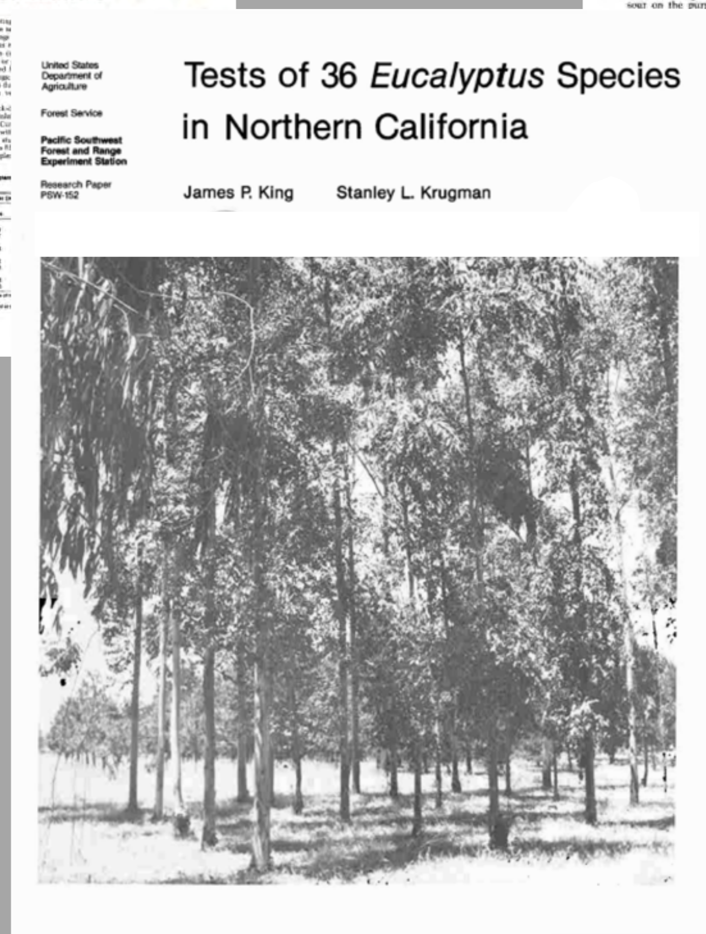
Source plants

Propagation

Cuttings are rooted in plastic planting tubes under intermittent misting.

Rooted C-1 eucalyptus stem cutting. Optimum rooting required about four weeks.

Trees from eucalyptus seedlings originally selected for uniformity may differ by two- or three-fold after transplanting because of genetic diversity.



United States Department of Agriculture

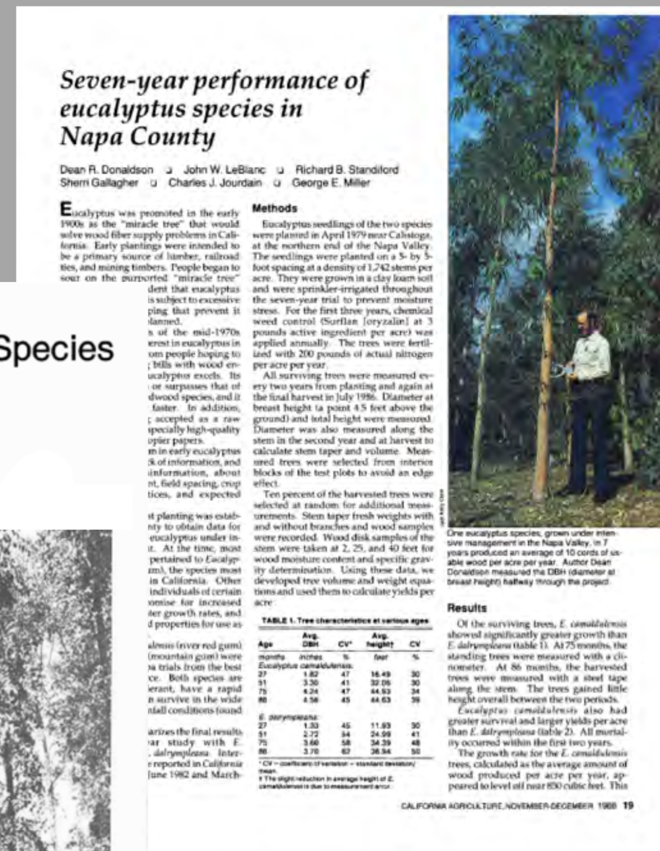
Forest Service

Pacific Southwest Forest and Range Experiment Station

Research Paper PSW-152

Tests of 36 *Eucalyptus* Species in Northern California

James P. King   Stanley L. Krugman



Seven-year performance of eucalyptus species in Napa County

Dean R. Donaldson □ John W. LeBlanc □ Richard B. Standiford
Sherri Gallagher □ Charles J. Jourdain □ George E. Miller

Methods

Results

One eucalyptus species, grown under intensive management in the Napa Valley, in 7 years produced an average of 10 cords of usable wood per acre per year. Author Dean Donaldson measured the DBH (diameter at breast height) halfway through the project.

CALIFORNIA AGRICULTURE, NOVEMBER-DECEMBER 1988 19

Major Species of Eucalyptus Planted in California

Blue Gum

Red Gum

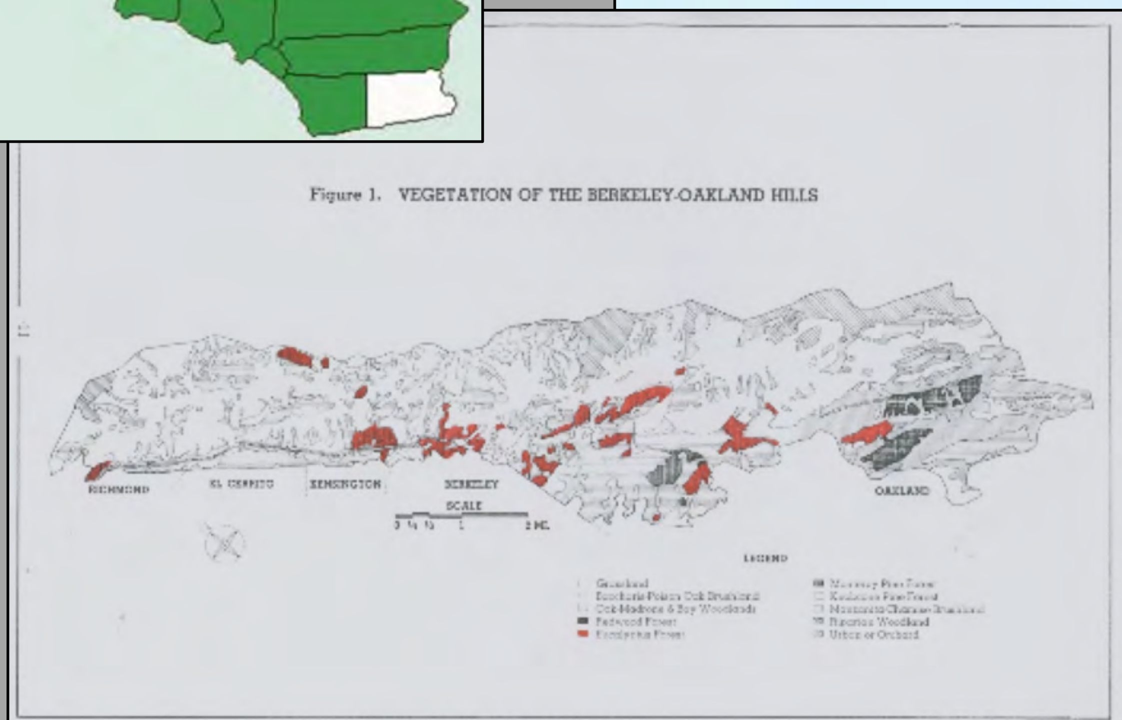
Sugar Gum

Red Ironbark

Silver Dollar

Lemon Scented

Distribution of Blue Gum Eucalyptus



Characteristics of Eucalyptus Plantations

Structural Characteristics

Location	Number of Stands	Ave. Stand Area (ac.)	Ave. Max. Height (ft.)	Ave. Max. Diameter (in.)	Ave. Number of trees/acre
Presidio	28	3.7	80	26	163
Land's End	4	2.3	75	26	364
Tilden Park	5	0.7	60	16	540
East Ft. Baker	1	8.1	50	36	1795

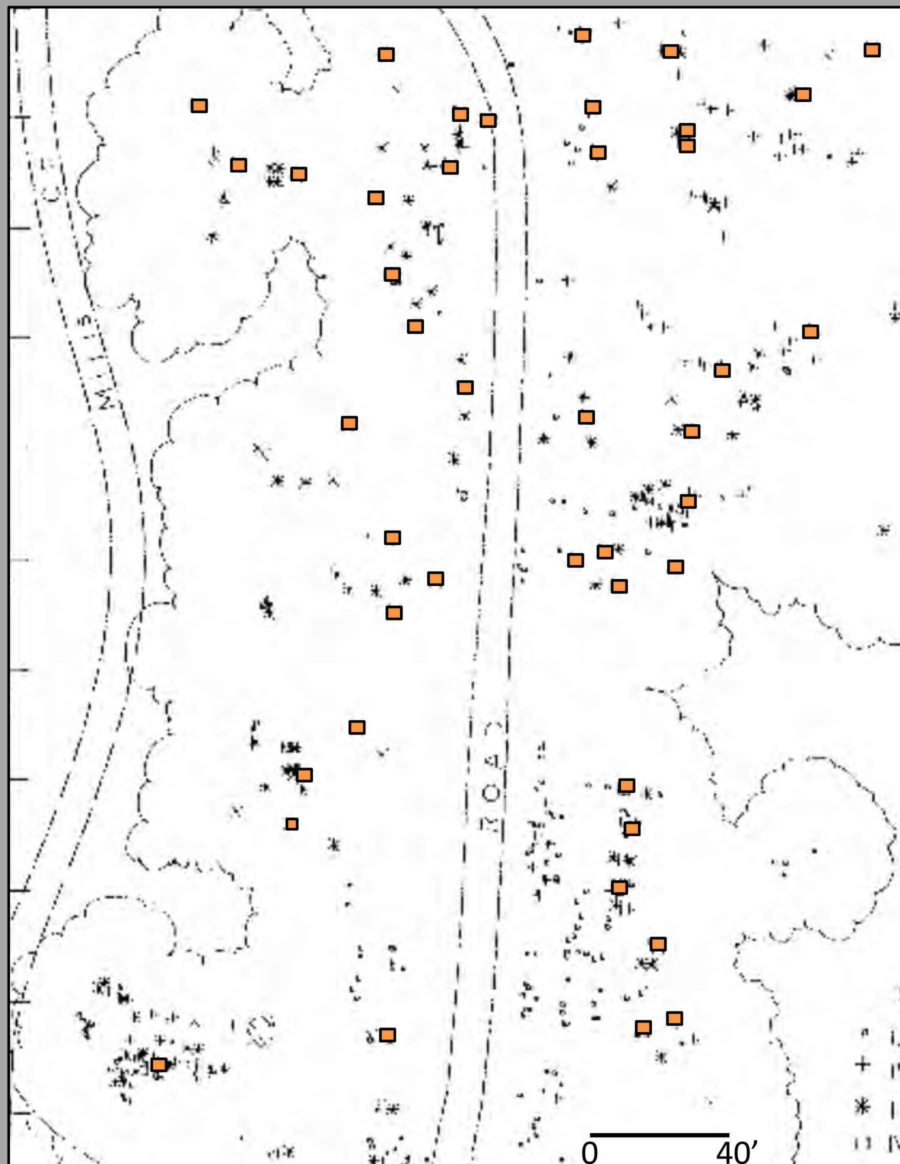
Initial Spacing of Trees in Plantations

(Angel Island State Park)

Plantation Number	Tree Spacing	Trees/Acre
6	8 x 8	680
9	8 x 8	680
10	8 x 8	680
11	8 x 8	680
15	8 x 8	680
1	12 x 12	302
16	12 x 12	302
3	15 x 15	193
12	15 x 15	193
13	25 x 25	70
2	30 x 30	48
5	30 x 30	48
7	30 x 30	48
Average	14 x 14	349
Modal	8 x 8	680

Diameter Distribution of Eucalyptus along Mill Creek

(Burleigh Murray Ranch State Park)



Size Class

- ▫ I. ht < 4'8" or dbh ≤ 0.2"
- + II. 0.2" < dbh ≤ 6"
- ✳ III. 6" < dbh ≤ 18"
- ▫ IV. 18" < dbh ≤ 36"

Size Class	Density per Acre
I	57
II	27
III	25
IV	17

Species Composition of Eucalyptus Plantations

Eucalyptus Understory Plant Species Survey

(Tilden Park – 1990)

FAMILY	SCIENTIFIC NAME	COMMON NAME
Amaryllidaceae	*Brodiaea puchella*	Blue dicks
Anacardiaceae	*Toxicodendron diversiloba*	Poison oak
Apiaceae	*Heracleum lanatum*	Cow parsnip
	Sanicula crassicaulis	Snakeroot
Boraginaceae	*Cynoglossum occidentale*	Hound's tongue
Brassicaceae	*Brassica nigra*	Black mustard
Caprifoliaceae	*Lonicera hispidula*	California honeysuckle
	Sambucus caerulea	Blue elderberry
	Symphoricarpus mollis	Snowberry
Compositae	*Artemisia douglasiana*	California mugwort
	Aster radulinus	Broad-leaf aster
	Cirsium vulgare	Bull thistle
	Solidago californica	California goldenrod
Curcurbitaceae	*Marah fabaceus*	Wild cucumber
Euphorbiaceae	*Euphorbia helioscopia*	Wartweed
Fagaceae	*Quercus agrifolia*	Coast live oak
Graminae	*Avena fatua*	Wild oat
	Bromus diandrus	Ripgut
	Bromus mollis	Soft chess
	Cynosurus echinatus	Dogtail
	Elymus glaucus	Blue wild-rye
Iridaceae	*Sisyrichium bellum*	Blue-eyed grass
Labiatae	*Mentha pulegium*	Pennyroyal
	Mentha arvensis	Field mint
	Stachys bullata	California hedge nettle
	Stachys rigida	Hedge nettle
Lauraceae	*Umbellularia californica*	Bay
Leguminosae	*Lathyrus vestitus*	Hillside pea
	Lupinus albifrons	Lupine
	Vicia americana	American vetch
	Vicia sativa	Spring vetch
Plantaginaceae	*Plantago lanceloata*	English plantain
Polygonaceae	*Rumex pulcher*	Fiddle dock
Rosaceae	*Fragaria californica*	Wood strawberry
	Rubus ursinus	California blackberry
Solanaceae	*Solanum nigrum*	Black nightshade
Umbelliferae	*Conium maculatum*	Poison hemlock
Crucifereae	*Dentaria californica*	Milkmaids

Summary

Number of Families = 21

Number of Genera = 34

Number of Species = 38

Introduced Species Eucalyptus Understory Plant Species Survey

(Tilden Park – 1990)

Summary

Number of Families = 21

Number of Genera = 34

Number of Species = 38

Native to California = 24

*Introduced to California = 14

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Comparison of Species composition of Eucalyptus with Oak Woodland

(Tilden Park – 1990)

Eucalyptus Plantation	Oak Woodland
Number of Families = 21	Number of Families = 16
Number of Genera = 34	Number of Genera = 19
Number of Species = 38	Number of Species = 19
Native to California = 24	Native to California = 14
Introduced to California = 14	Introduced to California = 5

Plant Species Richness in Eucalyptus Plantations and Oak Woodlands

Location	Habitat	Vegetation Type	Number of Species
Tilden Park[1]	Upland	Eucalyptus	21
		Oak Woodland	12
Tilden Park[2]	Upland	Eucalyptus	38
		Oak Woodland	21
Murray Park[3]	Riparian	Eucalyptus	34
		Riparian Woodland	58

1 = Jewell Lake (Contra Costa County); 2 = Golf Course Road (Contra Costa County); 3 = San Mateo County, near Half Moon Bay

Understory Conditions and the Establishment of Plant Species

South Facing Slope
Edge Site: 15 species
Interior Site: 15 species

North Facing Slope
Edge Site: 8 species
Interior Site: 8 species

Variation in Understory Species in Eucalyptus Plantations

Understory Species beneath Eucalyptus Canopy

(Tilden Park - March 19, 2014)

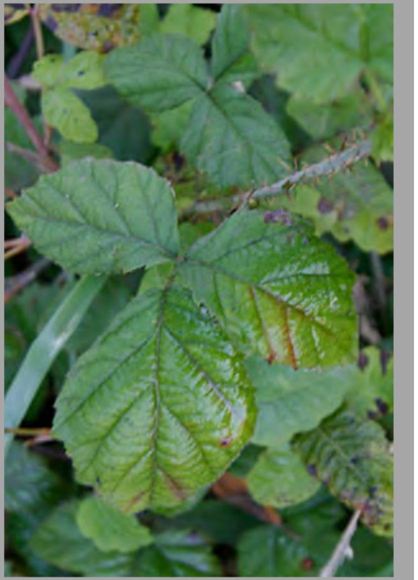
Species	South Facing Slope		North Facing Slope	
	Edge	Interior	Edge	Interior
Bedstraw (*Galium aparine*)	•	•	•	•
California Bay (*Umbellularia californica*)	•	•	•	•
California blackberry (*Rubus ursinus*)	•	•	•	•
Chickweed (*Stellaria media*)	•	•	•	•
Coast Live Oak (*Quercus agrifolia*)	•	•	•	•
Poison oak (*Toxicodendron diversiloba*)	•	•	•	•
Wild cucumber (*Marah fabaceus*)		•		•
Annual grass (*Poaceae*)	•	•		
Cotoneaster (*Cotoneaster sp.*)	•	•		
Coyote brush (*Baccharis pilularis*)	•	•		
Milkmaids (*Dentaria californica*)	•	•		
Snakeroot (*Sanicula crassicaulis*)	•	•		
Snowberry (*Symphoricarpos mollis*)	•	•		
Checker bloom (*Sidalcea malvaeflora*)	•			
French Broom (*Genista monspessulana*)	•			
Wood Rose (*Rosa gymnocarpa*)	•			
Hedge Nettle (*Stachys rigida*)		•		
Toyon (*Heteromeles arbutifolia*)		•		
California Polypody fern (*Polypodium californicum*)			•	
Giant periwinkle (*Vinca major*)			•	
English ivy (*Hedera helix*)				•

Ubiquitous Understory Species


California Bay


Coast Live oak


Poison Oak


California Blackberry


Bedstraw

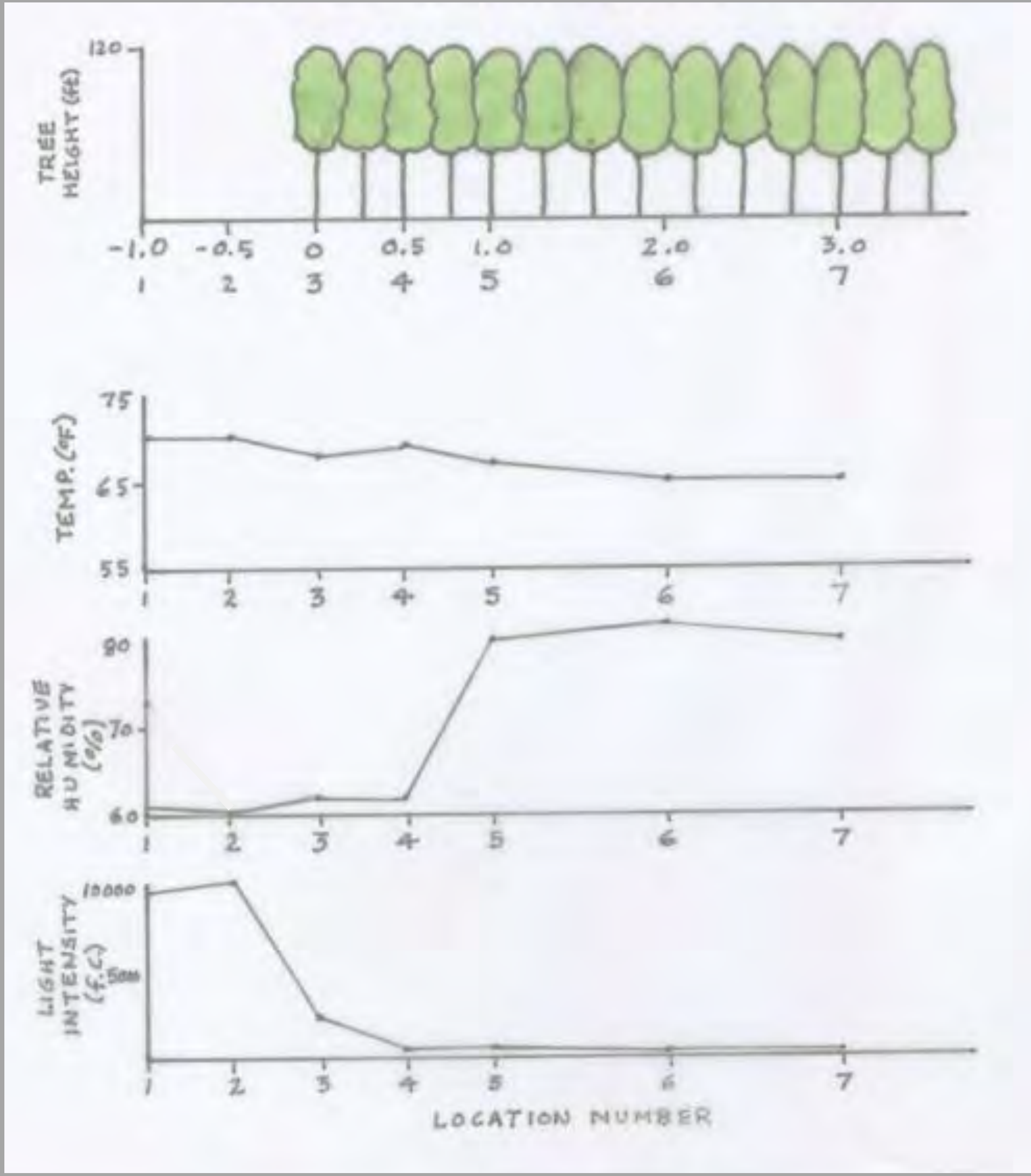

Chickweed

Modification of Site Conditions by Eucalyptus

- Microclimate
- Soil
- Streams

Effects of Eucalyptus Plantation on Microclimate

(Tilden Park, 2101)



Eucalyptus Modification of Grassland Microclimates

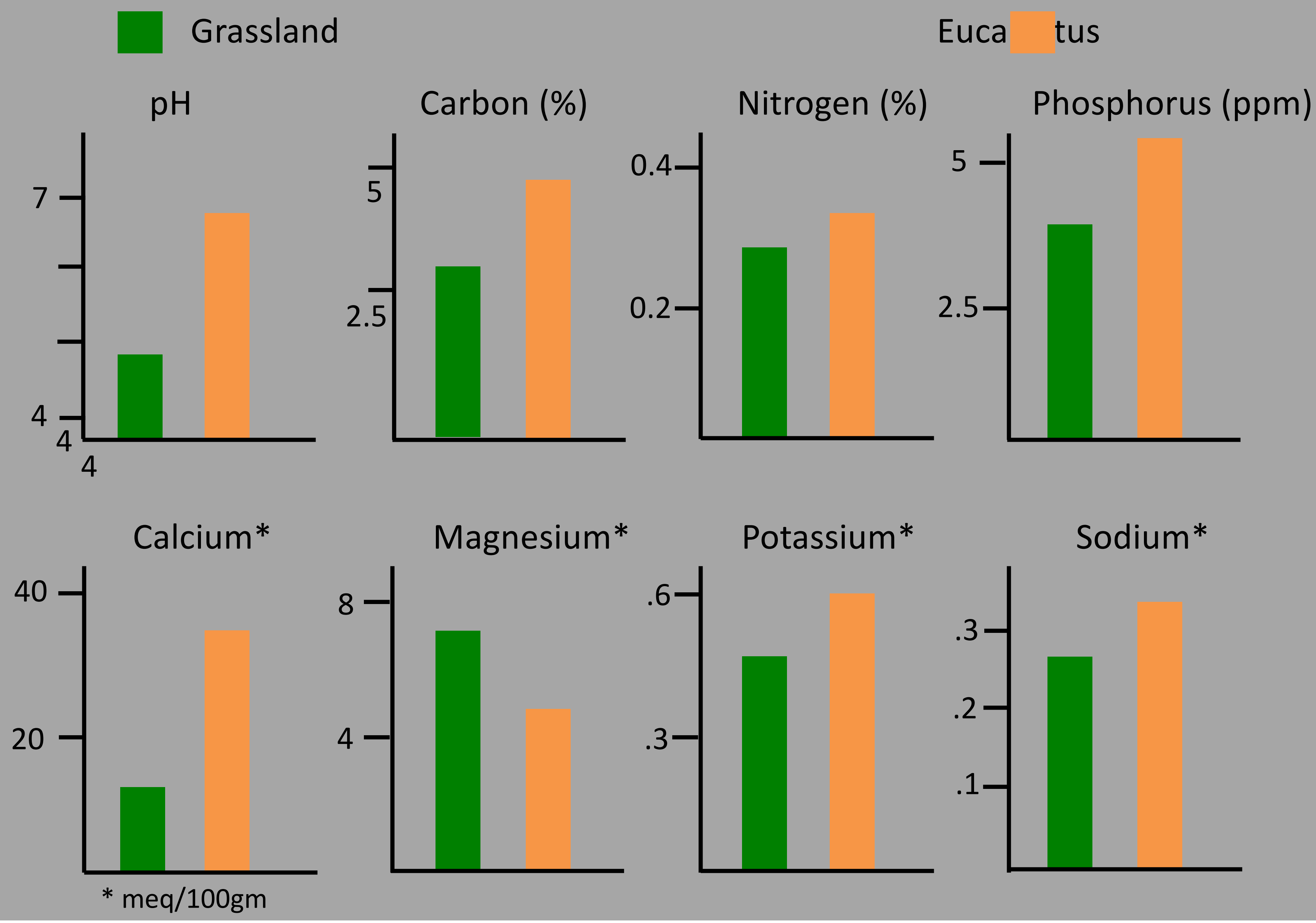
(Presidio)

Factor	Modification under Eucalyptus
Temperature (day)	- 10%
Temperature (night)	+ 5%
Relative Humidity	+ 5%
Light Intensity	- 90%
Wind Velocity	- 40%
Precipitation	- 12%
Fog Drip	+ 300%

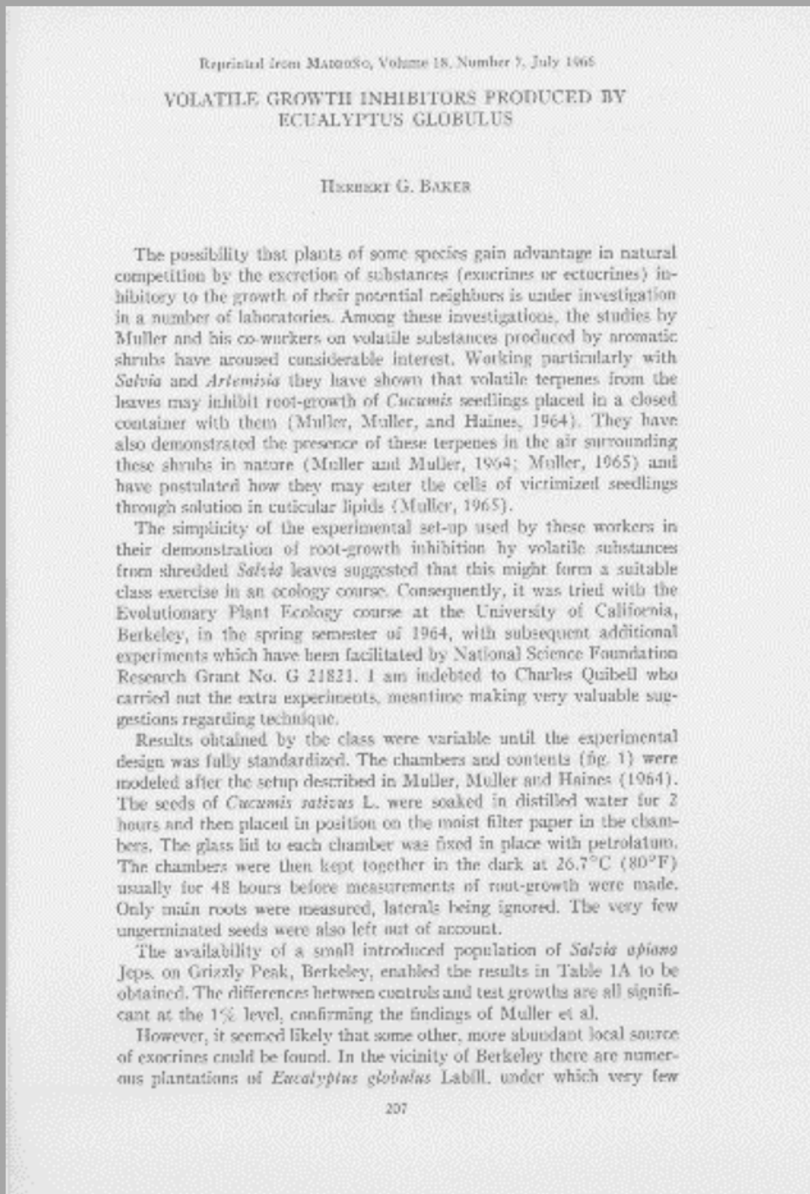
Effects of Eucalyptus on Soil Characteristics

Effects of Eucalyptus on Soil Characteristics

(Zinke *et al*, 1988)



Allelopathic Effects of Eucalyptus



Reprinted from Madroño, Volume 18, Number 7, July 1966

VOLATILE GROWTH INHIBITORS PRODUCED BY ECUALYPTUS GLOBULUS

Herbert G. Baker

The possibility that plants of some species gain advantage in natural competition by the excretion of substances (exocrines or ectocrines) inhibitory to the growth of their potential neighbors is under investigation in a number of laboratories. Among these investigations, the studies by Muller and his co-workers on volatile substances produced by aromatic shrubs have aroused considerable interest. Working particularly with *Salvia* and *Artemisia* they have shown that volatile terpenes from the leaves may inhibit root-growth of *Cucumis* seedlings placed in a closed container with them (Muller, Muller, and Haines, 1964). They have also demonstrated the presence of these terpenes in the air surrounding these shrubs in nature (Muller and Muller, 1964; Muller, 1965) and have postulated how they may enter the cells of victimized seedlings through solution in cuticular lipids (Muller, 1965).

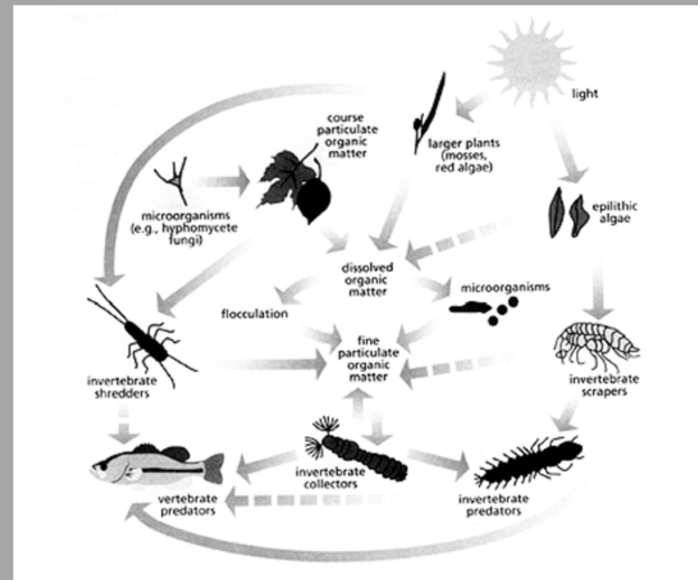
The simplicity of the experimental set-up used by these workers in their demonstration of root-growth inhibition by volatile substances from shredded *Salvia* leaves suggested that this might form a suitable class exercise in an ecology course. Consequently, it was tried with the Evolutionary Plant Ecology course at the University of California, Berkeley, in the spring semester of 1964, with subsequent additional experiments which have been facilitated by National Science Foundation Research Grant No. G 21821. I am indebted to Charles Quibell who carried out the extra experiments, meantime making very valuable suggestions regarding technique.

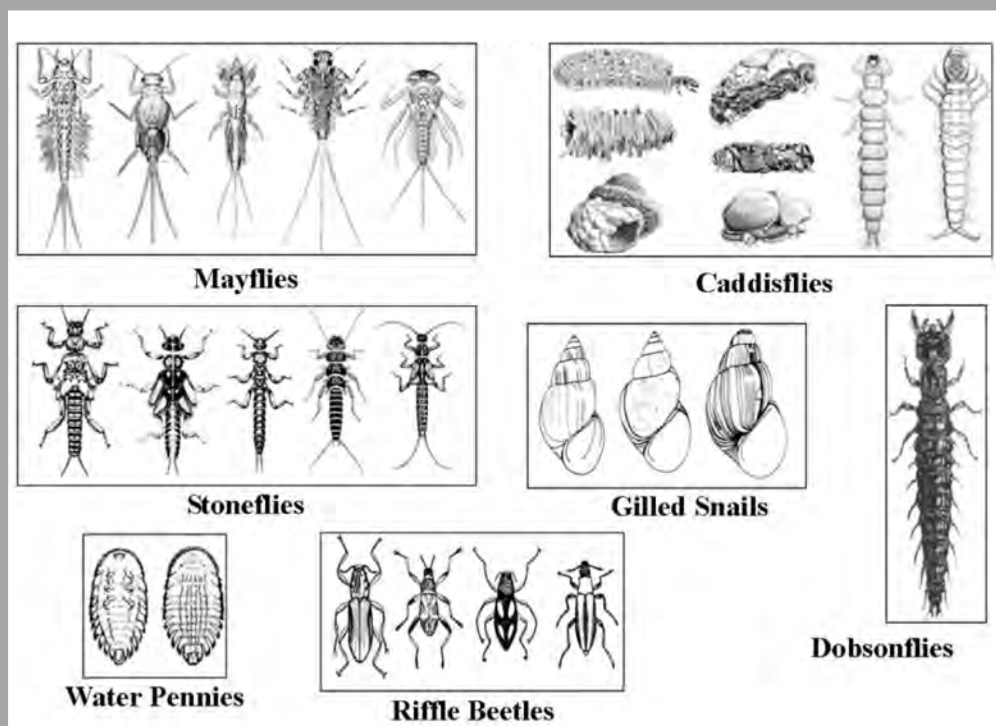
Results obtained by the class were variable until the experimental design was fully standardized. The chambers and contents (fig. 1) were modeled after the setup described in Muller, Muller and Haines (1964). The seeds of *Cucumis sativus* L. were soaked in distilled water for 2 hours and then placed in position on the moist filter paper in the chambers. The glass lid to each chamber was fixed in place with petrolatum. The chambers were then kept together in the dark at 26.7°C (80°F) usually for 48 hours before measurements of root-growth were made. Only main roots were measured, laterals being ignored. The very few ungerminated seeds were also left out of account.

The availability of a small introduced population of *Salvia apiana* Jeps. on Grizzly Peak, Berkeley, enabled the results in Table 1A to be obtained. The differences between controls and test growths are all significant at the 1% level, confirming the findings of Muller et al.

However, it seemed likely that some other, more abundant local source of exocrines could be found. In the vicinity of Berkeley there are numerous plantations of *Eucalyptus globulus* Labill. under which very few

Eucalyptus Litter and Stream Insects





Eucalyptus Litter and Stream Insects

(Lacan, Resh, and McBride, 2009)

Litter Type	Annual Input	Decomposition	Macroinvertebrate
Eucalyptus	950 $gm/m^2/yr$	0.0193 gm/day	
			species richness species diversity pollution tolerance no significant difference
Native Riparian	669 $gm/m^2/yr$	0.0134 gm/day	

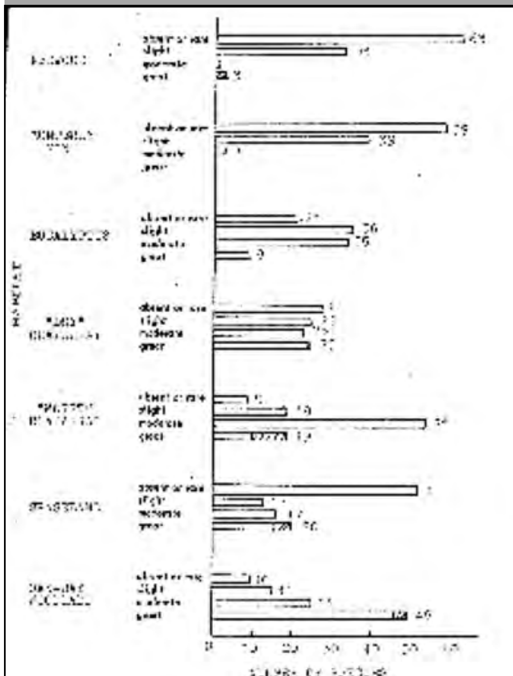
Wildlife Habitat Value of Eucalyptus Plantations



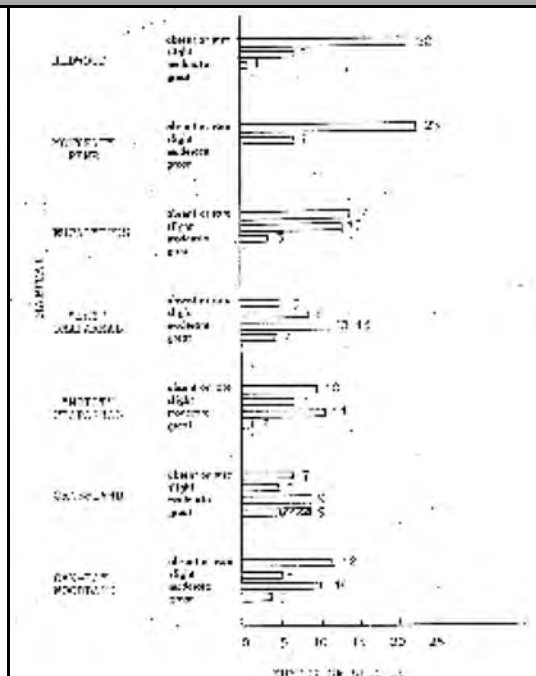
Use of Habitats in the East Bay Regional Parks

(Stebbins, 1978)

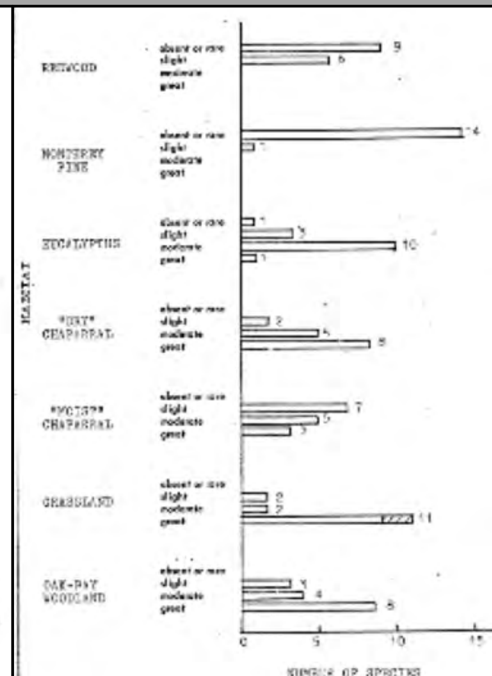
Birds



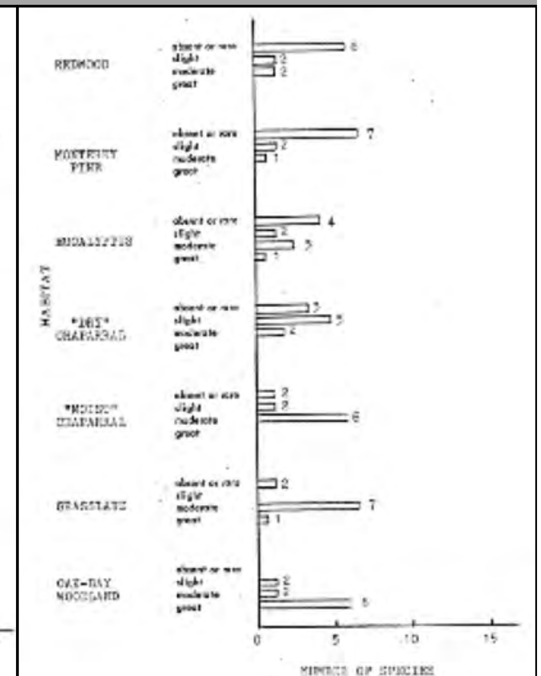
Mammals



Reptiles



Amphibians



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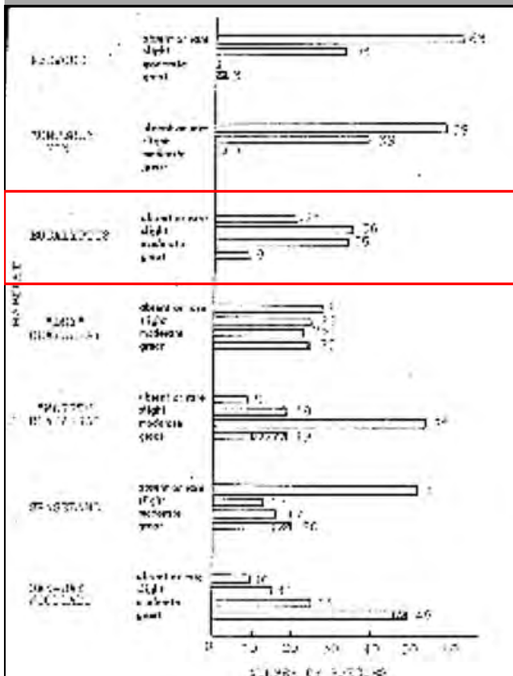

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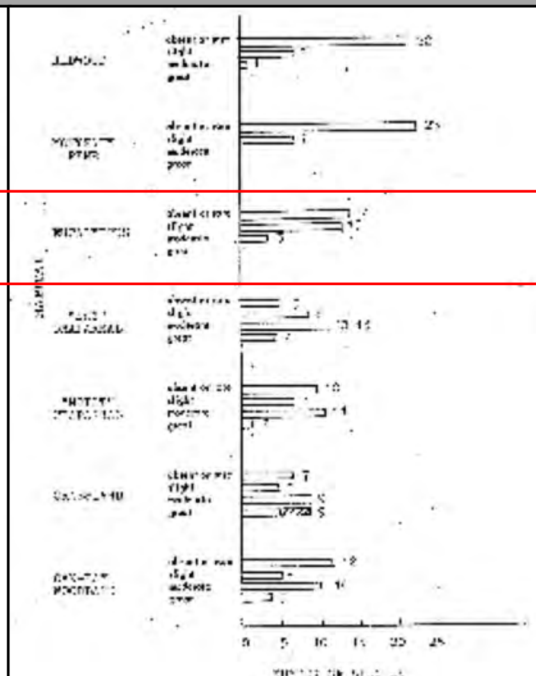

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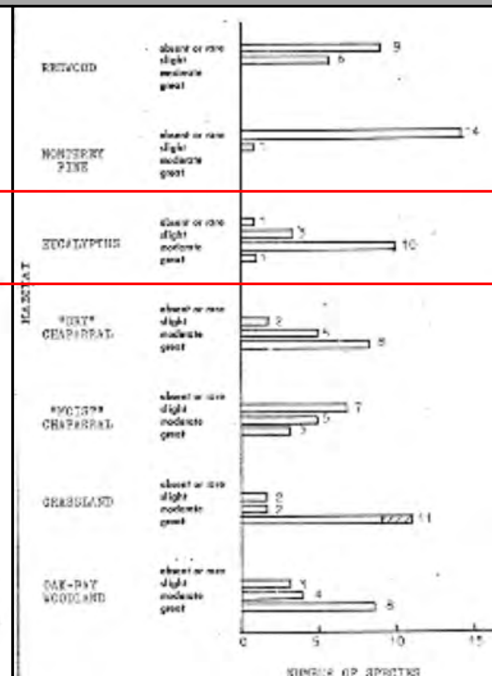
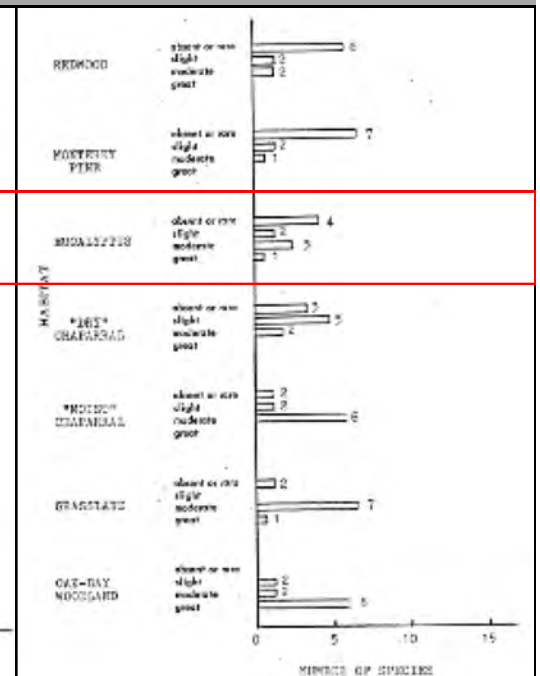


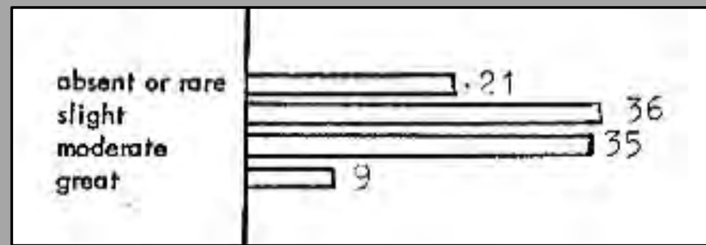
Amphibians



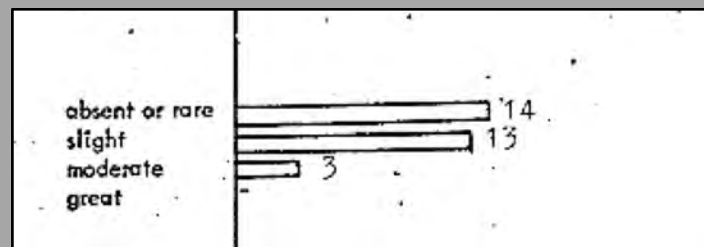
Use of Eucalyptus in the East Bay Regional Parks

(Stebbins, 1978)

Birds



Mammals



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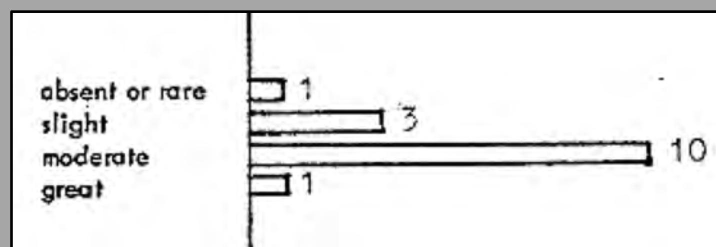

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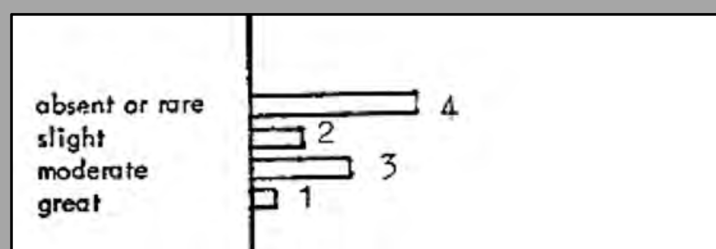


Birds making “great” use of Eucalyptus habitat

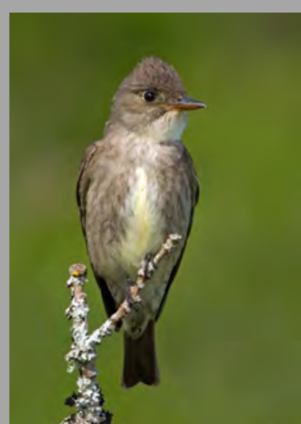
Mourning Dove

Great Horned Owl

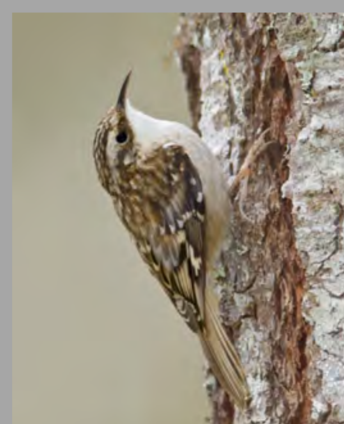
Steller Jay

Yellow-bellied Sapsucker

Allen Hummingbird



Olive-sided Flycatcher



Brown Creeper

Dark-eyed Junco

Audubon Warbler

Reptiles and Amphibians making "great" use of Eucalyptus habitat

Southern Alligator Lizard

Slender Salamander

Small Mammal Use of Eucalyptus Plantations

(Tilden Park, 1990)

	Number of Animals Captured*	
Vegetation Type	Deer Mouse	California Meadow Mouse
Eucalyptus	35	0
Grassland	3	1

(*200 trap nights)

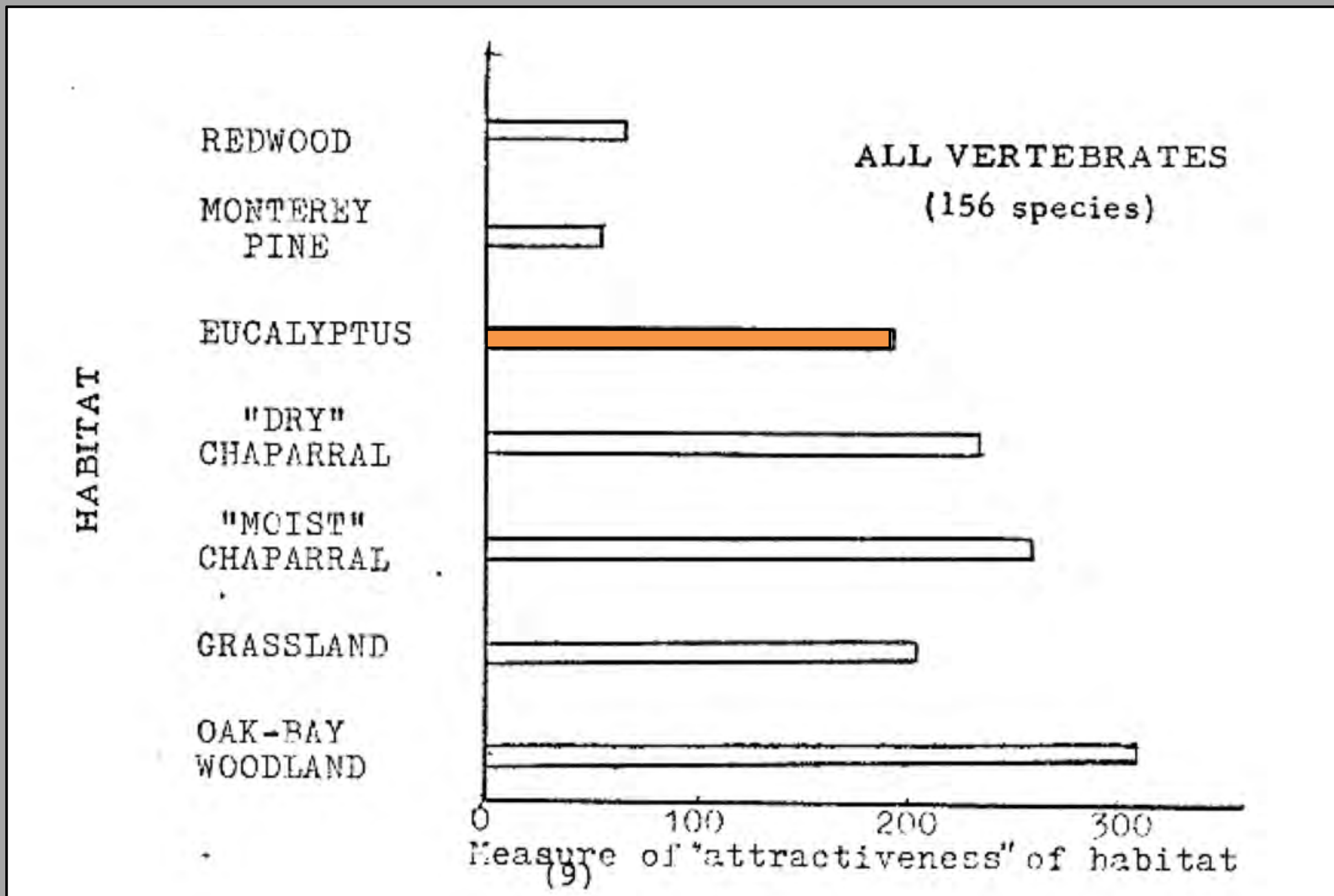
Deer Mouse
(Peromyscus maniculatus)

California Meadow Mouse
(Microtus californicus)

Attractiveness of Habitats in the East Bay Regional Parks

(Stebbins, 1978)

All Species Making Use of Habitat



Use of Eucalyptus Plantations by Insects

Eucalyptus and Monarch Butterflies

Site	County	Number	Tree
Presidio Park	San Diego	900	Eucalyptus
UCSD	" "	4,500	Eucalyptus
Hosp Grove	" "	900	Eucalyptus
Doheny Grove	Orange	1,000	Not specified
Huntington Central Park	" "	3,500	Eucalyptus
Norma Gibbs Park	" "	700	Not specified
Leo Carrillo State Beach	Los Angeles	800	Eucalyptus
Camino Real Park	Ventura	10,000	Eucalyptus
Harbor Boulevard	" "	23,000	Eucalyptus
Ellwood Main	Santa Barbara	85,000	Not specified
Tecolote Canyon	" " "	22,000	Eucalyptus
Refugio State Beach	" " "	2,500	Palm & Eucalyptus
Oceano Campground	San Luis Obispo	20,000	Monterey cypress
Pismo State Beach	" " "	110,000	Not specified
Los Osos, Sweet Springs	" " "	8,000	Not specified
Andrew Molera State Park	Monterey	10,000	Eucalyptus
Pacific Grove	" "	45,000	Monterey pine
Lighthouse Field State Beach	Santa Cruz	50,000	Monterey cypress & Eucalyptus
Natural Bridges State Beach	" "	95,000	Not specified
New Park Mall	Alameda	500	Eucalyptus
Ardenwood Regional Reserve	" "	20,000	Eucalyptus
San Leandro Golf Course	" "	25,000	Eucalyptus
Muir Beach	Marin	4,000	Monterey cypress
Bolinas Terrace	"	18,000	Not specified
Bodega Dunes Campground	Sonoma	400	Eucalyptus & Monterey cypress

Eucalyptus Longhorned Borer

(*Phorocantha semipunctata*)

Parasitic Wasp of Eucalyptus Longhorned Borer

(*Avetianella longoi*)

Red Gum Lerp Psyllid

Jack Kelly Clark

UC Berkeley entomologist Don Dahlsten counts the number of red gum lerp psyllids, a new eucalyptus pest, on river red gum foliage in Ardenwood Park, Alameda County.

Scientists have released *Psyllaephagus bliteus* (shown next to white lerp cover) and are monitoring to see if the parasitic wasp controls red gum lerp psyllid.

Jack Kelly Clark

Jack Kelly Clark

The life stages of red gum lerp psyllid. *Clockwise from bottom:* eggs, late instar, white cover and adult.

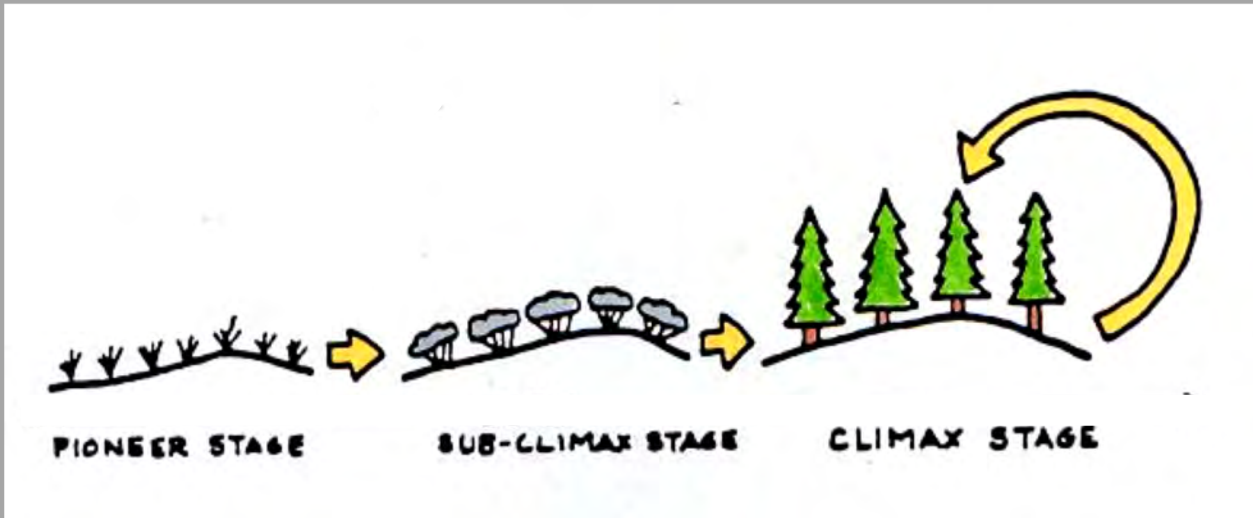
Future of eucalyptus plantations in the San Francisco Bay Area

- Successional change
- Invasion of adjacent vegetation types
- Potential impacts of naturalized pest species

Plant Succession in Eucalyptus Plantations

- Concept of succession
- Current trends in the understory of Eucalyptus plantations

Plant Succession



Plant Succession in Eucalyptus Plantations

Coast Live oak

California Bay

Comparative Shade Tolerance

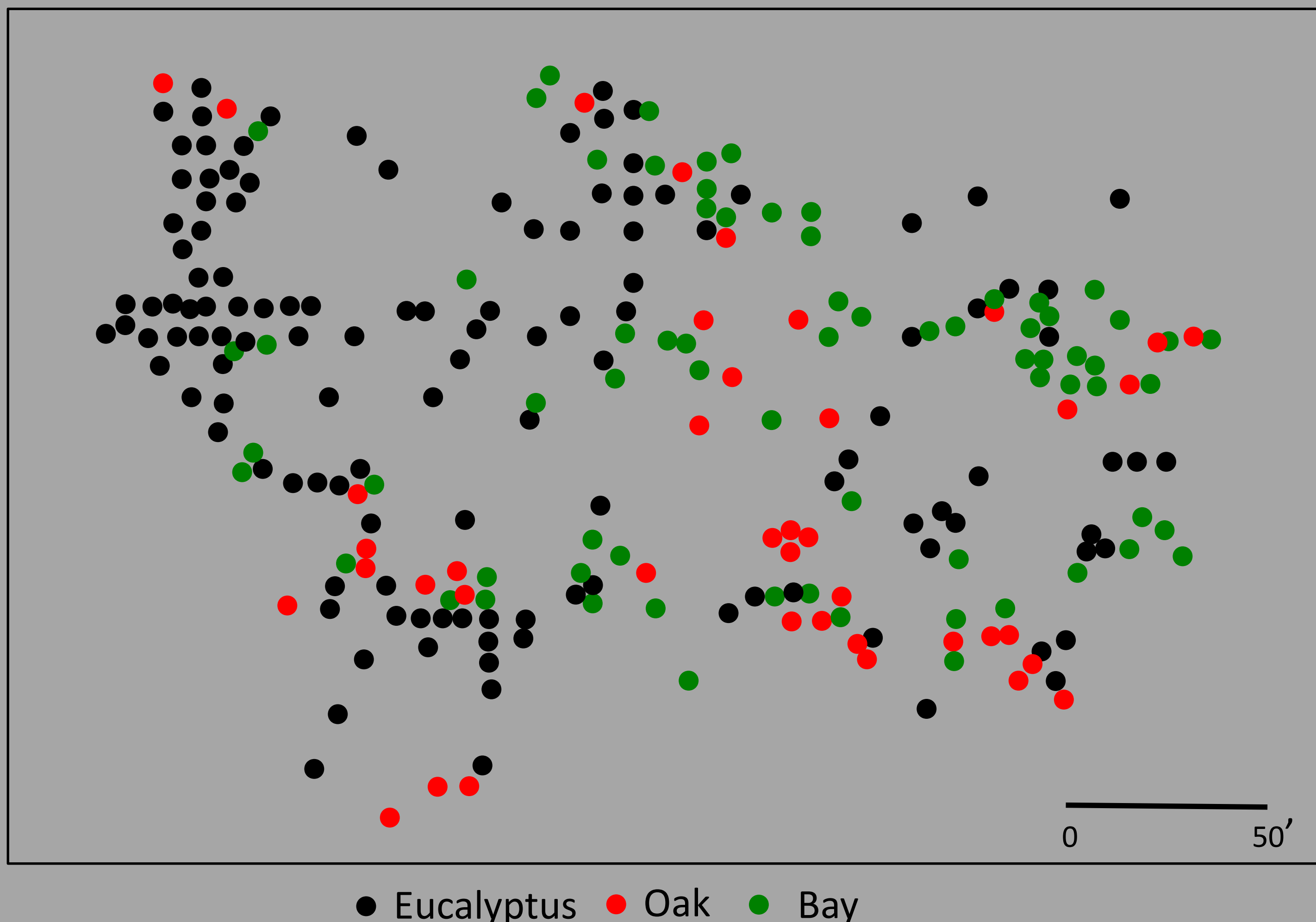
Species	Shade Tolerance
Eucalyptus	intolerant
Coast Live Oak	tolerant
California Bay	very tolerant

Oak and Bay in Understory of Eucalyptus

(Tilden Park)

Occurrence of Oak and Bay in Eucalyptus Understory

(Tilden Park, 1990)

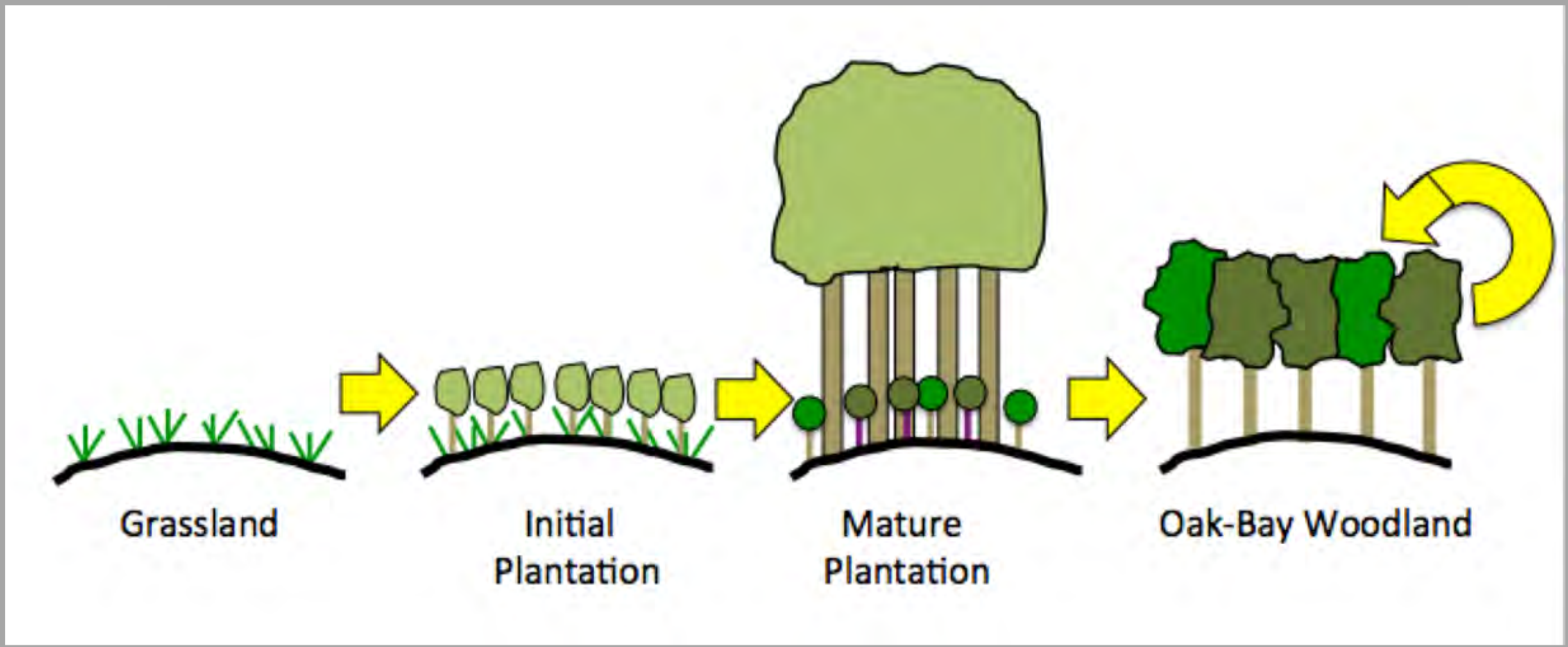


Oak and Bay Trees in Eucalyptus Plantations

(Tilden Park, 1990)

Stand Number	Number of Trees per Acre		
	Eucalyptus	Coast Live Oak	California Bay
1	477	74	97
2	520	42	33
3	530	41	32
4	697	22	129
5	416	10	0
Average	540	38	58

Succession in Eucalyptus Plantations



Fire and Eucalyptus

Fuel Loading in Eucalyptus Plantations

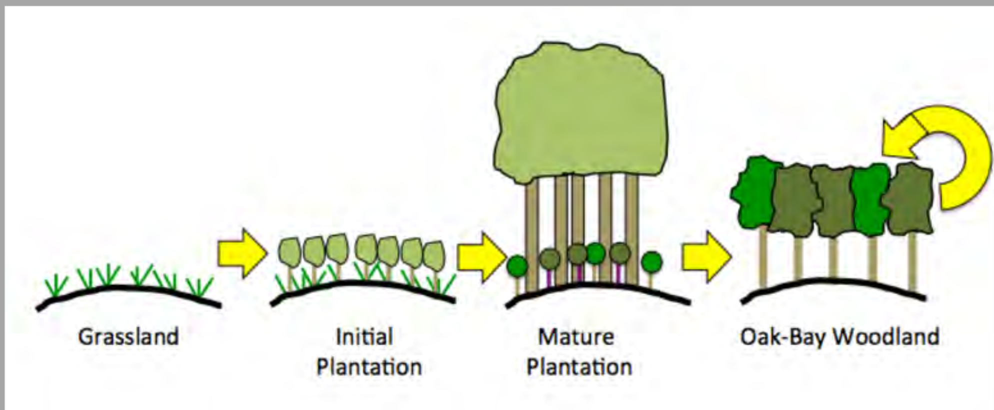
FUEL ELEMENT	Live Component	Dead Component	Live Component	Dead Component	Live Component	Dead Component
Herbs and grasses	0.03	0.02	0.42	0.18	0.31	0.17
Shrubs and saplings	0.49	0.0	0.27	0.01	0.25	0.03
Fine twigs (1-hour)		1.33		0.69		1.18
Small branches (10-hour)		2.94		1.93		4.60
Medium branches (100 hour)		1.41		2.67		2.40
Logs (1,000 hour)		19.63		11.06		0.69
Litter (leaves, bark, needles, etc.)		4.99		1.70		2.19
TOTAL FUELS	Eucalyptus - 30.84 tons per acre		California Bay - 18.93 tons per acre		Coast Live Oak - 11.82 tons per acre	

From: U. S. National Park Service

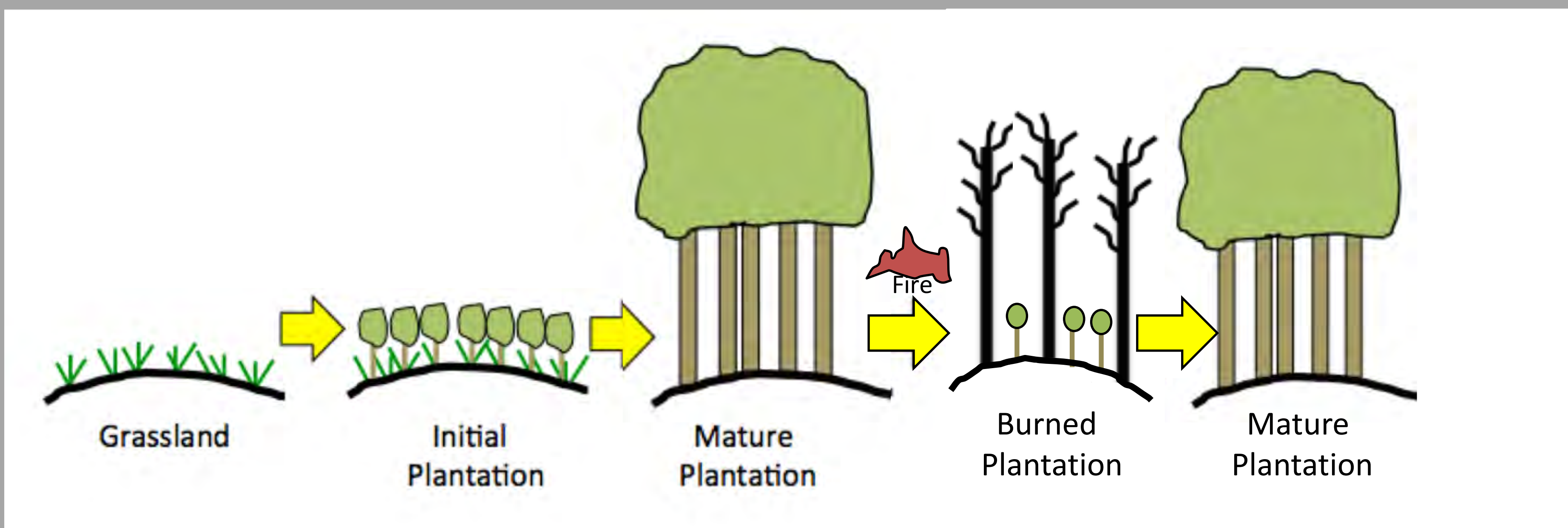
Response of Eucalyptus to Burning

Succession in Eucalyptus Plantations

Without Fire:



With Fire:

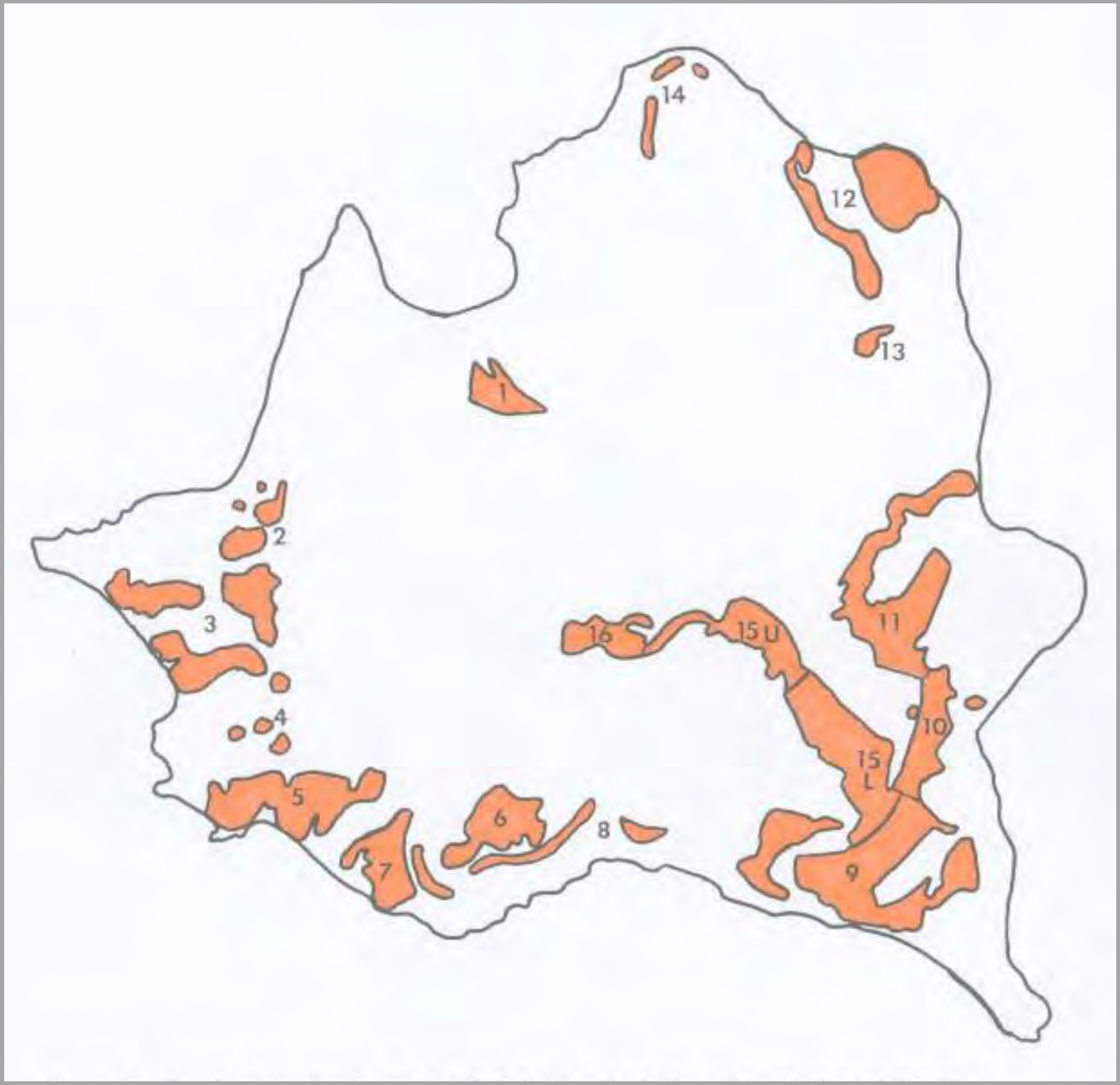


Future of Eucalyptus Plantations in the San Francisco Bay Area

- Successional change
- Invasion of adjacent vegetation types
- Management objectives

Eucalyptus Plantations on Angel Island

(1988)

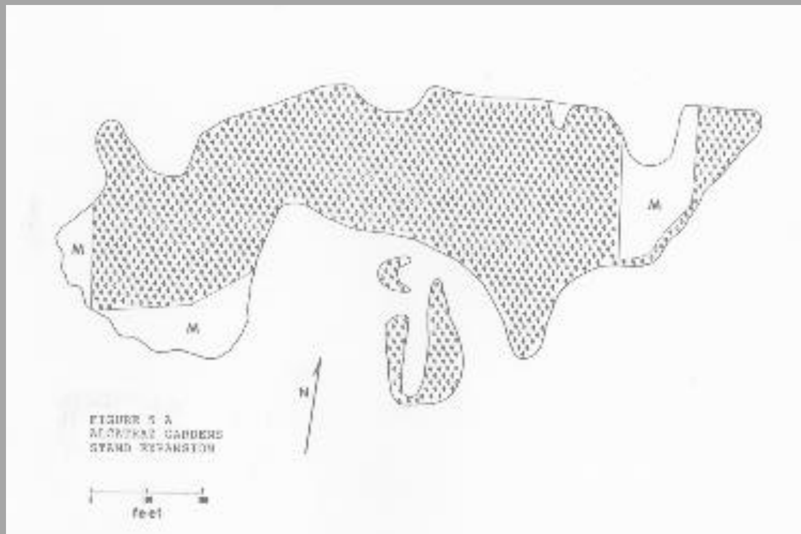


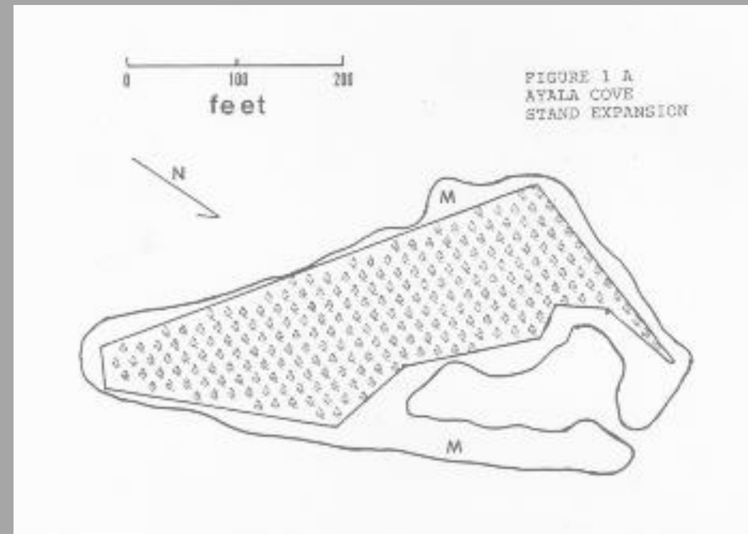
Expansion of Eucalyptus Plantations on Angel Island

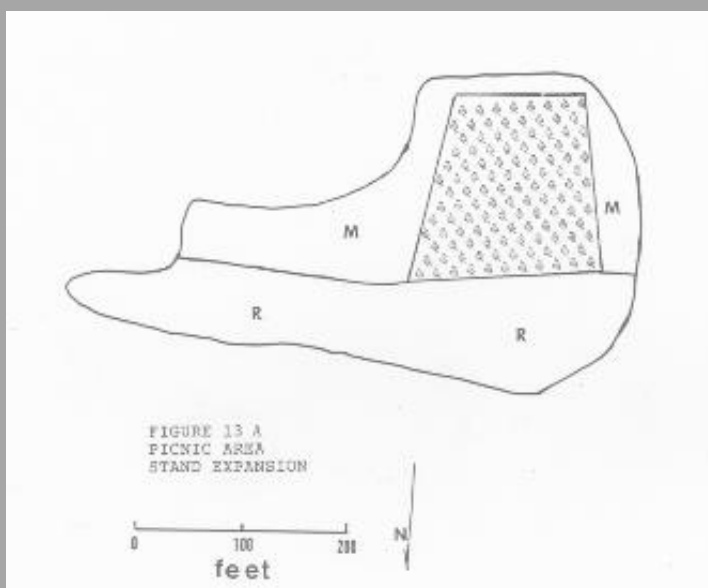
TABLE 1. AREA COVERED BY EUCALYPTUS STANDS

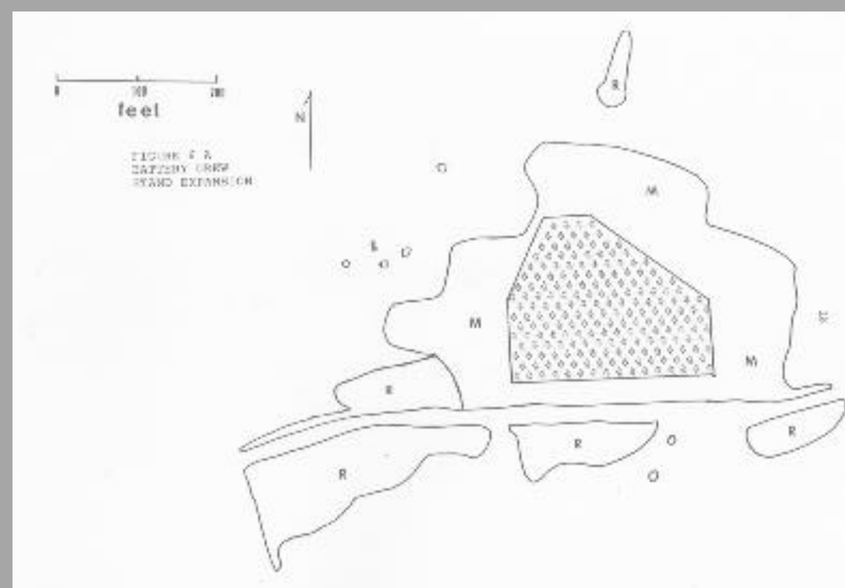
Map Unit	Acres Planted	Total Acres	Expansion Acres
1	1.2	1.9	0.7
2	1.6	2.5	0.9
3	0.1	9.3	9.2
4	0.1	1.5	1.4
5	1.2	8.2	7.0
6	1.0	3.9	2.9
7	2.2	4.4	2.2
8	0.1	1.5	1.4
9	4.3	14.9	10.6
10	1.0	4.9	3.9
11	3.1	10.6	7.5
12	0.7	4.4	3.7
13	0.6	2.2	1.6
14	0.1	0.8	0.7
15	6.0	12.6	6.6
16	0.3	2.5	2.2
Total	23.6	86.1	62.5

Expansion of Eucalyptus Plantations on Angel Island

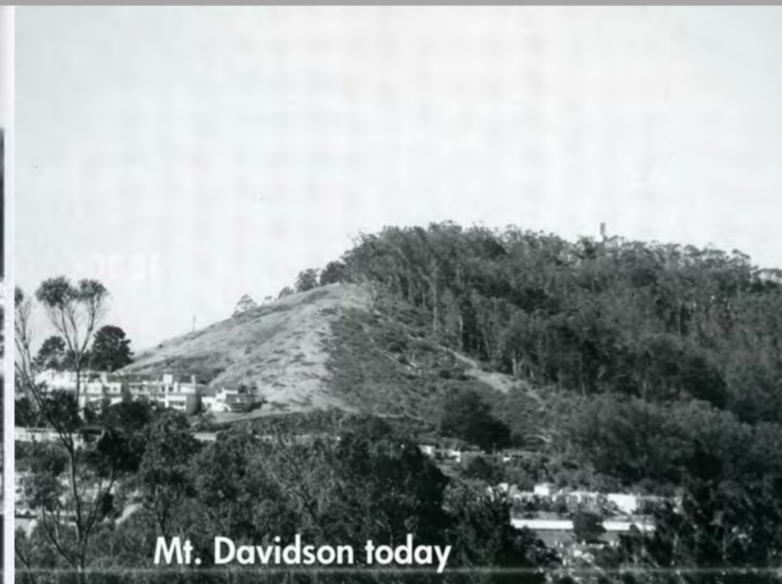


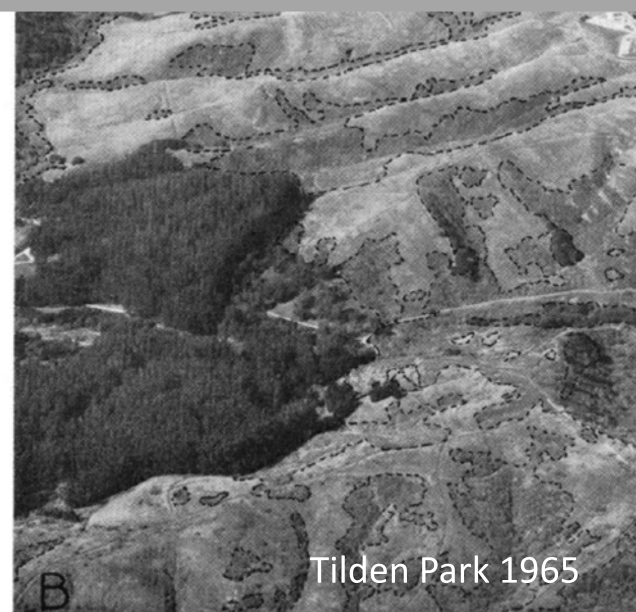






Stable Boundaries of Eucalyptus Plantations





Decline in Area of Eucalyptus
(1939-1997)

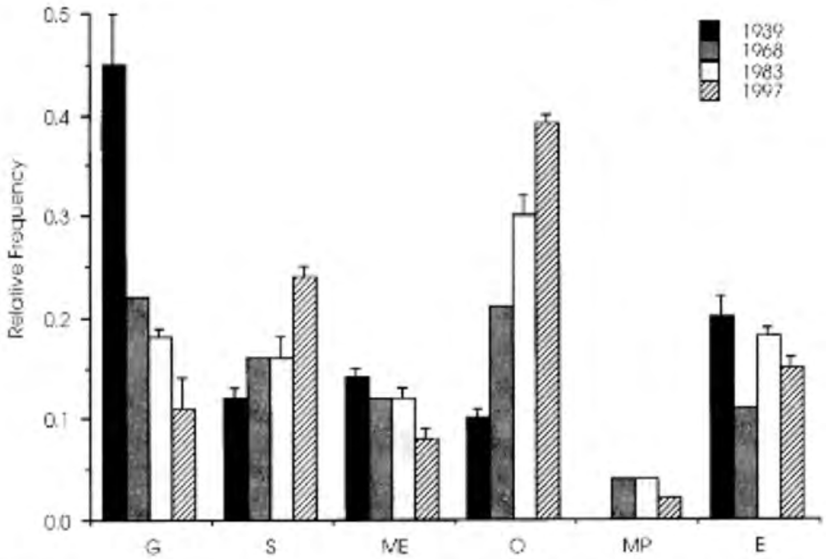


Fig. 2. Relative frequency of six vegetation types. (G: grass, S: shrub, ME: mixed evergreen, O: oak woodlands and savannas, MP: Monterey pine, E: eucalyptus), in Chabot Regional Park. Error bars indicate 1 S.E.

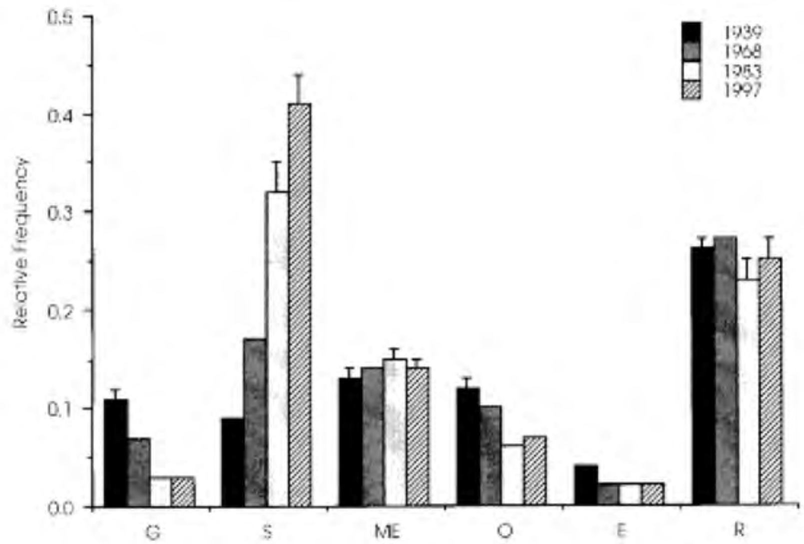


Fig. 3. Relative frequency of six vegetation types. (G: grass, S: shrub, ME: mixed evergreen, O: oak woodlands and savannas, E: eucalyptus, R: redwood), in Redwood Regional Park. Error bars indicate 1 S.E.

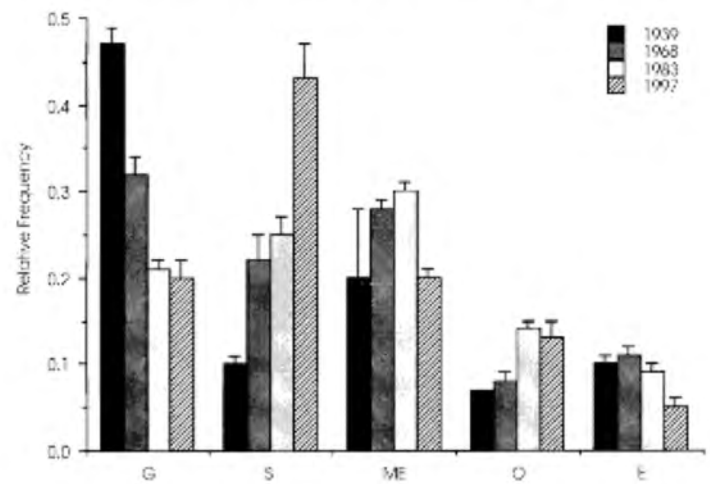
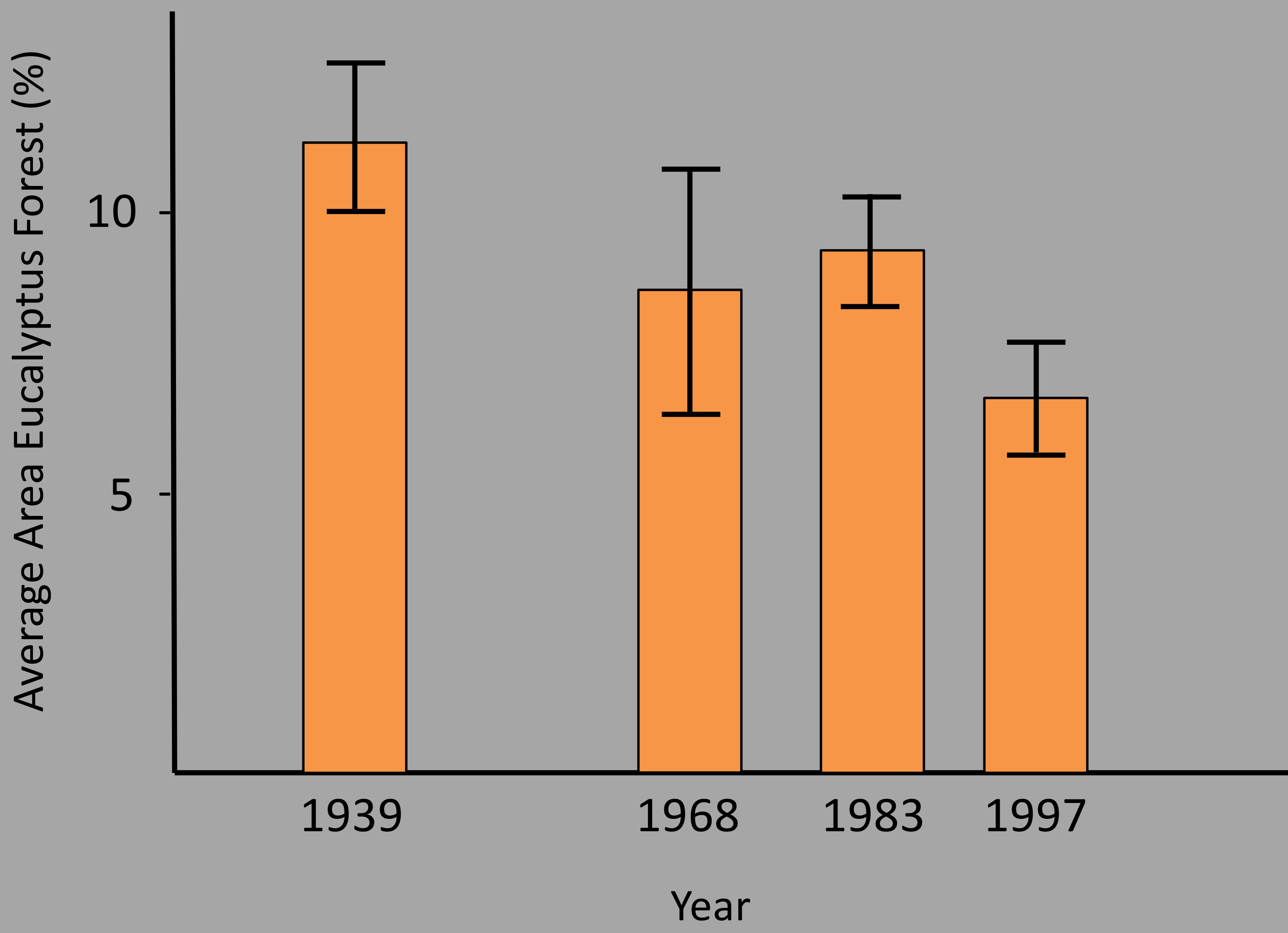


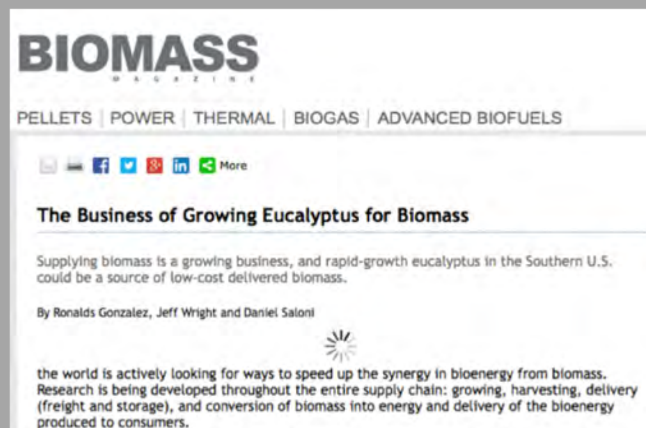
Fig. 4. Relative frequency of five vegetation types. (G: grass, S: shrub, ME: mixed evergreen, O: oak woodlands and savannas, E: eucalyptus.), in Tilden Regional Park. Error bars indicate 1 S.E.

Decline in Eucalyptus in Three East Bay Parks



Alternative Management Objectives for Eucalyptus Plantations

Recreation



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More

The Business of Growing Eucalyptus for Biomass

Supplying biomass is a growing business, and rapid-growth eucalyptus in the Southern U.S. could be a source of low-cost delivered biomass.

By Ronalds Gonzalez, Jeff Wright and Daniel Saloni

the world is actively looking for ways to speed up the synergy in bioenergy from biomass. Research is being developed throughout the entire supply chain: growing, harvesting, delivery (freight and storage), and conversion of biomass into energy and delivery of the bioenergy produced to consumers.

Wood Products

Removal

January 12, 2014

The Great Eucalyptus Debate: A Love/Hate Relationship

SF Chronicle "Insight"

Photo by Michael Short, Special to the Chronicle

(Posted by John Maybury, Pacifica Riptide, Pacifica, California)

Gone Native

California's love-hate relationship with eucalyptus trees

by Jared Farmer

APRIL 1970. The Beatles announce their breakup. U.S. forces
the invasion of Cambodia. By most measures, the world had see
Using a slogan modified from John and Yoko — "Give Earth
— students at some 1,500 American schools prepare for a n
Environmental Teach-In, better known as the first Earth Day.
In Ventura County, 50 tree-huggers from Moorpark College lie in front of
Los Angeles Avenue near Simi Valley. Even here, far away from Berkeley, "ecolo
students" (to use the words of the *Los Angeles Times*) could be found protesting th
of a tree-lined road. The police arrest 10. On April 22, the defendants are arraign
court. By the end of the week, the trees are gone.
What had been lost? Ancient redwoods? Historic oaks? Not quite. The trees i
were Australian eucalyptus.
Since the 1850s, Californians had assisted a continuous introduction of eucal
tuated by two frenzied periods — one in the 1870s, the other from 1907 to 191
believed variously that eucalypts would provide fuel, improve the weather, boost
ductivity, defeat malaria, preserve watersheds, and thwart a looming timber famin
foremost, however, Californians planted the trees to domesticate and beautify the
to make it more green.
By the mid-20th century, the distinctive blue-green foliage of eucalyptus tree
seen all over the state. The Australian genus was far more prevalent than the red
official state tree, and scarcely less iconic. The immigrant plant had been natural

Eucalyptus: California Icon, Fire Hazard and Invasive Species

Liza Gross, KQED Science Contributor | June 12, 2013 | 42 Comments

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Specialized reproductive structures called "epicormic shoots" sprout from buds on the bushfire damaged trunk of a Eucalyptus tree, about two years after the 2003 Eastern Victorian alpine bushfires. Near Anglers Rest, Victoria, Australia. (Photo: jjron)

Acknowledgements

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Igor Lacan
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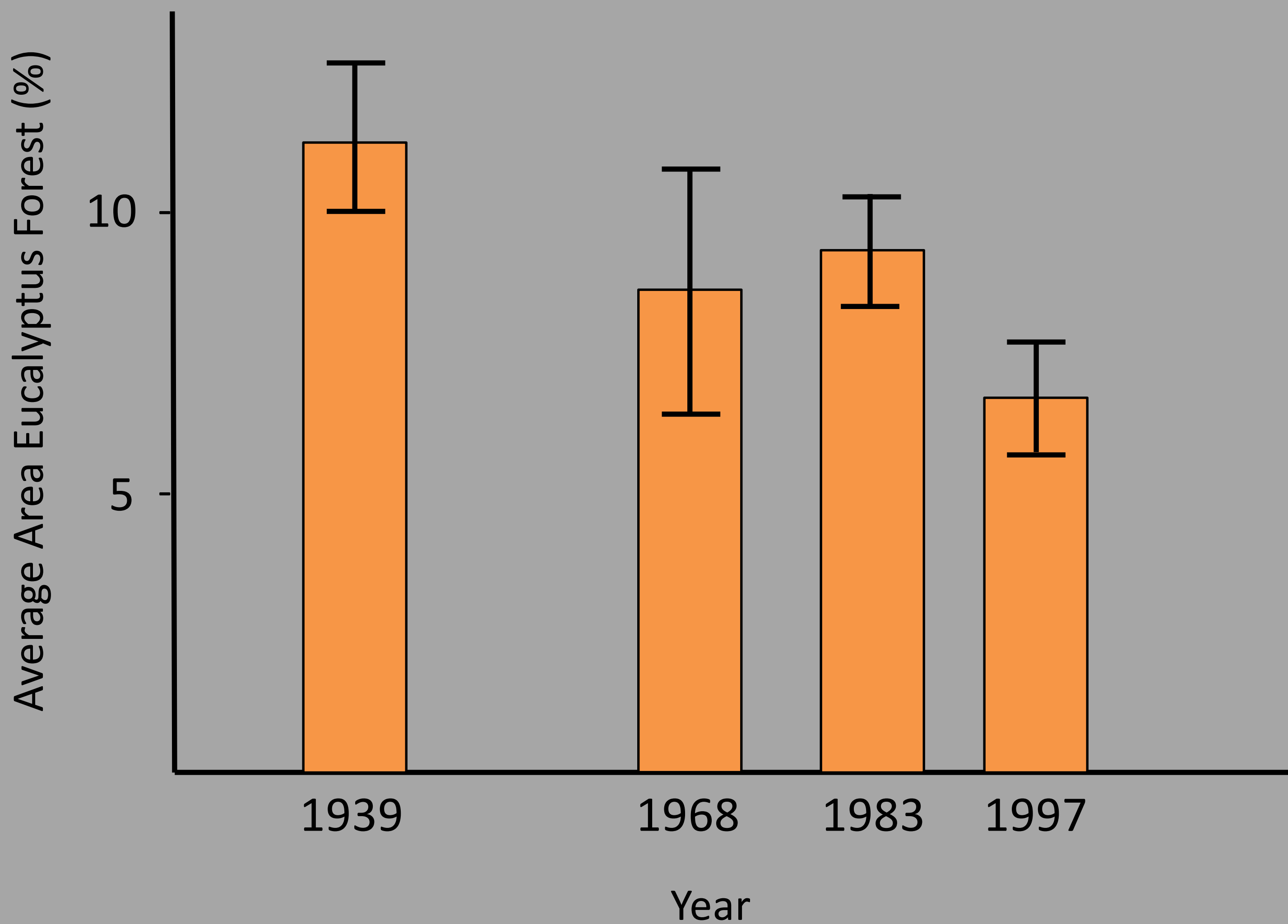
Rowan Rowntree
Will Russell
Al Stangenberger
Neil Sugihare
Paul Zinke

End

California Bay in Understory of Eucalyptus

(Tilden Park)

Decline in Eucalyptus in Three East Bay Parks



Attractiveness of Habitats in the East Bay Regional Parks

(Stebbins, 1978)