Env 121: Conservation of Biodiversity

Lecture 2: What's at stake?
A case history of California oak
3 April 2007
Professor Victoria Sork

Outline of Lecture

I. **Valley oak: a signature oak of California**
II. Ecological challenges for Valley oak
III. Patterns of gene flow in Valley oak
IV. Geographical history of Valley oak
V. Using genetic markers for reserve design
VI. Implications for environmental change

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Landscapes of valley oak

California Valley oak, *Quercus lobata*

- Endemic to California
- Other major oak species:
  - Coast live oak (sudden oak death disease)
  - Blue oak (major woodland oak species
- Keystone species
  - Defines ecosystem
  - Insect diversity
  - Wildlife dependence
- Major habitats of CA
  - Oak savanna, oak woodland, riparian oak

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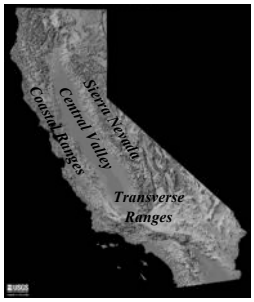
Natural history of California valley oak

Distribution of California valley oak (*Quercus lobata*)



Outline of Lecture

I. Valley oak: a signature oak of California
II. Ecological challenges for Valley oak
- **Loss of habitat**
- **Lack of population recruitment**

III. Patterns of gene flow in Valley oak
IV. Geographical history of Valley oak
V. Using genetic markers for reserve design
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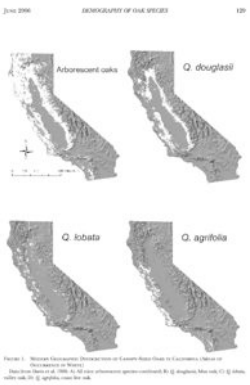
Contemporary distributions of major oak species in California:
- Blue oak
- Valley oak
- Coast live oak



Causes of oak habitat loss

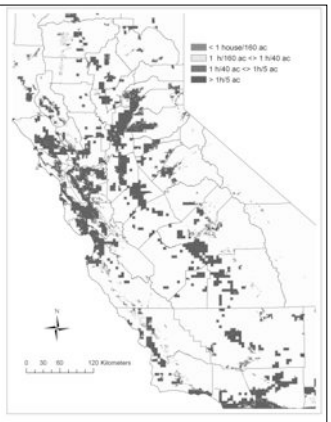
- Conversion of oak savanna to grasslands for grazing
  - Introduction of European grasses
  - Grazing by cattle
- Conversion of agricultural and grazing land into residential subdivisions
  - Fragmentation of large land holdings into rural residential parcels
- Conversion to vineyards
  - Economic value of land for grazing is 10-20% of that for wine grapes
  - Sometimes oaks left behind

Why isn't oak habitat protected?

- Wrong place at the wrong time
- Oak habitat isn't considered "forestry": Not protected by Board of Forestry and the California Dept of Forestry and Fire Protection.
- CEQA: California Environmental Quality Act: has not played a major role in protection
- Estate taxes can cause families to subdivide land.

Valley oak distribution and development

- Map shows distribution of valley oak and the density of housing for that area.
- Dark shading means many houses



Ecological challenges to oak recruitment

Oak life history stages and risks.

Tyler et al, 2006 Quarterly Review of Biology

Factors limiting oak seedling recruitment

- Experiment conducted by Tyler et al. 2002
- Treatments: Open, no grazers, no rodents
- Result: Rodents were biggest cause of early mortality

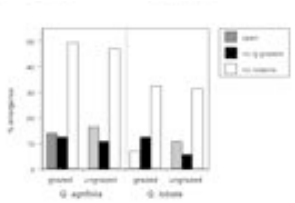


Figure 2—Total percent emergence of seedlings planted in 2000-2001 with various levels of protection from herbivores. Data are from May/June 2001.

Survival of 1 year old seedlings

Tyler *et al* study, continued

- After 3 yrs, treatments with protection from rodents did best
- Grazing may not be key cause of seedling mortality

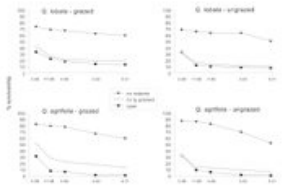


Figure 4—Percent survivorship of 3-yr-old seedlings (planted in 1997-98) in large plots grazed by cattle, vs. those fenced to exclude cattle. Data are totals for three experimental treatments (fig. 1) for five sampling dates.

Summary of ecological challenges to California tree oak species

- Loss of habitat due to changes in land use
- Changes in quality of habitat since Europeans
- Problems with seedling recruitment
  - Grazing
  - Rodents
  - Competition from grasses?
- Will fragmentation cause future losses if populations are isolated?

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I. Valley oak: a signature oak of California
II. Ecological challenges for Valley oak
III. Patterns of gene flow in Valley oak
- Contemporary pollen movement
- Contemporary seed movement

IV. Geographical history of Valley oak
V. Implications for reserve design
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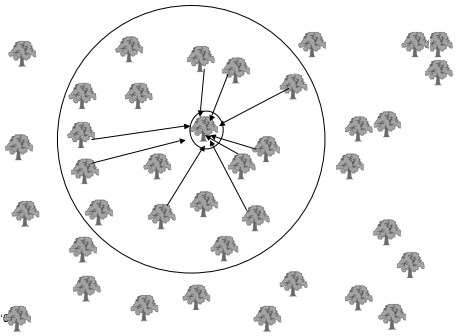
Part I. Contemporary pollen movement

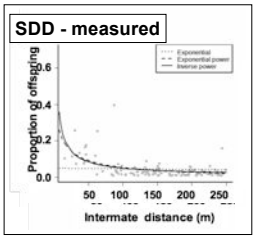
Local pollen flow in Valley oak : Paternity Analysis Approach



Materials and methods

- *Quercus lobata* (Née)
- Continuous populations in oak savanna
- genotype seeds and adults
- paternity analysis

What is the pattern of pollen movement?

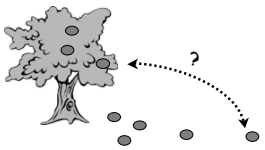


- **Most pollen movement is local; but a long tail**

BACKGROUND

Seed dispersal: critical process

- Gene flow
- Colonization



Tracking dispersed seeds:
an old problem

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Seed dispersal in valley oak

Woodpecker-mediated seed movement

$N_{em} \sim 2$

Limited number of seed donors

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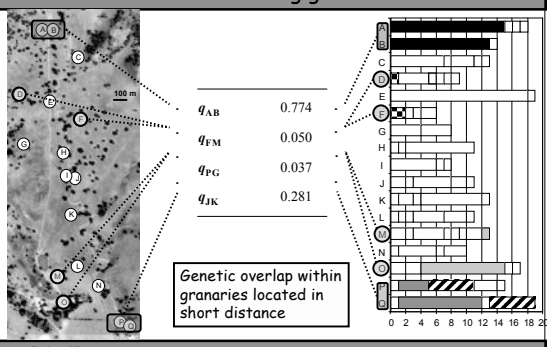
RESULTS: among granaries



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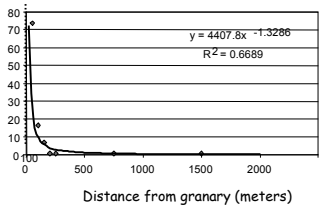
Acorn movement: Maternity approach (7 loci)

Frequencies of maternal genotypes



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Dispersed seed results

DNA from leaf tissue

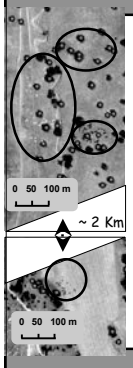
biparental genotype

DNA from pericarp

maternal genotype

7 nuclear microsatellites

SEEDLINGS IN OPEN PATCHES



Patch 1 = 54

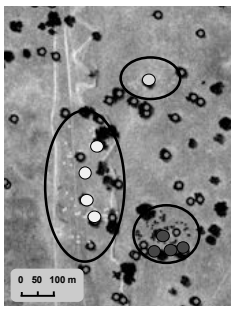
Patch 2 = 40

Patch 3 = 82

Patch 4 = 45

Total = 220 seedlings

MATERNITY ANALYSIS



~1km ~1km

Pericarps

- Sample size = 176 acorns
- 56% with unique seed donor
- All came from neighbors, except 4

• Restricted acorn movement
• Limited genetic overlap among patches for the seedlings identified

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I. Valley oak: a signature oak of California
II. Ecological challenges for Valley oak
III. Patterns of gene flow in Valley oak
IV. Geographical history of Valley oak
  - Based on movement of seeds
V. Implications for reserve design
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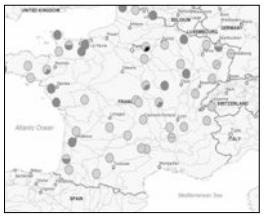
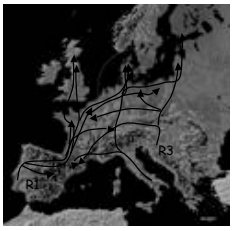
Distribution of Valley oak and location of sampling localilties.

Colonization history in Europe in *Quercus robur/petraea*

Distribution of choloroplast haplotypes



Recolonization routes

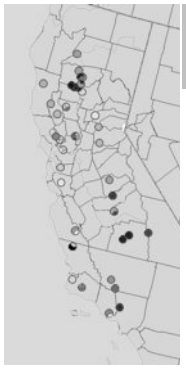


CHLOROPLAST DIVERSITY: *Q. lobata versus Q. robur*

Primer	μdt1	μdt3	μdt4	μcd4	μcd5	ccmp10	# Haplotype
Origin	*Q. robur*	*Q. robur*	*Q. robur*	*Q. robur*	*Q. robur*	*N. tabacum*	
# alleles *Q. lobata*	4	5	3	3	3	4	**39**
# alleles *Q. robur*	3	2	3	2	2	2	**4**

Diversity: *Q. lobata* >> *Q. robur/petraea*

Ccmp10: Weising and Gardner (1999) - Others: Deguilloux *et al.* (2003)

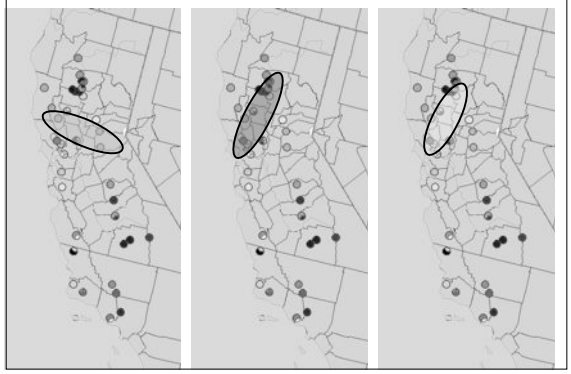


Results: distribution of chloroplast haplotypes

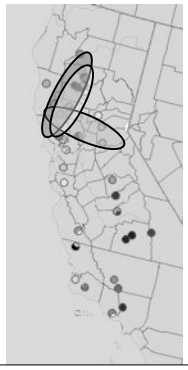
39 haplotypes
- 32 within 17 western sites (N=50)
- 12 within 17 eastern sites (N=55)

[Grivet, Deguilloux, Petit, Sork. 2006. Molecular Ecology]

Long distant haplotype movement in Quercus lobata



Why movement in the north?



Summary of historical genetic studies in valley oak

What we know:

1. Haplotype diversity is high--> no major recent extinctions
2. Genetic structure is high-->seed dispersal has been restricted compared to European oaks
3. Local bottlenecks, rather than a few refugia, during Pleistocene cooler climate

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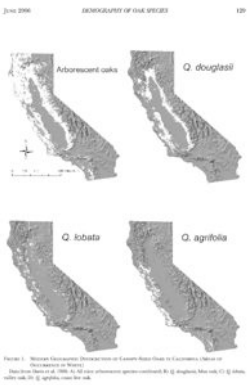
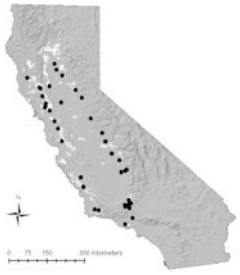


Strategies for reserve design of California valley oak

- Ecological criteria
- Geographical criteria
- Areas of threat
- Opportunity and cost
- Evolutionary history and potential

➢ This part of lecture addresses the question of incorporating evolutionary processes

Methods: sampling and markers



Chloroplast data set
- 32 sites
- 97 individuals
- 6 cp microsatellite primers

Nuclear dataset
- 37 sites
- 113 individuals
- 7 nuclear microsatellite primers

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Questions

I. What are the geographic trends in chloroplast and nuclear genetic markers?

II. Can genetic information help in designing reserve network?

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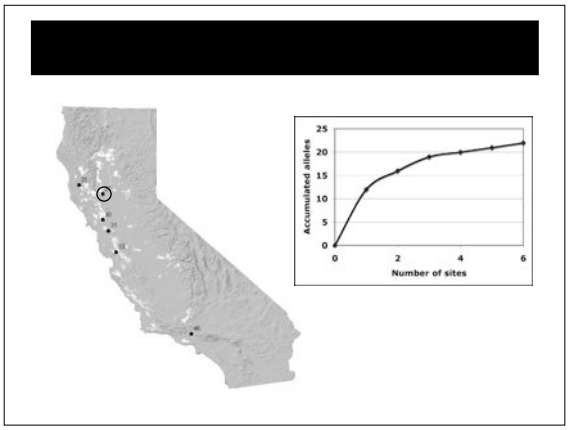
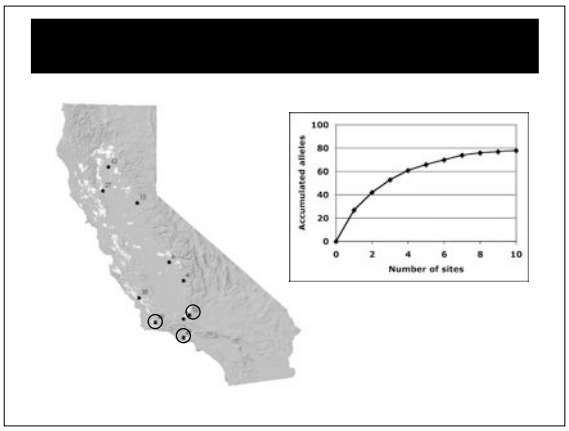
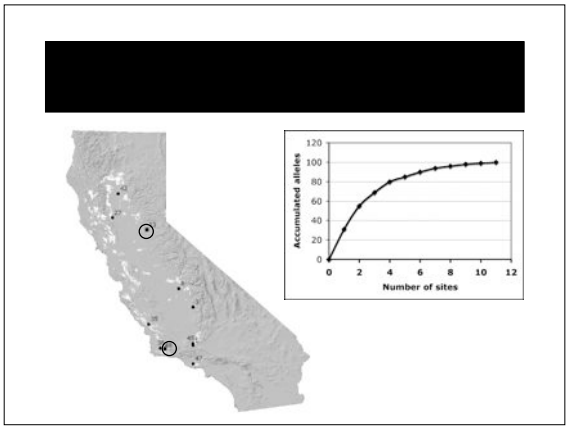
[redacted]

- MARXAN 1.8 reserve design software
- Minimum number of sites and
  maximum number of alleles
- Chloroplast alleles
- Nuclear alleles
- Combined model
- Analyses are based on simple model and no additional weightings (e.g. threat, cost, opportunity)


Accumulated alleles
25
20
15
10
5
0
0
2
4
6
Number of sites

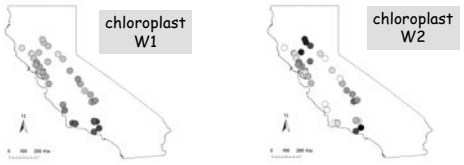

Accumulated alleles
100
80
60
40
20
0
0
2
4
6
8
10
Number of sites

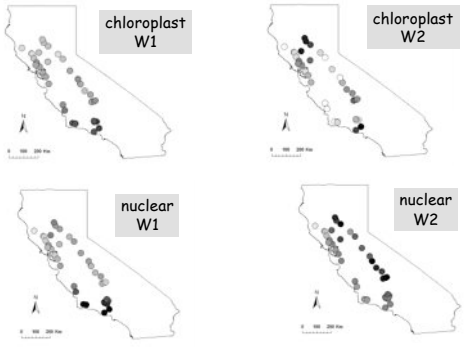

Accumulated alleles
120
100
80
60
40
20
0
0
2
4
6
8
10
12
Number of sites

- Caution: data are preliminary
  - Need more nuclear loci
  - Need more sites (e.g. gallery forest, Santa Lucia Mtns)

- **Findings suggest multiple sites will be needed including Bay area and several in Southern California**
- Use of reserve design models are applicable to genetic data
  - •Identify areas of genetic interest
  - •Identify areas of genetic uniqueness that might not otherwise be selected
- **Genetic/evolutionary criteria complement ecological and socio/economic criteria**

Now, let's look at patterns of genotypes





Comparison of cp and nuclear patterns

- Both markers show same trends
  - **1st axis: north/south gradient**
  - **2nd axis: east/west**
- Similar areas of genetic uniqueness
  - **San Francisco Bay area**
  - **Southern part of range**
- Are these indicators of centers of diversity?

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Development: threat to California ecosystems

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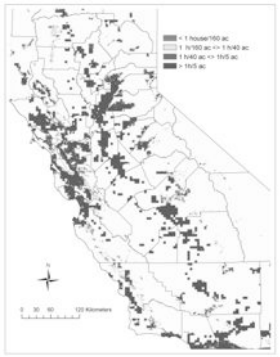
Development overlaid on valley oak distribution



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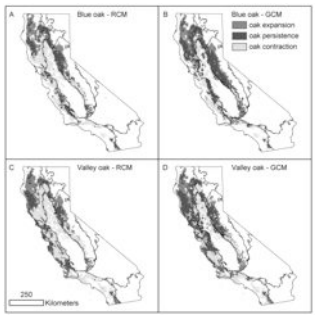
Is Valley oak currently in protected areas?

Historical change: Pleistocene glaciation 10-20 yrs ago.

- Climate change is a natural phenomenon
- What's the difference between then and now?

Global climate change and future distributions



Policy implications

- Evolutionary history provides insight about future movement
- Human activities are jeopardizing current ecosystems and ability to adapt
- Management changes alter evolutionary effects?

Policy recommendations

- Design a preservation strategy of reserve networks
  - Focus on areas of greatest threat
  - Retain ecological, geographical criteria
  - Include areas of evolutionary potential
- Implement "zoning" policies that maintain connectivity
  - Riparian corridors
  - Clusters of local trees
  - Retention of existing trees
  - Preservation of areas for recruitment