IS PINE FOREST CANOPY BENEFICIAL TO THE ESTABLISHMENT OF Quercus calliprinos IN THE PRESENCE OF MEDITERRANEAN DROUGHT?

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Introduction:
Sustainable Mixed Forest Management

Coniferous
Planted

Broad-leaved
Native
Possible Transitions Between Various Forest States

- Pine Plantation
- Pine overstory
- Chaparral species
- understory
- Mixed Forest
- Natural woodland
- Chaparral

Possible transitions are indicated by arrows.
1. Can Chaparral species naturally regenerate within pine plantations of Israel?
2. What management is required to facilitate regeneration (if any)?

1. The eco-physiological aspect: Can woody broadleaved species establish and develop in forest shade?

2. The spatio-temporal aspect: How does forest heterogeneity and its dynamics affect regeneration?
1. The eco-physiological aspect: Can woody broadleaved species establish and develop in forest shade?

- Lower temperatures
- Higher soil moisture
- Lower light level
- Drought in Mediterranean environments

Shade combined with Drought
1. The eco-physiological aspect

Plant response to the combined effect of drought and shade:

**Trade-off Hypothesis**

Smith & Huston 1989

Drought dramatically decreases the ability to tolerate shade

**Independent Effect**

Nobel 1999
Sack and Grubb 2002

The impacts of drought and shade are orthogonal

**Amelioration Effect**

Holmgren 2000
Shade improves water relation in the presence of drought
Is there a trade-off between drought and shade tolerance?

√ In temperate species the combined tolerance to both shade and drought is rare - Niinemets & Valladares F. 2006

Species of the Dry Mediterranean:

√ Trade-off (in the forest shade) - Maestre et al. 2003.

✗ No trade-off - Sanchez-Gomez et al 2006

! Species-specific - Sanchez-Gomez et al. 2006.

The spatio-temporal aspect:

Forest heterogeneity & temporal variation affect woody species establishment

**Forest mosaics:**
- Gaps and variable tree densities

**Forest heterogeneity**
- Tree density modifies biota and environmental conditions, affecting availability of sites for establishment

**Temporal variation**
- Variation among years (climate conditions)
- Forest development and Gap Dynamics affect the availability of sites for establishment
Managing for Biodiversity in the Forests of the Pacific Northwest US

Dense patches

Sparse patches

Gaps

Photos from Thomas A. Spies PNW Research Station Corvallis, OR, USA
Research questions

Case study: Common Oak *Quercus calliprinos*
*Late successional, dominates the Chaparral*

- Is forest canopy beneficial to the establishment and development of *Q. calliprinos* in the presence of droughts?

Specifically:
- What is the effect of canopy openness?
Study site: Masua Forest

400 mm rainfall per year
Creating canopy openness gradient

Spatial heterogeneity of pine density gradient

- Gap
- Gap margin
- Sparse forest
- Dense forest
- North & South facing slopes

Gap | Margin | Sparse forest | Dense forest
Experimental design

- 6 (North) + 8 (South) blocks
- 7 plots per block
- 64 acorns per plot
Radiation (PAR)

% Radiation per hr during the day

* PPFD throughout the year

* Photosynthetic Photon Flux Density

Over the canopy
Seedling emergence and establishment

Establishment rate = surviving seedlings / total seeds
Q. calliprinos establishment  27 months post sowing

✓ Significant effect of shade and aspect

✓ Lowest establishment rates in forest gap (0% shade) and margin
✓ Highest establishment rate in 50% and 70% shading nets
✓ Higher establishment rate in the forest compared to the gap
Significant effect of shading on seedling basal diameter

Highest in the open gap, lowest under canopy and deep shade

(p<0.00001)
Q. calliprinos development (27 month old)
Branching and number of leaves

✓ Significant effect of shading on number of leaves and branches
✓ Highest in gap, lowest under forest canopy and in deep shade.
Significant effect of shading on seedling height (p<0.00001)

Highest under deep artificial shade, lowest under forest canopy.
Q. calliprinos development (27 month old)

- **Height (mm)**
- **No. of Branches**
- **No. of Leaves**
- **Basal diameter (mm)**

- 90% gap,
- 70% margin,
- 50% sparse,
- 0% dense
Shade, if not deep, ameliorates seedling survival and establishment.

However, seedling development is best in full sunlight.

Suitable sites for establishment and development are different.
Establishment

Trade-off

Development

Establishment
Q. Calliprinos Physiological Performance (34 month old)
Discussion and conclusions

In an heterogeneous forest, Where is the best site for common oak recruitment?

- Individual development is most vigorous in forest gap.
- On the population level, seedling survival is the highest under the forest canopy.

**Gap**
Small, but developed population

**Forest canopy**
Larger, poorly developed
THANK YOU!

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