“Resin resource monitoring & modelling in a context of climate change”

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Disturbance legacies, climate and biotic stressors help to explain widespread decline of *P. pinaster* in mixed forests in Central Spain

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Synergistic abiotic and biotic stressors explain widespread decline of *Pinus pinaster* in a mixed forest☆

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Land-use and climate legacies help to explain *P. pinaster* decline and mortality at its dry limit

Global change and forest dynamics :

- Climate change: warming, enhancement in overall water stress in the Mediterrranean.
- Land-use legacies: fire, management, resin tapping, grazing,…

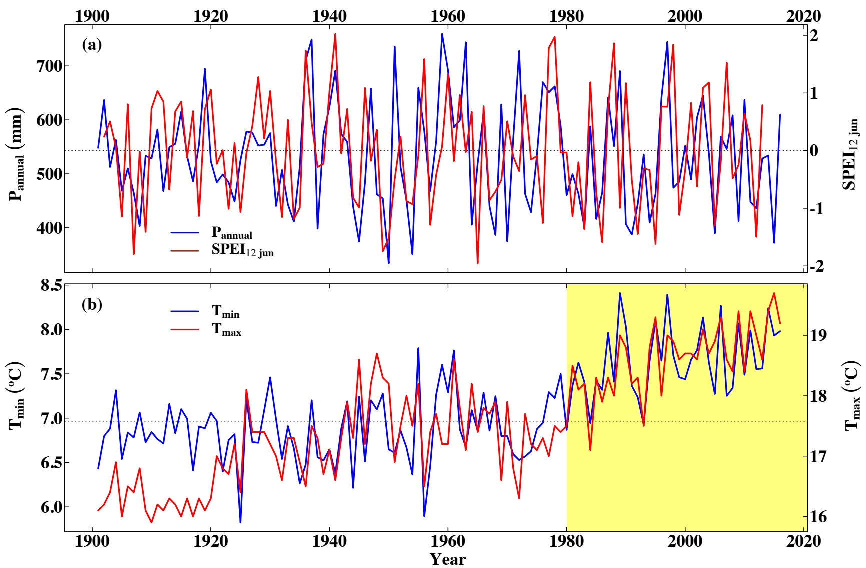
Transformed landscapes: palaecology, socioeconomy

Implications for species dynamics and sustainability:

- Species decline?
- Accelerated mortality? Baseline mortality part of healthy forests

Where? Why? How ?

Need to study interactions between biotic and abiotic factors and their relationship with physiological processes (C-starvation and hydraulic failure)



Climate trends for the study area

✧ **But forest decline is not everywhere!**

Where? Why? How? In the Central System at xeric sites, like low-altitudes and shallow soils a the species low elevation limit in SW Madrid (Study site). Disturbed forest ecosystems.

➢ Implications for the resin business…. Which very much helps to explain the species distribution today.

Objective

Characterize biotic and abiotic factors producing *P. Pinaster* decline in a mixed forest in Central Spain at its dry altitudinal limit (dry-edge, rear-edge) > 700 m asl. Submediterranean *P. pinaster* sspp. (Costa et al. 2005. Los Bosques Ibéricos)

Study site

- Mixed forest: dominant *P. pinaster*, *P. pinea*, *Q. ilex*, *J. oxycedrus* (more drought-tolerant)
- 518 mm annual precipitation 12.7ºC mean temperature
- 45 plots (10-m radius) along altitudinal gradient, 790 -1200 m

Characterise **biotic and abiotic factors**, fungi, insects, growth:

  - Plot level, including regeneration
  - 60 target (cored) *P. pinaster*, 3 health classes

Pine decline=canopy symptoms (0-4):

- **Defoliation levels**
- **Mistletoe infection**

- **But also growth decline and lack of regeneration (particularly if climate forcing)**

P. pinaster **decline in the area is not new, at least:**

- **Pine decline in forest managers reports since the late 1990s (earliest reports available)**
- **In ICP forest plots in the area**

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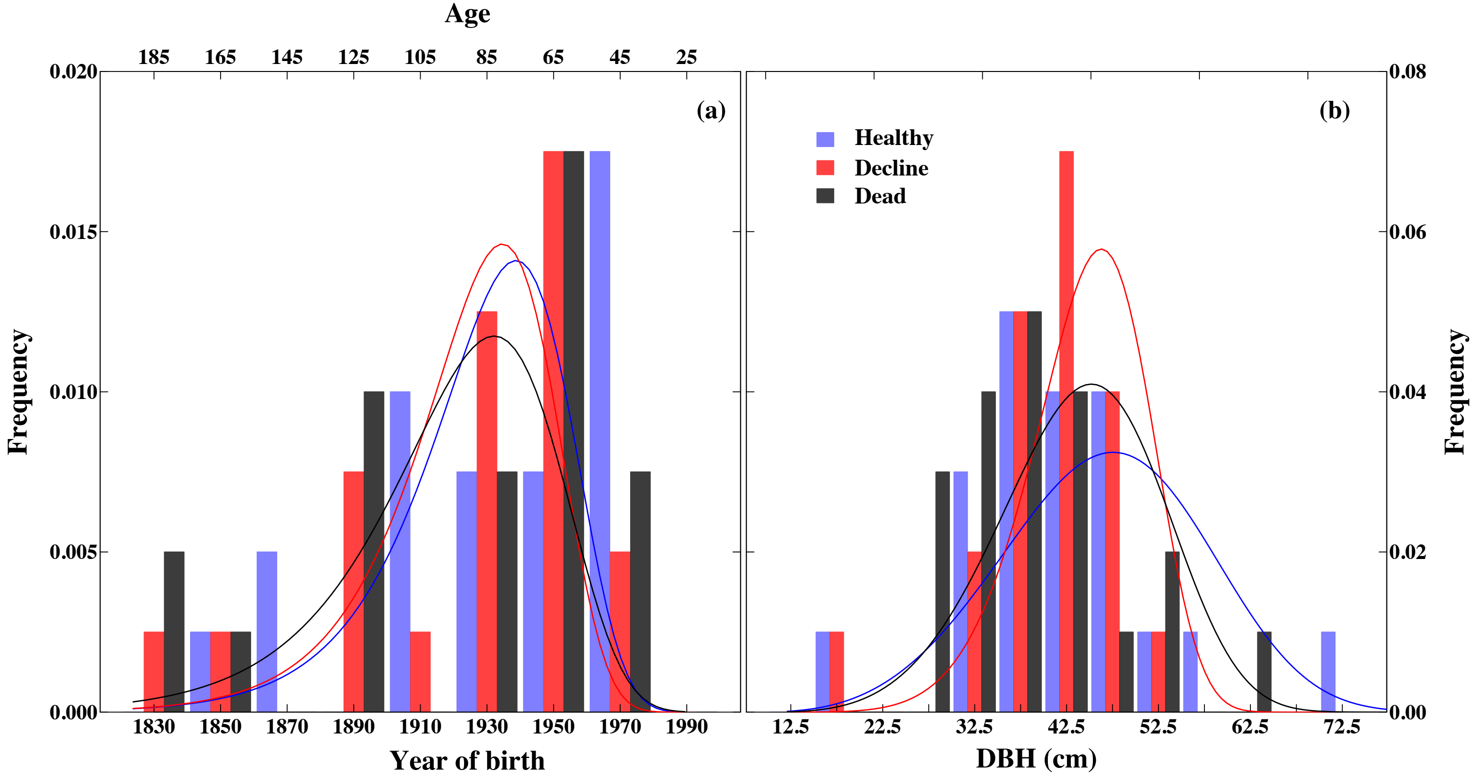
Dead trees in every age class!



Group	Plots (All trees) DBH (cm)	Height (m)	Density (trees/ha)	BA (m^2/ha)	CI	Cored trees (*P. pinaster*) # trees	DBH (cm)	Height (m)	Age (years)
Healthy	39.8 a (14.7)	14.0 a (6.8)	301.4 a (207.7)	26.1 a (19.9)	1.14 a (1.06)	20	42.8 a (11.3)	15.7 a (4.9)	82 a (35)
Decline	27.0 b (13.2)	10.4 b (4.6)	269.2 a (199.0)	18.7 a (12.6)	0.95 a (0.79)	20	40.5 a (7.8)	13.9 a (3.5)	88 a (37)
Dead	24.4 b (41.3)	8.8 c (3.9)	314.3 a (219.2)	19.2 a (14.2)	1.01a (0.73)	20	39.8 a (8.9)	13.1 a (3.1)	95 a (45)

- Already a pine stand in the early 1800s, in 1855 pinea forest (from Madoz, L. Gil com. Pers); resin business blooming since the1850s: 1871, resin plant in Navas del Marqués by Duchess of Medinaceli (Hernández 2006). Most likely resin extraction for more than 100 years in the area until the 1970s.
- Our maximum age pinaster and pinea 200 years: the two species were already 200 years ago.

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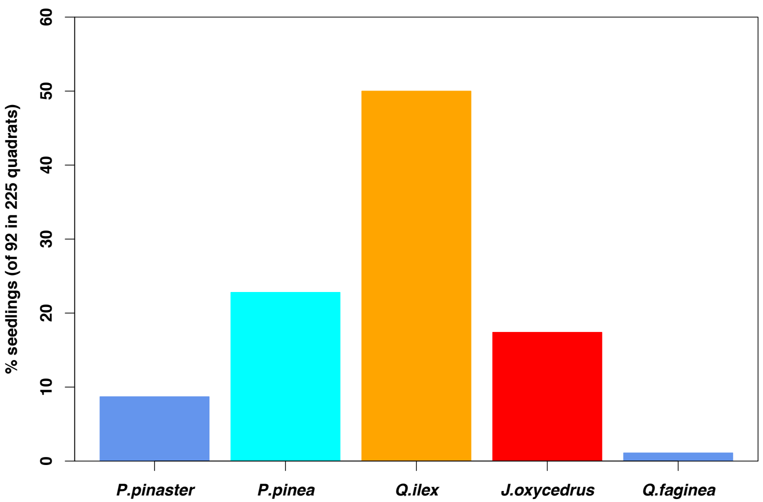
Decline/health classification: medians are shown, whereas minimum and maximum values are between parentheses.

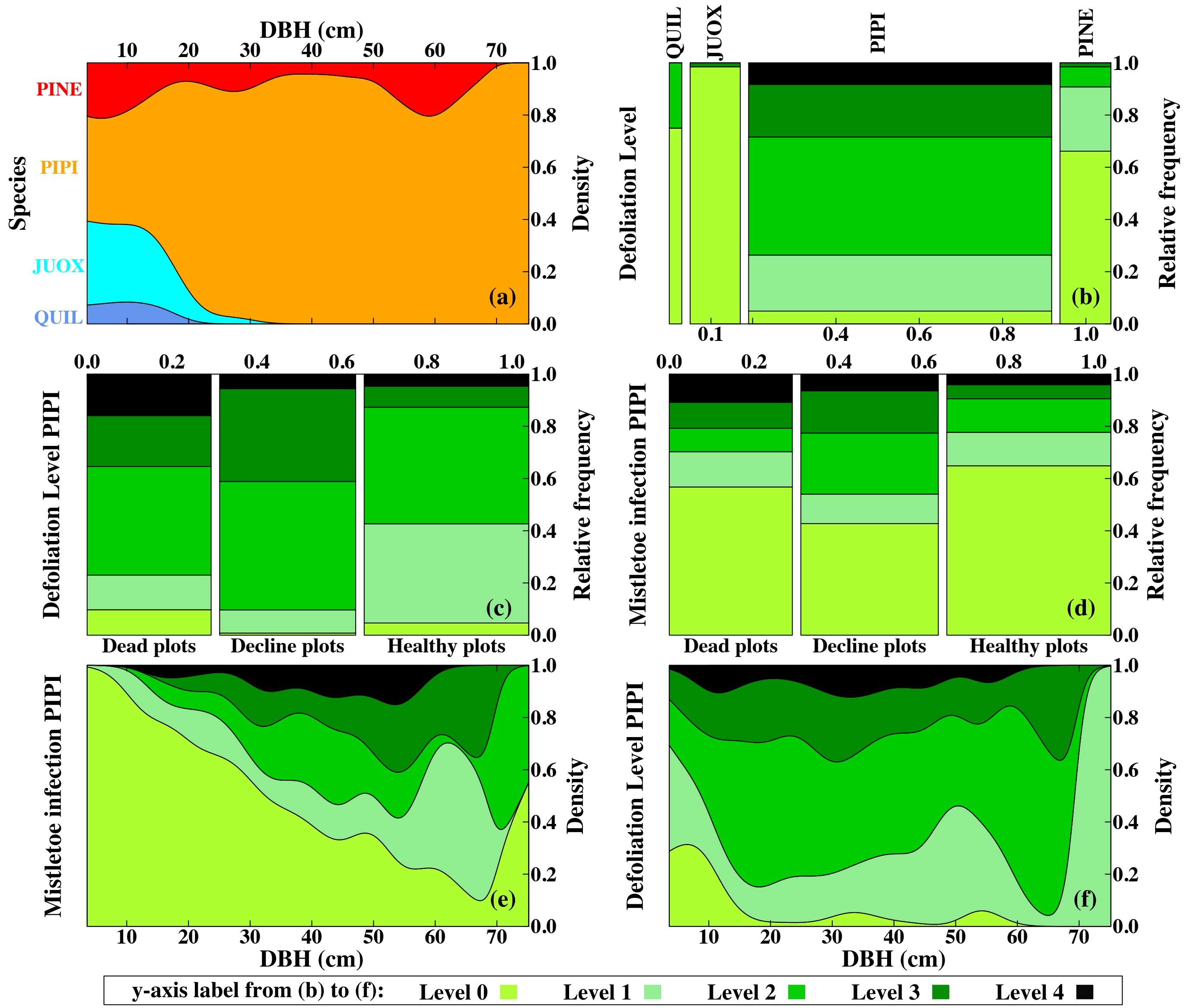
Groups	Health classification	
	Defoliation (0-4)	Mistletoe infection (0-4)
Healthy	1 (0-2)	0 (0-2)
Decline	3 (2-3)	3 (2-4)
Dead	4	3 (0-4)



Regeneration (pinaster dominant canopy sp.)

- Only 1.4% of 225, 1 m^2 quadrats with saplings.
- 22.5% of quadrats with some seedling.

- Only *P. pinaster* decline symptoms.
- Regeneration and lower diameter classes: more abundant drought-tolerant species.
- Abundant canopy decline at the plot level.



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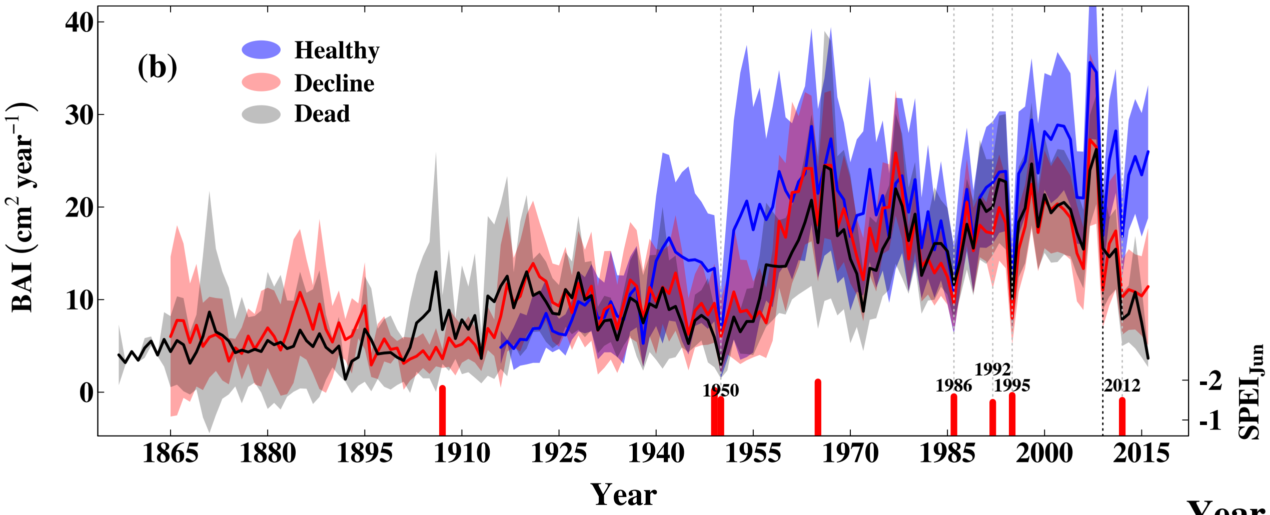
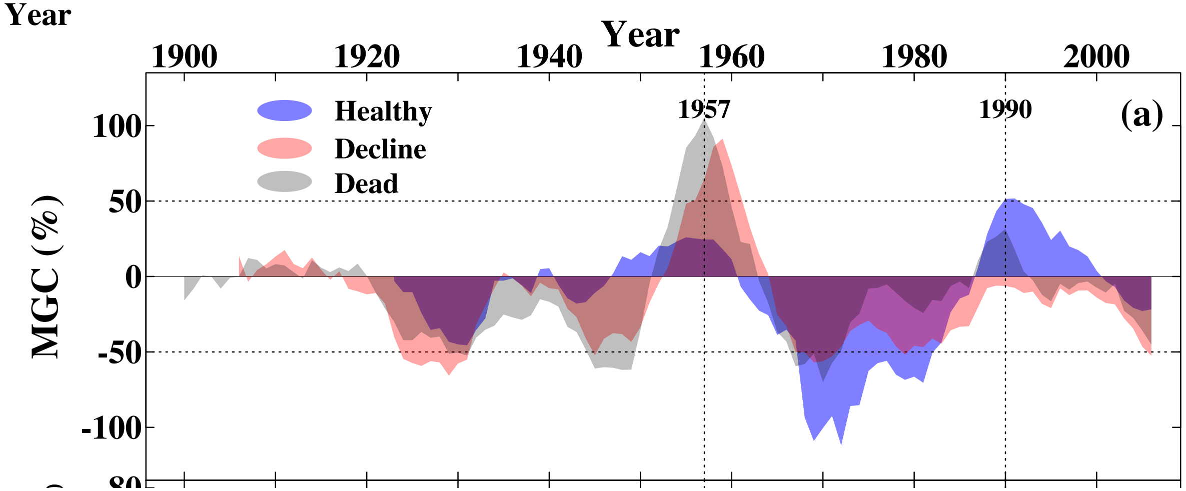
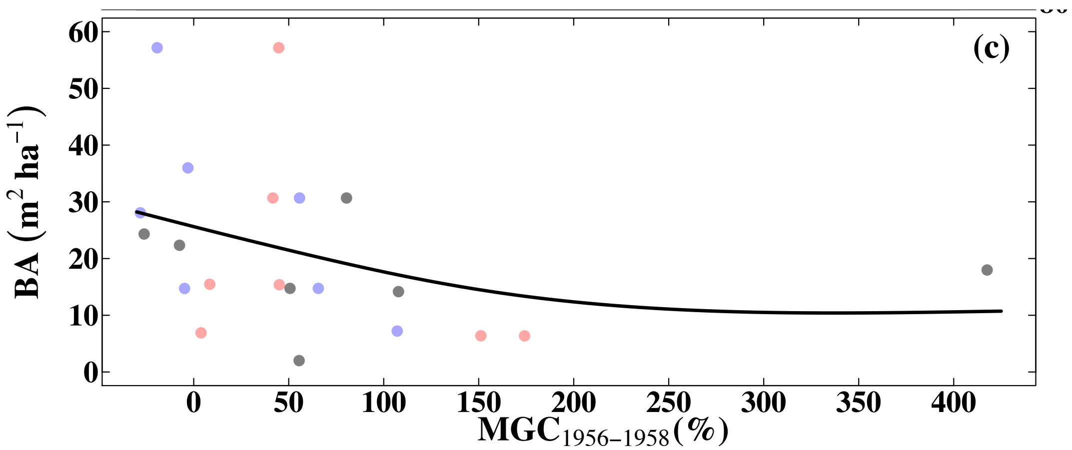


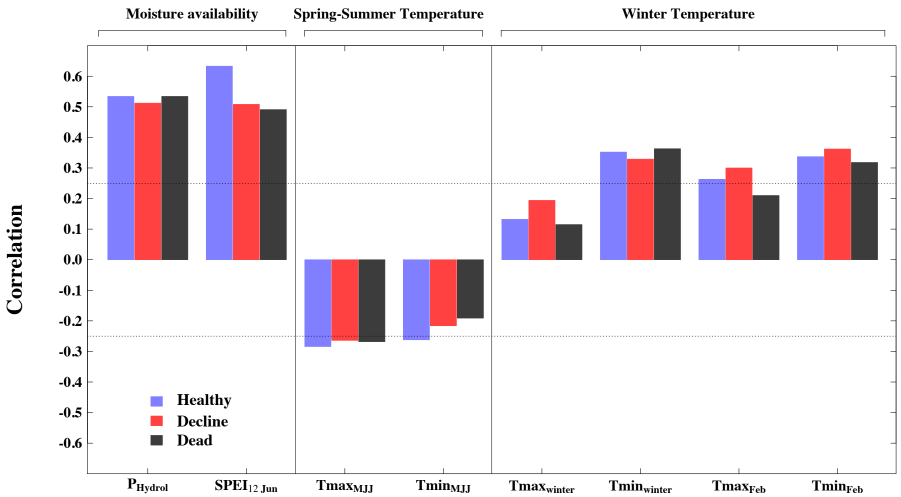
- ✧ Negative growth trend in non-healthy trees.
- ✧ Growth departure between groups since droughts in the early1990s?



- ✧ Declining and dead trees identical growth trends: future mortality of abundant declining trees? Similar in *P. sylvestris* close forests (Gea-Izquierdo et al. 2014).
- ✧ Open stands: drought-related mortality after 1950 (and also 1995)? Fire? Slow recovery dynamics.



Classic Mediterranean growth response to climate



But what about biotic factors?

- Overall 53 fungi detected, few pathogens (leaves, collar root and bole, soil).
- Low levels of infection found: no *Heterobasidion*, no *Phytophthora, some Armillaria mellea* (9.5% of soil samples).
- **No systematic infection of any fungi or insect** (bark, wood-boring, leave defoliators).
- No pine nematode reported in the studied area.

Decline in *Pinus pinaster*: **Take home message**

- Factors causing pine decline at the **species dry-edge**: pathogens like *A. mellea* could be contributing factors, but **abiotic factors** dominant; particularly **water stress related factors** (including mistletoes, climate) and land-use legacies as predisposing (long-term) and inciting factors (short-term).
- What about land-use legacies? Great consequences for species dynamics today, including decline. We have much to learn, including **implications of historical forest use on current (and future) species dynamics**.
- Must take into acount all these factors in **mortality models** (hence in management), and learn how they interact to actually produce mortality (**physiology of tree decline**).
- In the literature other similar examples (e.g. next speaker. from the Northern Plateau)… so **decline is not ubiquitous but neither just a local phenomenon**, and the species (likewise others) is likely in decline in the most xeric sites, where (if) more drought-tolerant (or disturbance-tolerant) species are already substituting them. Consequences for future management of forests? Need monitoring.