Frost-induced changes in aboveground biomass stocks in the northmost Neotropical dry forest

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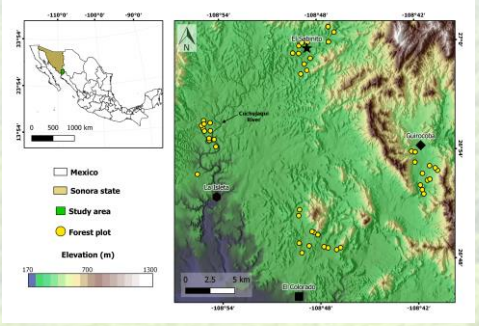
Introduction

- Extreme climatic events are inducing episodes of tree mortality worldwide[1,2], causing changes in the aboveground biomass stocks in natural ecosystems[5].
- An extreme frost affected most of North America in early February 2011 triggering extensive tree mortality in the lowland tropical dry forest of northwestern Mexico.
- This event was likely the most severe since 1949 in the region, where freezing temperatures lasted for nine consecutive days, but there are no reports about widespread tree mortality.
- Extensive tree mortality was observed across the landscape after the 2011 frost reaching up to ca. 90% (secondary) and 50% (mature) forests stands[6]. Tree mortality was highly heterogeneous across the landscape.
- Allometric equations (local and foreign) were used to estimate changes in live and dead aboveground biomass in the TDF lowland after the extreme frost.

Methodology

Study area



Study area (29 × 29 km) in the Alamos municipality, southern Sonora, Mexico.

Landscape is a matrix of mature and secondary tropical dry forests, annual crops and pastures[6].

Dots represent the 48 mature and secondary forest (24 per forest type) surveyed sites with different degrees of frost-induced vegetation damage. Map was generated with QGIS 3.16.5.

Forest without damage

Forest with damage

Vegetation sampling

In 48 200 × 50 study sites (10 50 ×2 m Gentry transects per site)

Field surveys:

- Diameter at breast height (D) of all individuals and stems ≥ 1 cm
- Total tree height (H)
- Condition of individuals and stems:
  - Live or dead

For each site, we obtained elevation (El) from a Digital Elevation Model (15 × 15 m resolution)

Aboveground biomass (AGB in kg/m²) estimation in the 48 forest study sites

Allometric equations used for AGB (kg) estimations in the tropical dry forest in the northwestern of México. WSD = average wood specific density.

	Equation	Reference
1	$AGB = 0.673 \times (WSD*D^2*H)^{0.976}$	Chave et al. 2014
2	$AGB = 0.3700 \times (D)^{1.9600}$	Návar et al. 2009
3	$AGB = 0.187634 \times (D*H)^{1.213918}$	Bojórquez et al. 2020

Application of allometric models in the forest stands:

DAP	Forest type	Predictor variables	Equation
≥ 5.2 cm	Mature and secondary	DAP,WSD, H	1
≥ 5.2 cm	Mature	DAP	2
1 and < 5.2 cm	Mature and secondary	DAP, H	3

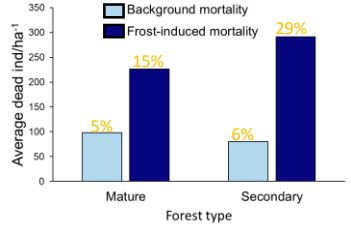
Average WSD per specie was obtained from regional[10] and global data bases[11].

Results

Density of individuals and aboveground biomass estimated in the tropical dry forest of Álamos, Sonora, México. Average in the 48 sites.

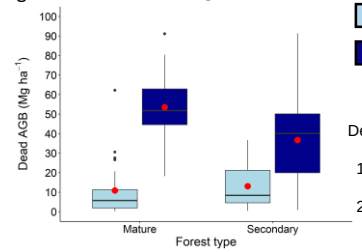
	Individuals per ha	Mg ha^{-1}
Dead	285	12
Live	1418	45.1

Fig. 1 **Tree mortality** Dead ind./live ind.



2.3 and 3.6 times above background mortality

Fig. 2 **Dead aboveground biomass**

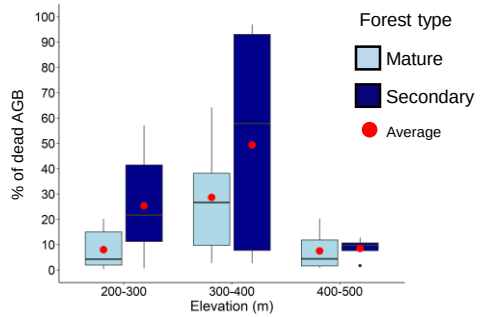


Dead AGB represents:

17% in mature forest

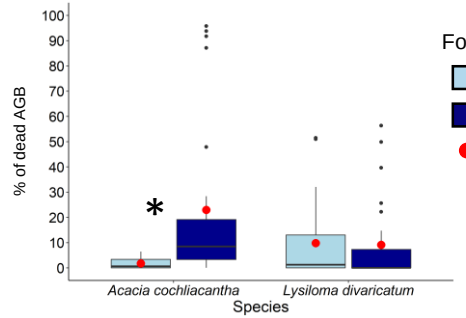
26% in secondary forest

Fig. 3 **Dead AGB across the landscape**



High dead AGB in lower and middle elevations (300-400 m a.s.l.) but higher in secondary forests

Fig. 4 **Ca. 80% of dead AGB occurred in two legume species**



High in secondary forest stands

High but similar between forests

Conclusions

- ❖ The extreme February 2011 frost induced extensive tree mortality and caused abrupt changes from live to dead AGB stocks in the northmost Neotropical dry forest.
- ❖ Magnitude of TDF dead AGB varied across the landscape, affecting severely two of the most abundant legume species in mature and secondary forests.
- ❖ High frost–induced tree mortality may have consequences in the successional pathway regeneration process.
- ❖ Our results demonstrate the high vulnerability of the tropical dry forest to extreme frost events, and the importance of accurate AGB estimations to understand its effects on the regional and global carbon cycle under future extreme climatic events.

Literature cited

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