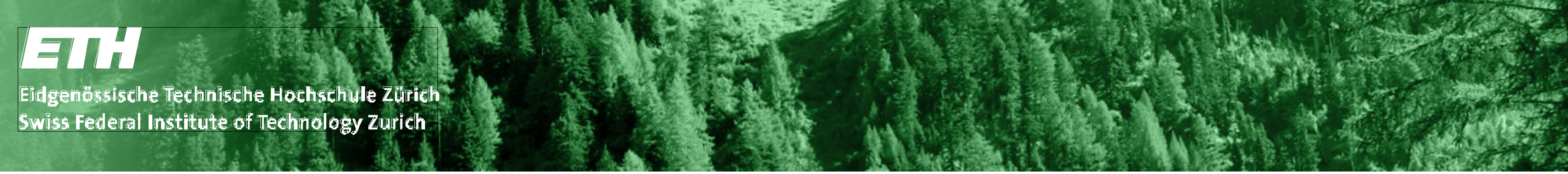
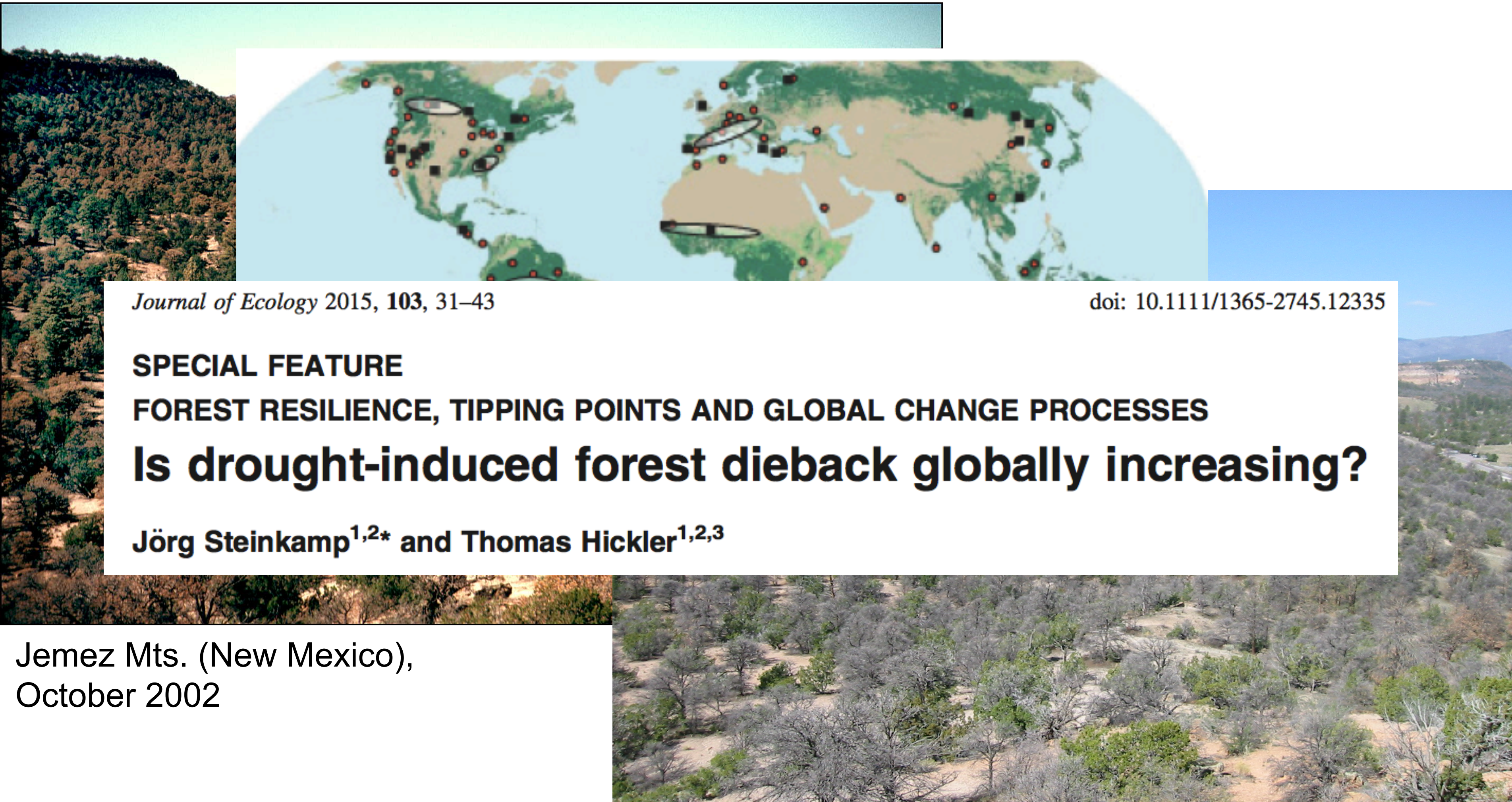


Typically, it's neither carbon starvation nor hydraulic failure: a modeling perspective on drought

Harald Bugmann

Forest Ecology, ETH Zürich, Switzerland

The case of tree mortality



Jemez Mts. (New Mexico), October 2002

Journal of Ecology 2015, **103**, 31–43 doi: 10.1111/1365-2745.12335

SPECIAL FEATURE

FOREST RESILIENCE, TIPPING POINTS AND GLOBAL CHANGE PROCESSES

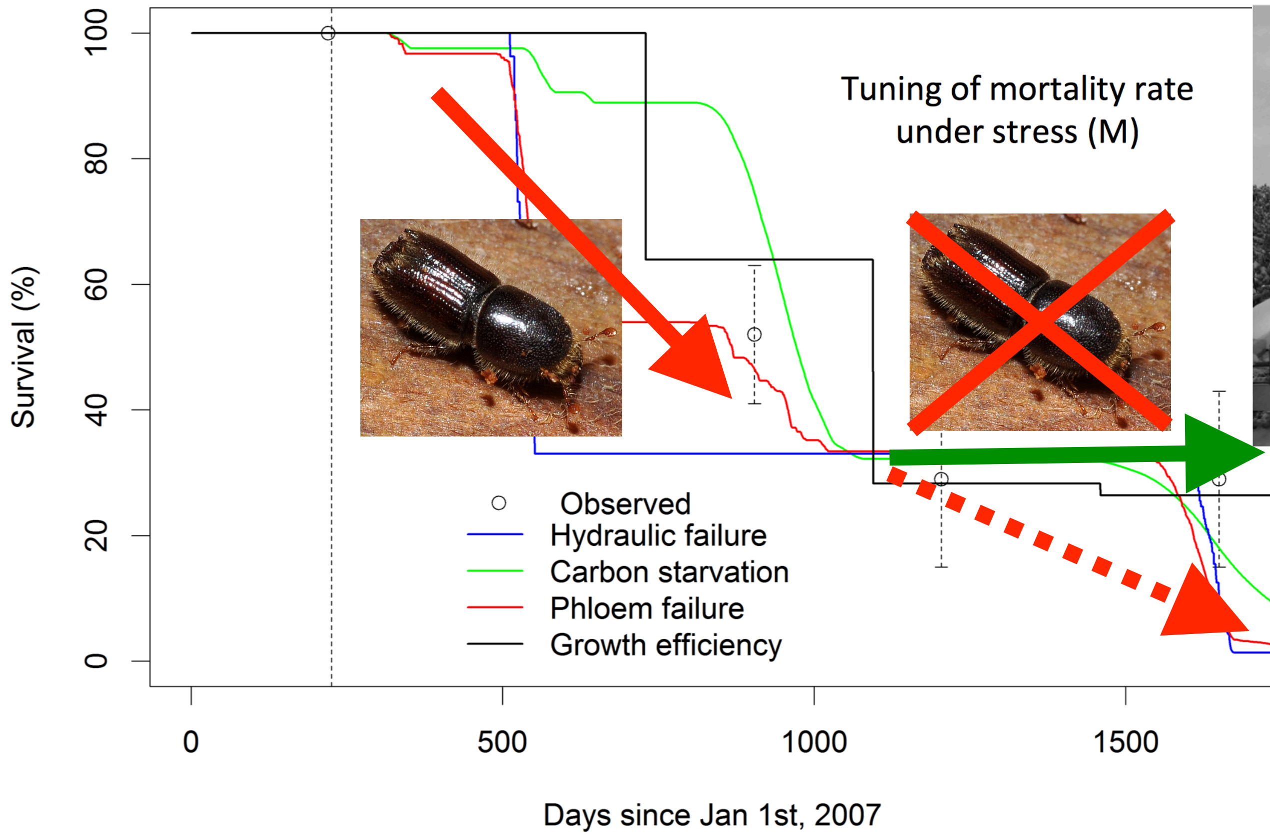
Is drought-induced forest dieback globally increasing?

Jörg Steinkamp[1,2]* and Thomas Hickler[1,2,3]

Jemez Mts., May 2004

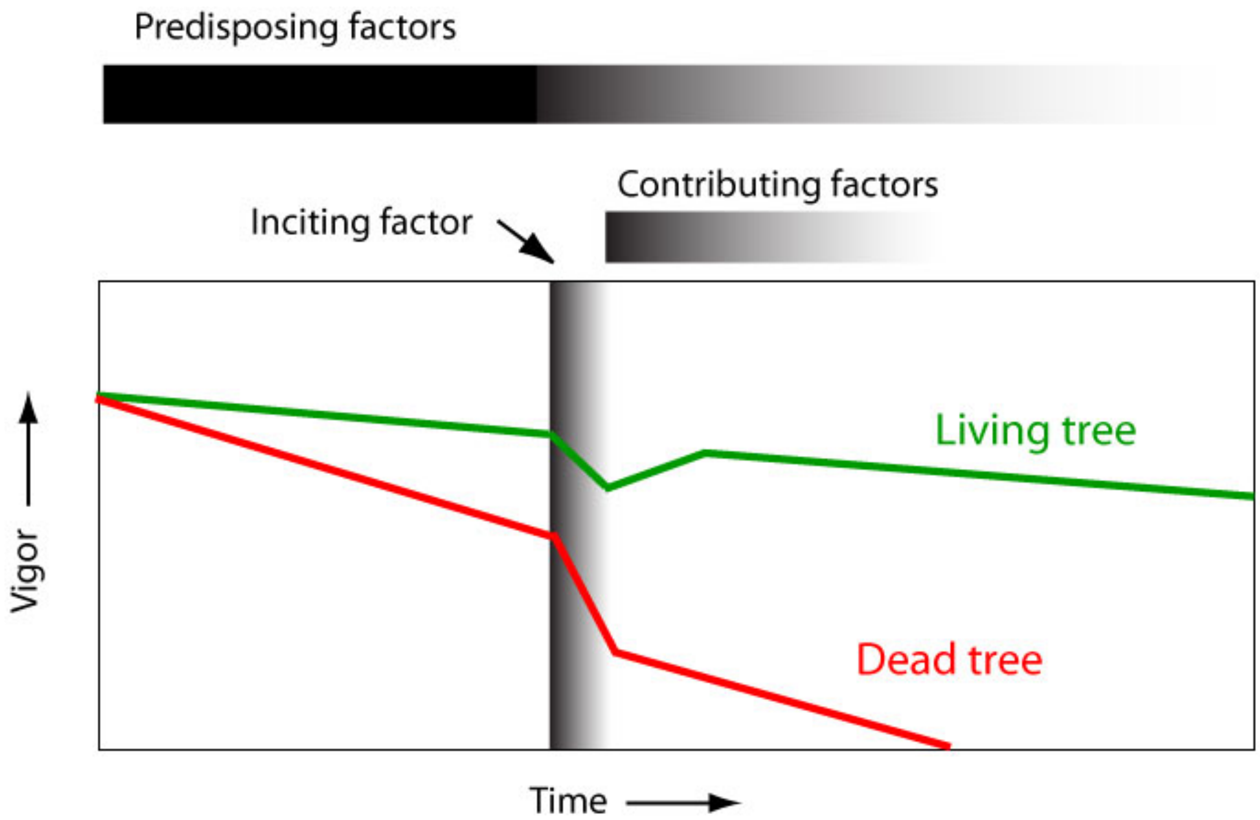
Allen et al. (2010), *For Ecol Management*; Pictures courtesy of C.D. Allen (USGS)

Pinyon pine drought experiment, Sevilleta



Xu et al., *in prep.*

Decline Disease "Theory"

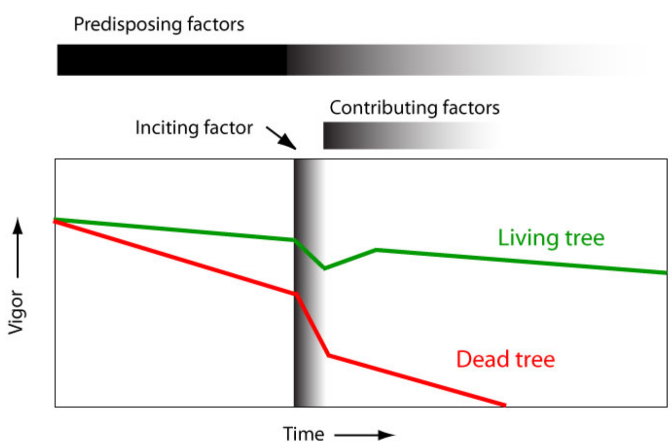


Manion (1981), *Tree disease concepts*

"Predicting" mortality

- Heat & drought in a developing country:
  Mortality = *f* (lack of water OR heart attacks OR disease) ?

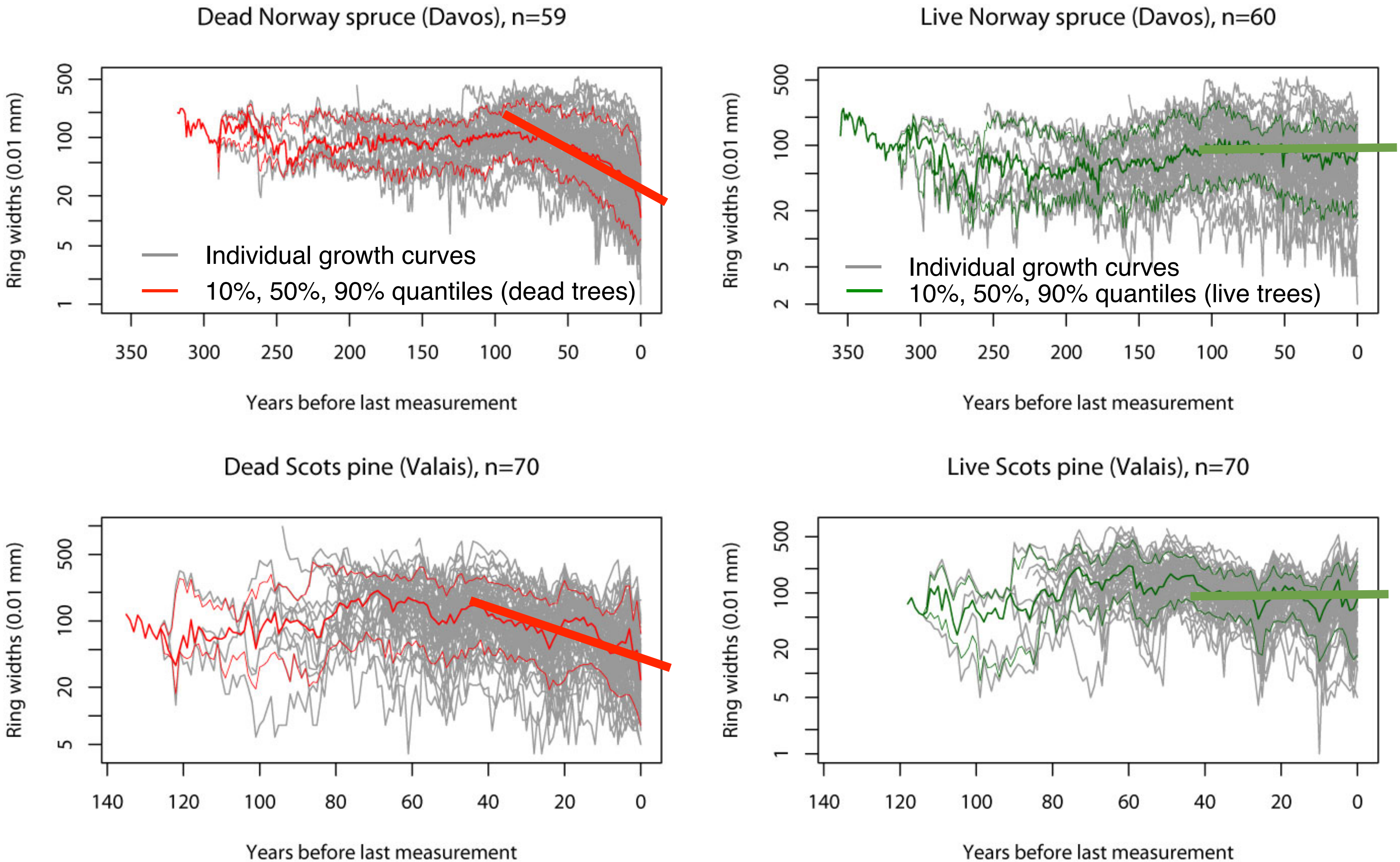
- Research is not unbiased: we do research on what we can measure (better – best ?):
  "*This reflects the human fascination with electronic machinery rather than spades, but lacks any scientific rationale*" Körner (1998), *Oecologia*



- Plant physiology may *not* provide robust estimators of tree mortality

- More integrative (aggregated) predictors are more likely to be successful

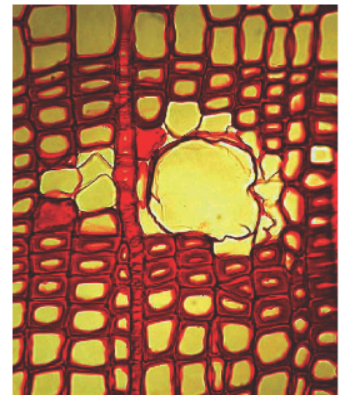
Tree rings are telling a story…

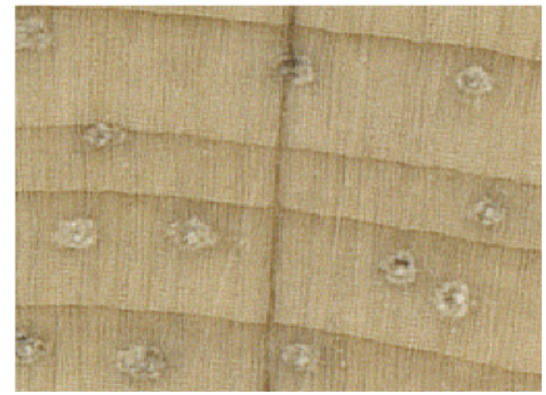


Bigler & Bugmann (2003), *Can J For Res*; Bigler et al. (2006), *Ecosystems*

Pinyon pine mortality in 1950s and 2000s

- Statistical models to predict fate of individual trees





- *Growth* variables:
  - Average ring width (mm)
  - Mean sensitivity
- *Wood anatomy* variables:
  - No. of resin ducts
  - Mean duct size
  - Duct density
  - Relative duct area

Macalady et al., *in prep.*; Macalady & Bugmann (2014), *PLoS ONE*

Pinyon pine mortality in 1950s and 2000s

	Fixed + (1 I site)	Coefficeints			Model Diagnostics			Correct Classification Rates			
								Internal			External
					Δ AIC	ROC	Evidence Weight	Dead Trees	Live Trees	All Trees	Dead Trees
	Growth and Resin Duct										
Top model overall	RW15 + Sens15 + Size3	-3.54	-7.06	410	0	0.94	9.68E+18	83.5%	81.7%	82.6%	70.0%
	RW20 + Sens15 + Size3	-3.6	-7.01	405	0.5	0.93	7.50E+18	83.3%	81.7%	82.5%	70.0%
	Resin Duct Only										
	RelArea3 + Size3	40.9	347		5.5	0.94	6.11E+17	85.6%	80.7%	83.2%	65.0%
	RelArea5 + Size3	56	353		5.8	0.94	5.34E+17	84.8%	83.2%	84.0%	65.0%
	Best 1-variable Resin Duct										
	Size3	366			17.7	0.92	1.40E+15	81.8%	74.9%	78.4%	56.5%
	Growth Only										
Reference model	log(RW3) + Sens20	0.79	-4.44		87.4	0.78	1.00E+00	70.2%	71.5%	70.8%	25.0%
	log(RW3) + Sens15	0.8	-3.39		92.1	0.76	9.76E-02	70.3%	69.1%	69.7%	30.0%
	Best 1-variable Growth										
	Sens20	-5.84			92.9	0.74	6.43E-02	66.7%	63.8%	65.2%	35.0%
	log(rw3)	1.23			99	0.73	3.02E-03	66.5%	69.8%	68.2%	40.0%

- Growth-only models — do a decent job classifying dead vs. surviving trees, **but** fail in external validation
- Growth + duct models — correctly classify over 80% of trees, **and** pass the external validation test

Macalady et al., *in prep.*

To conclude this very brief presentation…

- Tree mortality is a complex process that defies a physiological explanation based on one or a few factors
- Typically, trees die neither of carbon starvation nor of hydraulic failure (alone)
- Yet, to better understand hydraulic failure and carbon starvation is a laudable goal in itself
- If we want to predict future tree mortality, integrative approaches based on tree-ring or forest inventory data are more promising than “mechanistic”, “physiological” models