Tracking pesticide fate in conventional banana cultivation in Costa Rica: a disconnect between protecting ecosystems and consumer health

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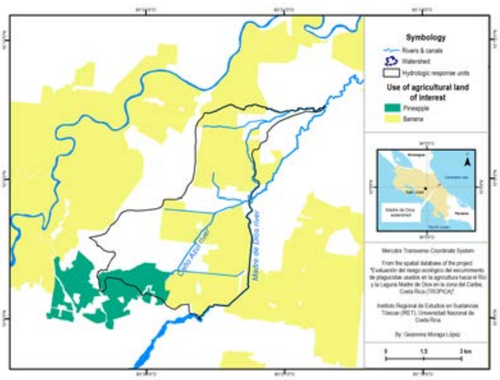
INTRODUCTION: Safe fruit = safe environment ?

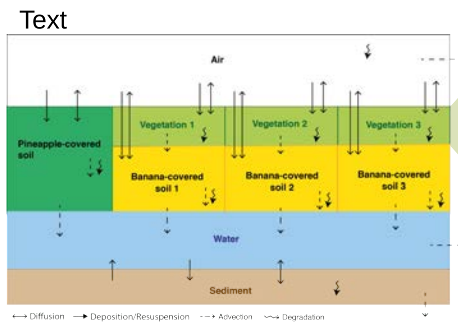
Conventional banana cultivation in Costa Rica, the world's 3rd largest exporter, relies on intensive pesticide use[1]: 76 kg a.i. ha^{-1} yr^{-1}. Most bananas (96%) are exported to Europe and the US[2], where pesticide monitoring programs have rarely found residues above thresholds (MRLs) set to protect consumer health[3,4].

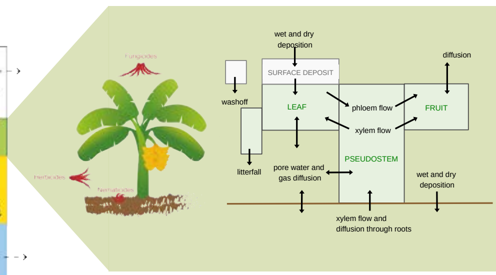
However, several studies have detected pesticide residues in coastal lagoons and surface waters of banana-producing regions, at levels associated with negative effects in biota and humans, such as recurring fish kills[5,6]. Most of these studies are snapshots, resulting in scattered insights on pesticide fate and transport to inform risk mitigation.

To describe pesticide dynamics, a multimedia model that captures the combined influence of changing environmental conditions, application patterns, and chemical properties on pesticide concentrations in the environment was developed for the Caño Azul River drainage basin.

METHODS: fugacity-based dynamic multimedia modeling

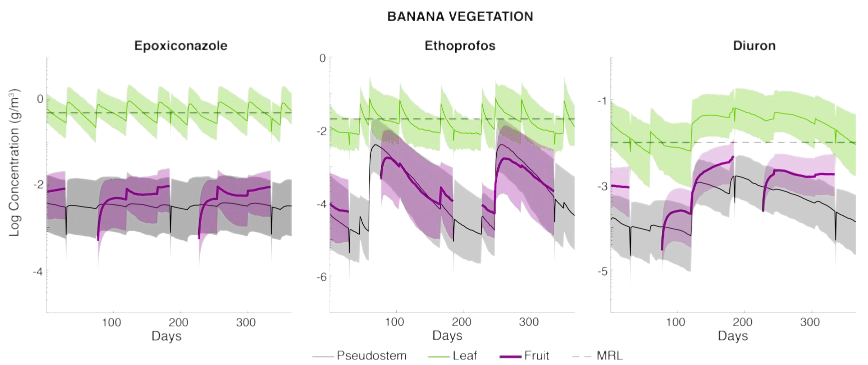






based on: Trapp 2007, Fankte 2012, Cousins and Mackay 2001, Undeman et al. 2009

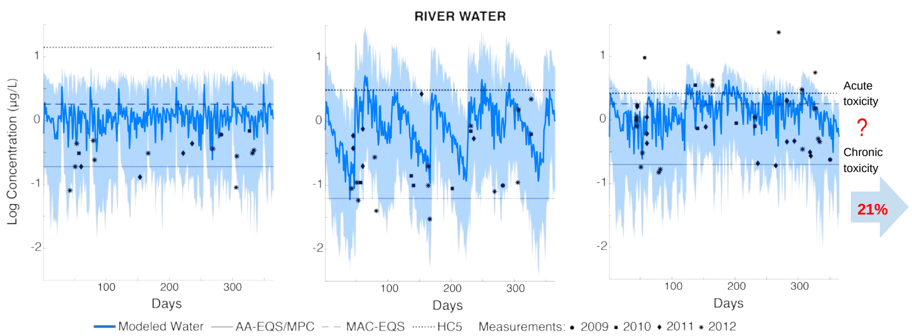
RESULTS: consumer health ✓ ecosystem health ?



	Diuron	Ethoprophos	Epoxiconazole
Function	herbicide	nematicide	fungicide
Annual applications	2 b*, 6 p	2 b, 6 p	8 b
Annual amount (kg a.i./ha)	0.04 b 0.5 p	1.38 b 9 p	0.08 b
logK_{ow}	2.68	3.59	3.44
logK_{aw}	-7.28	-5.18	-7.79
$t_{1/2}$ air (days)	0.12	0.11	0.87
soil	221	15	226
water	43	51	80
sediment	17	92	64
vegetation	30	7.4	30

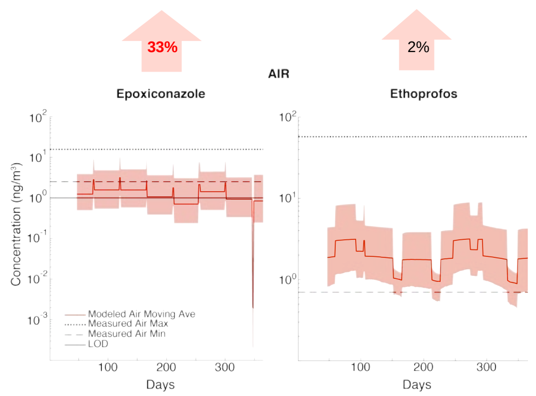
* b= banana p=pineapple

- Modeled pesticide concentration in fruit < MRL ✓



- Good model-measurement agreement
- High *variablity* of pesticide levels in water: driven by rainfall and emissions timing
- *Most* pesticide concentrations in water > *chronic toxicity* thresholds
- *Diuron* peaks in water > *acute toxicity* thresholds
- Large diuron exports downstream

- Large epoxiconazole exports from air



CONCLUSIONS

- MRLs derived from Good Agricultural Practice as environmental quality standards?
  NO: protective of consumers BUT not of local environments in production zones
- Ecological effects of repetitive exposure to peaks and pesticide mixtures?
- Dynamic multimedia model as decision-making support tool:
  - Modify application patterns to minimize pulses
  - Elucidate fate and transport of yet unmeasured chemicals (ie: mancozeb)

References

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