

# The challenge of warming winters

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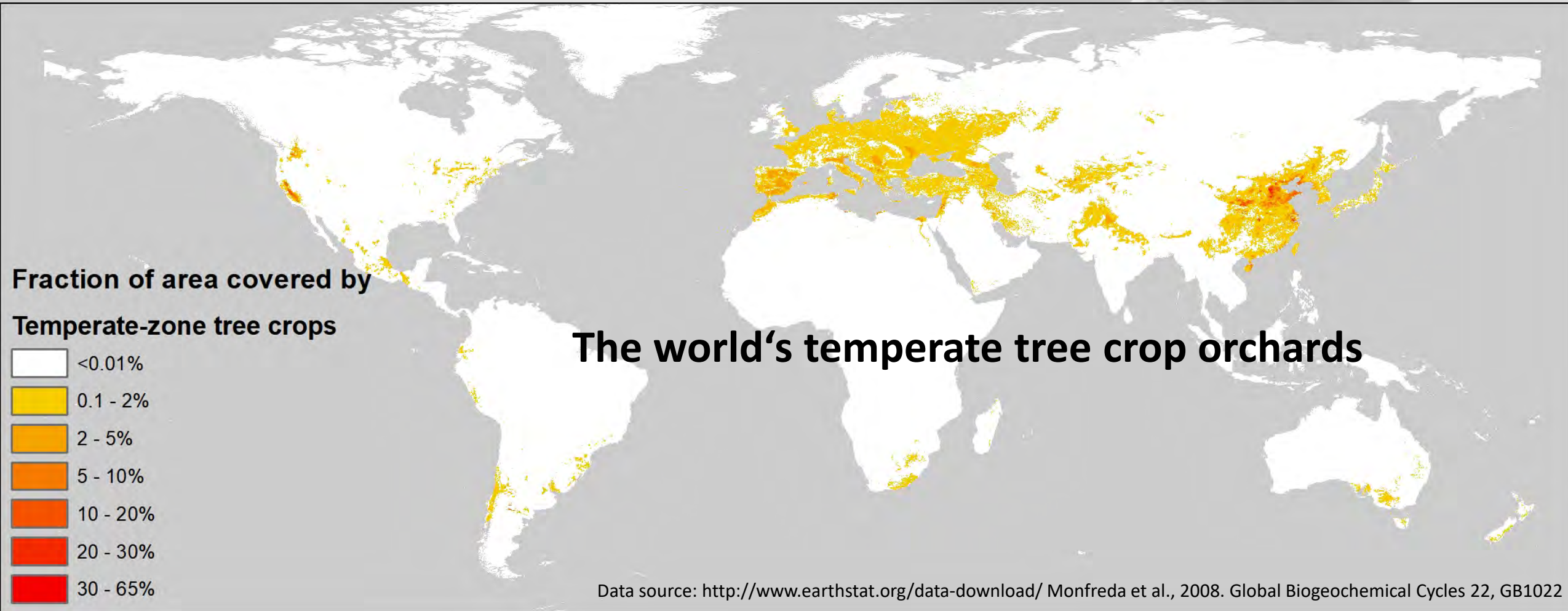
do we understand tree dormancy  
enough to prepare deciduous orchards  
in warm places?



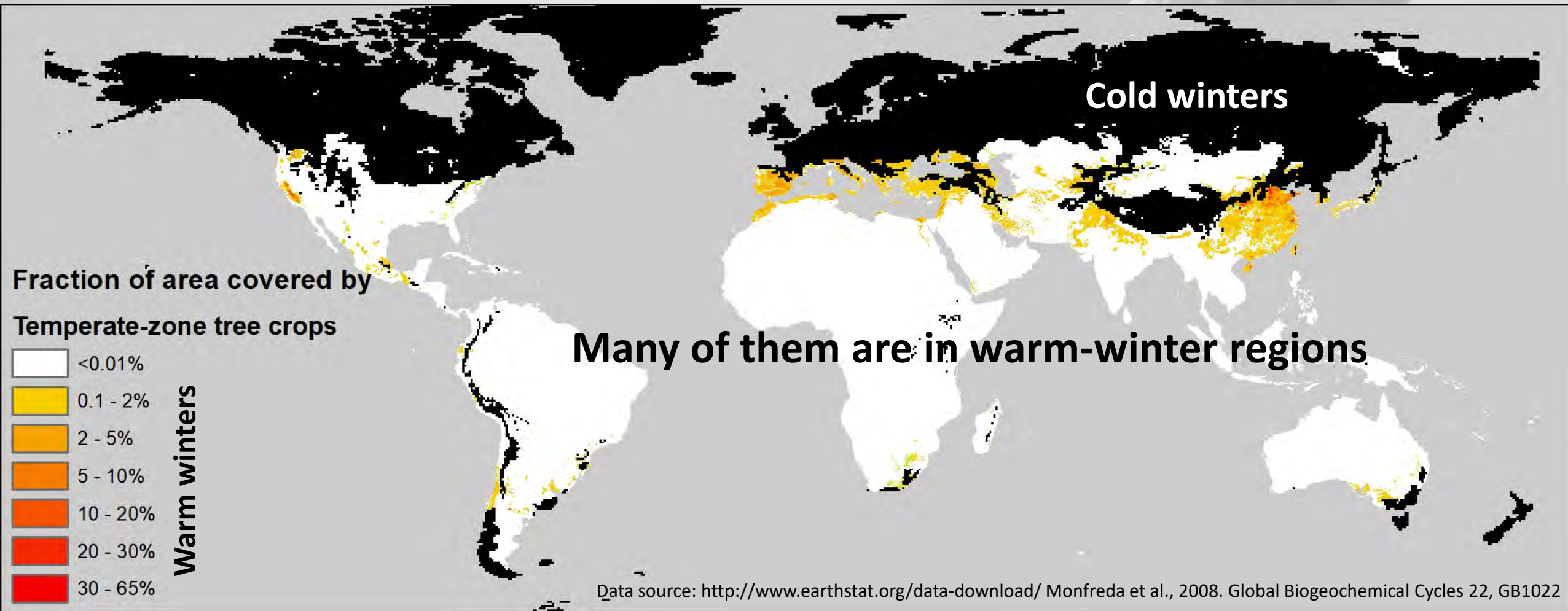
Eike Luedeling



# Temperate trees in warm places



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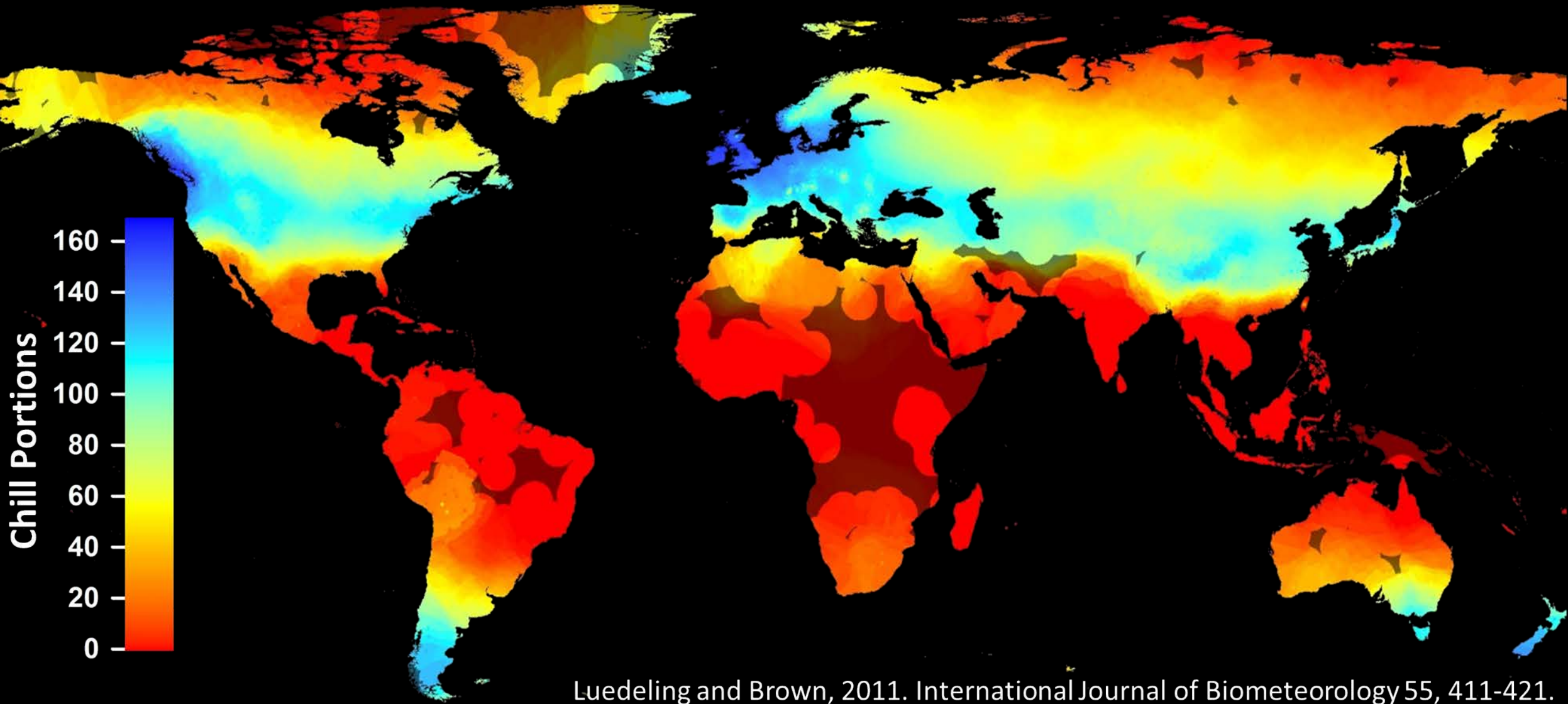


# These trees need chill

- (Winter) chill is a critical requirement for (commercially viable) production of temperate-zone tree crops
- Especially relevant in warm and warming places
- Even in cooler growing regions of high relevance due to relationship with late frost events
- Chill levels determine what trees can be grown where

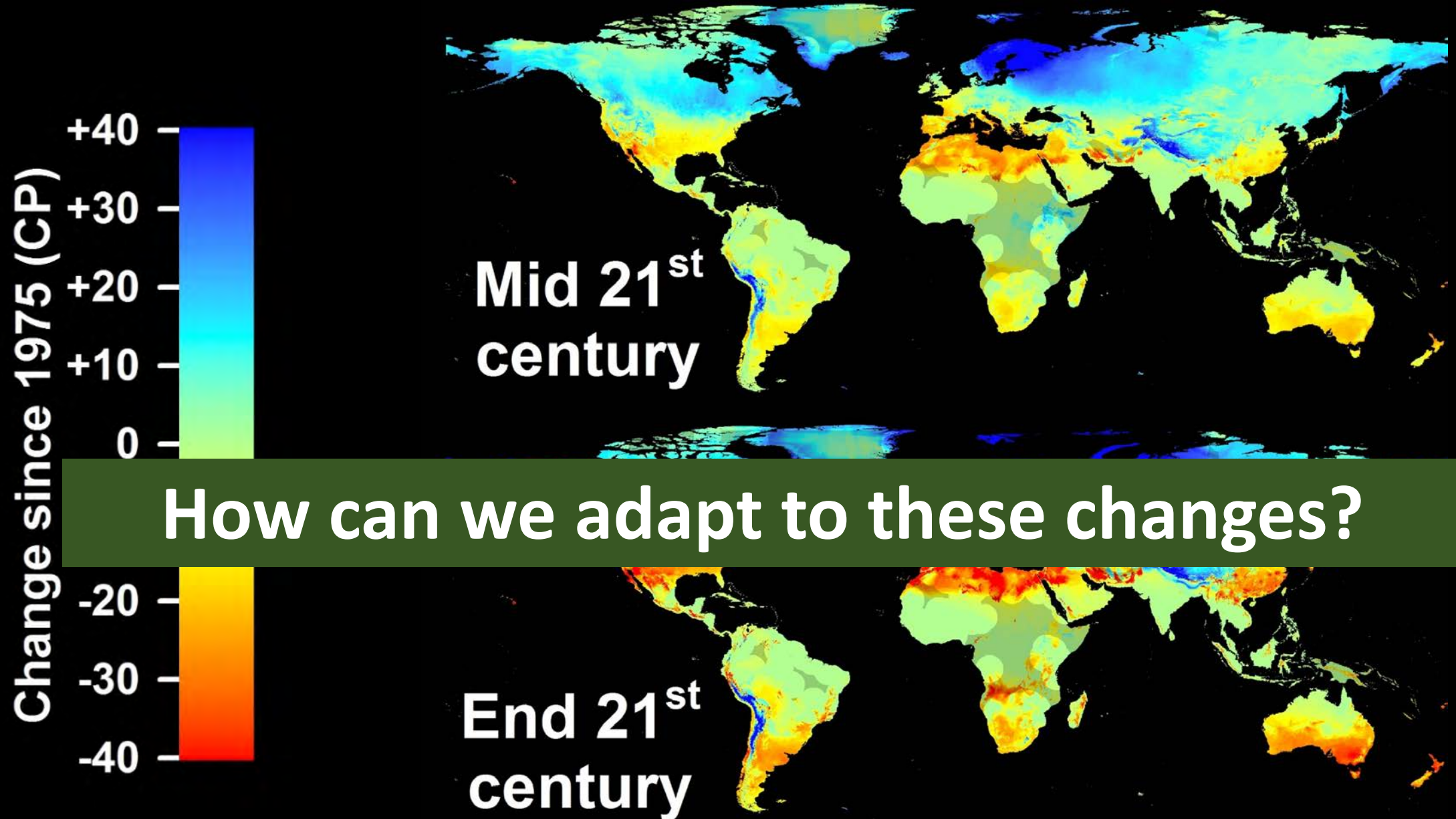


# Chill levels around the year 2000

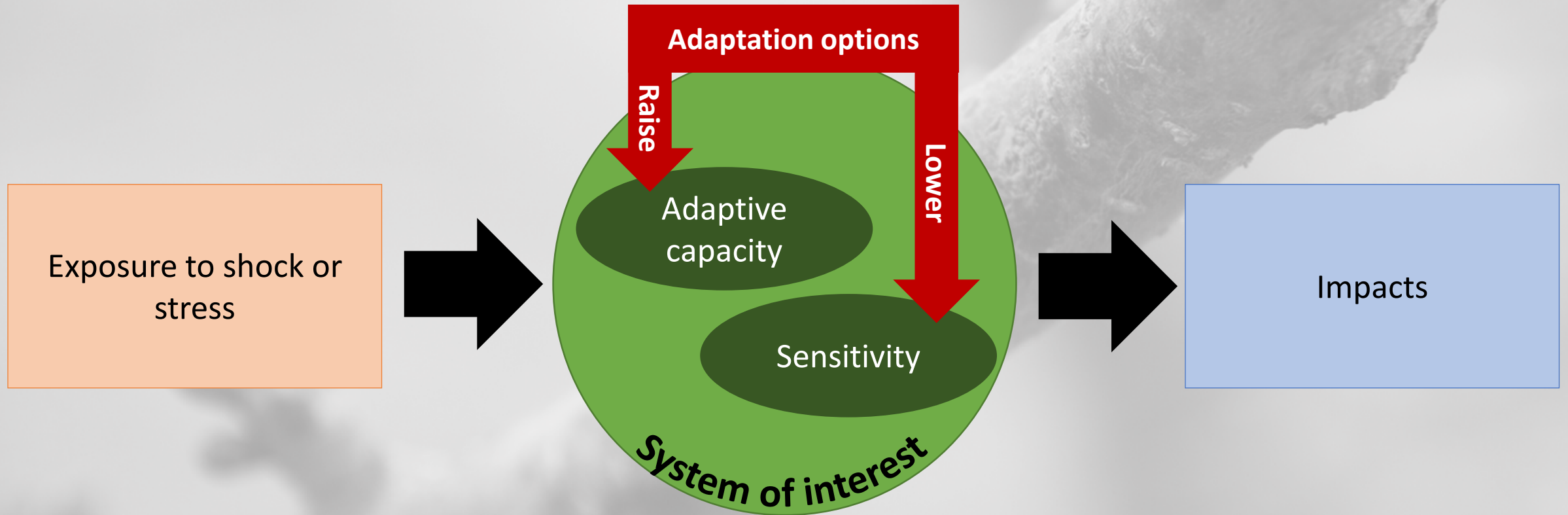


Luedeling and Brown, 2011. *International Journal of Biometeorology* 55, 411-421.

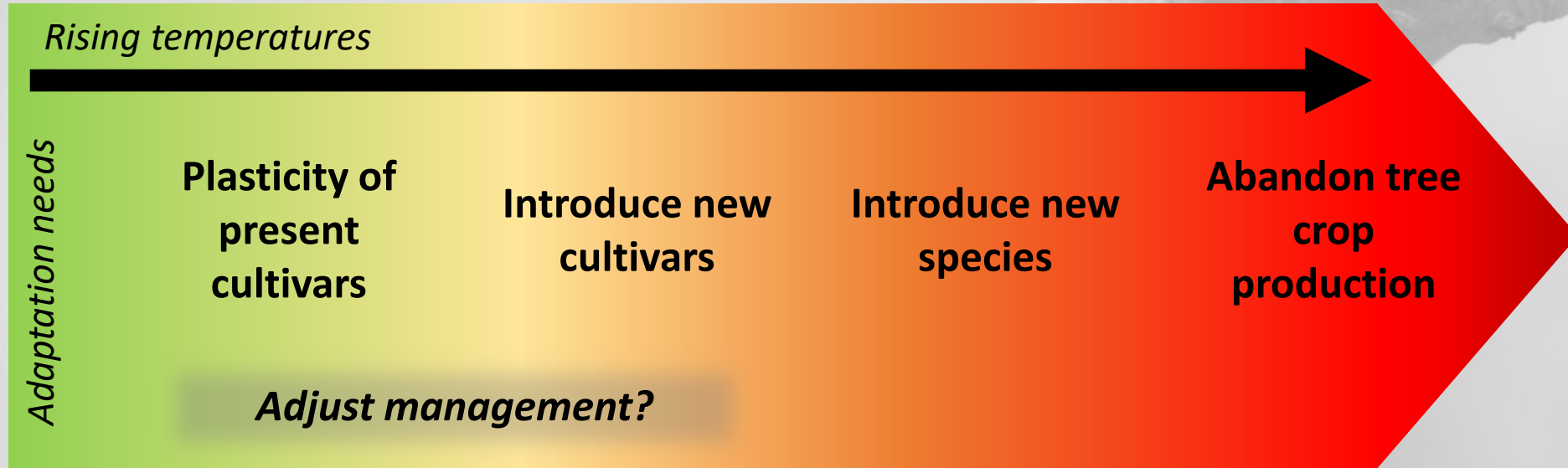
# Projected chill decline



# Adaptation to climate change



# Adaptation options

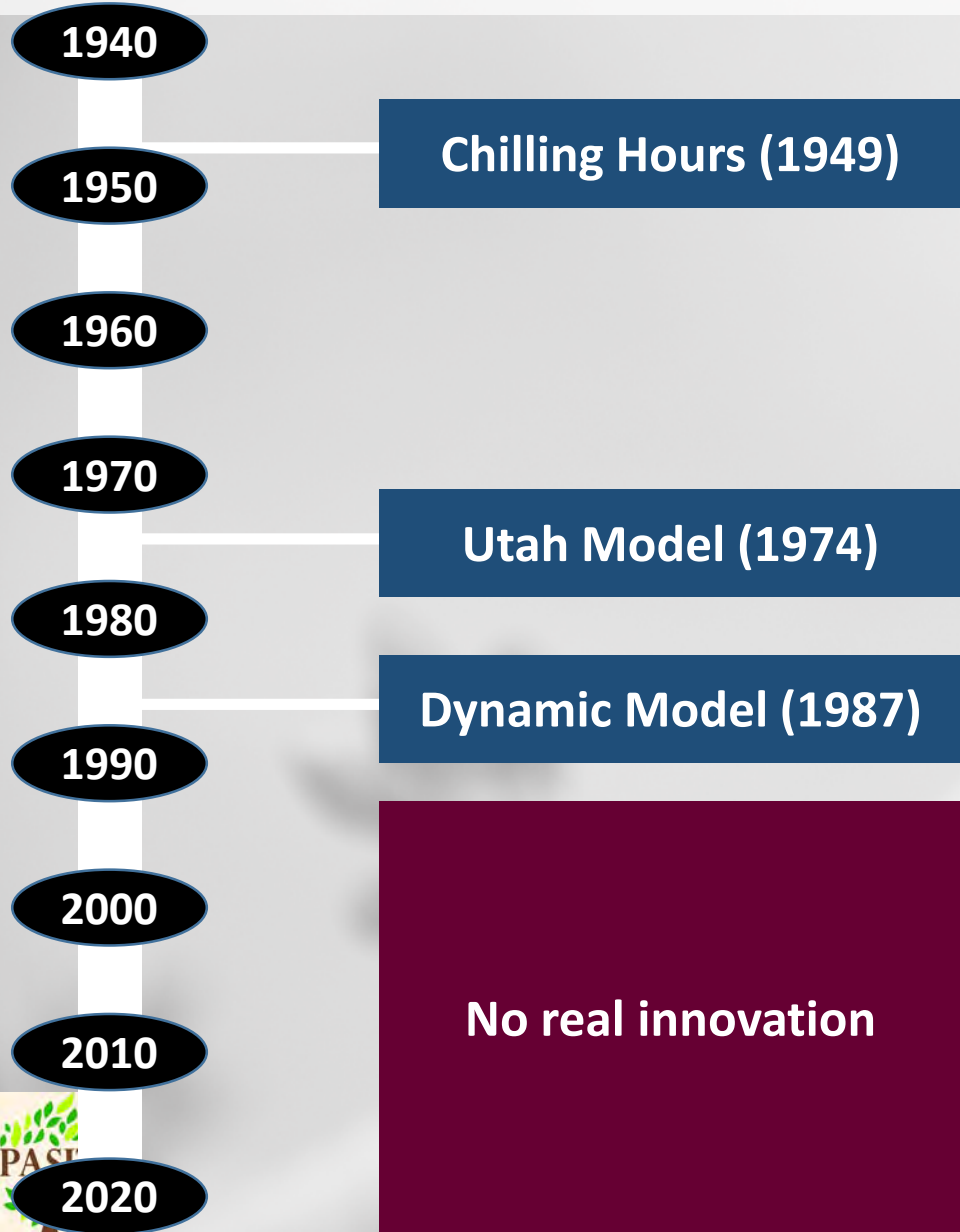


**Which measures are quantitatively appropriate?**

**This can only be decided with accurate chill models**



# Modeling chill for sensitivity assessments



- Use of the 70-year old Chilling Hours Model is still common
- Even in scientific publications on climate change!
- Why is this a problem?

# Some old things are good... ..and some aren't



<https://youthandeldersja.files.wordpress.com/2013/11/old-wine.jpg>



[https://nmwa.org/sites/default/files/media/images/work/spencer\\_lilly\\_martin\\_still\\_life\\_watermelon.jpg](https://nmwa.org/sites/default/files/media/images/work/spencer_lilly_martin_still_life_watermelon.jpg)

[http://www.fazemag.de/wp-content/uploads/2016/04/Compact\\_Cassette\\_BASF\\_60\\_SM\\_IMG\\_8508.jpg](http://www.fazemag.de/wp-content/uploads/2016/04/Compact_Cassette_BASF_60_SM_IMG_8508.jpg)



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# Old chill models in warm places

- Clearly inadequate temperature ranges
- Failure to explain lots of experimental results (moderate temperature, temperature cycles etc.) and observations
- Excessively sensitive to warming (hard thresholds, strong chill negation)
- Tree crops are grown where models say this isn't possible
- Inconsistent responses across temperature gradients
- Most artificial temperature treatments produce meaningless results

Luedeling, 2012. *Scientia Horticulturae* 144, 218-229.

Luedeling et al., 2009. *Agriculture, Ecosystems and Environment* 133, 23-31.

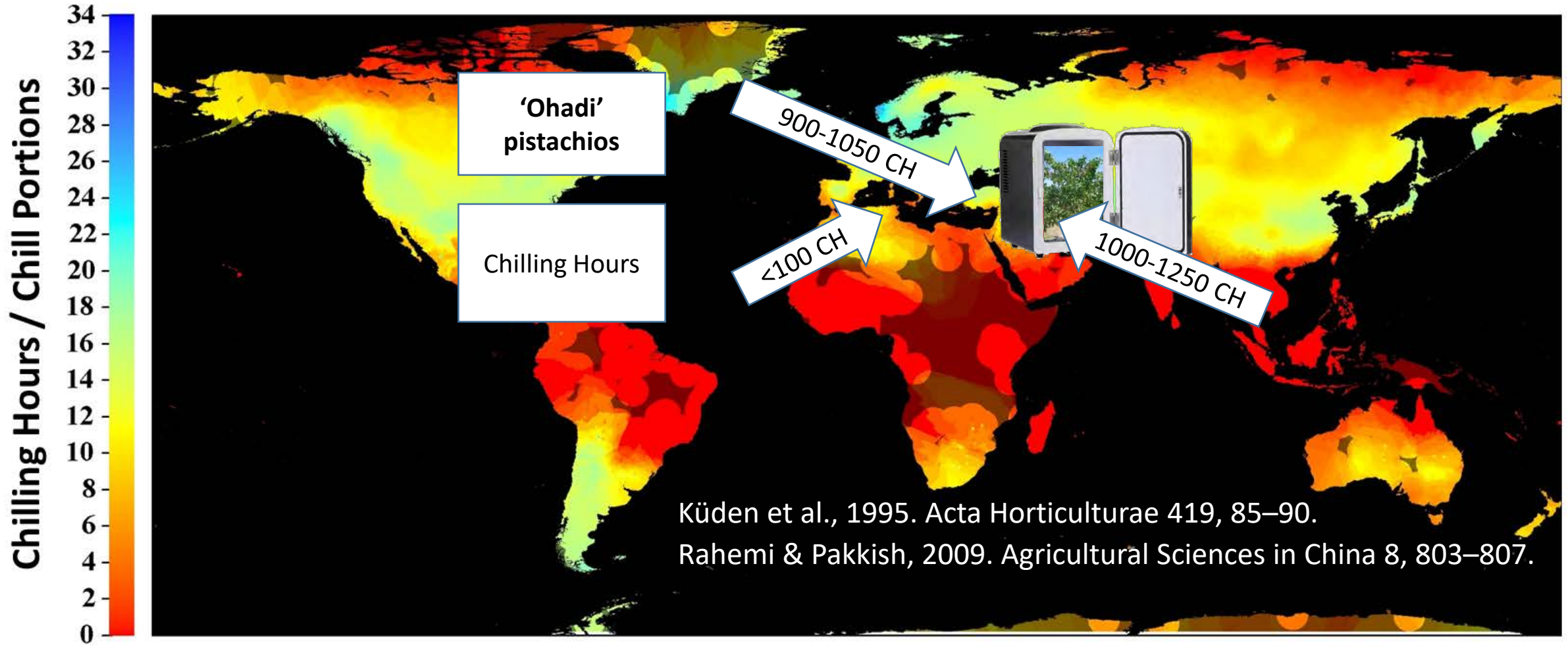
Benmoussa et al., 2018. *Environmental and Experimental Botany* 140, 76-85.

Luedeling et al., 2009. *Erwerbs-Obstbau* 51, 81-94.

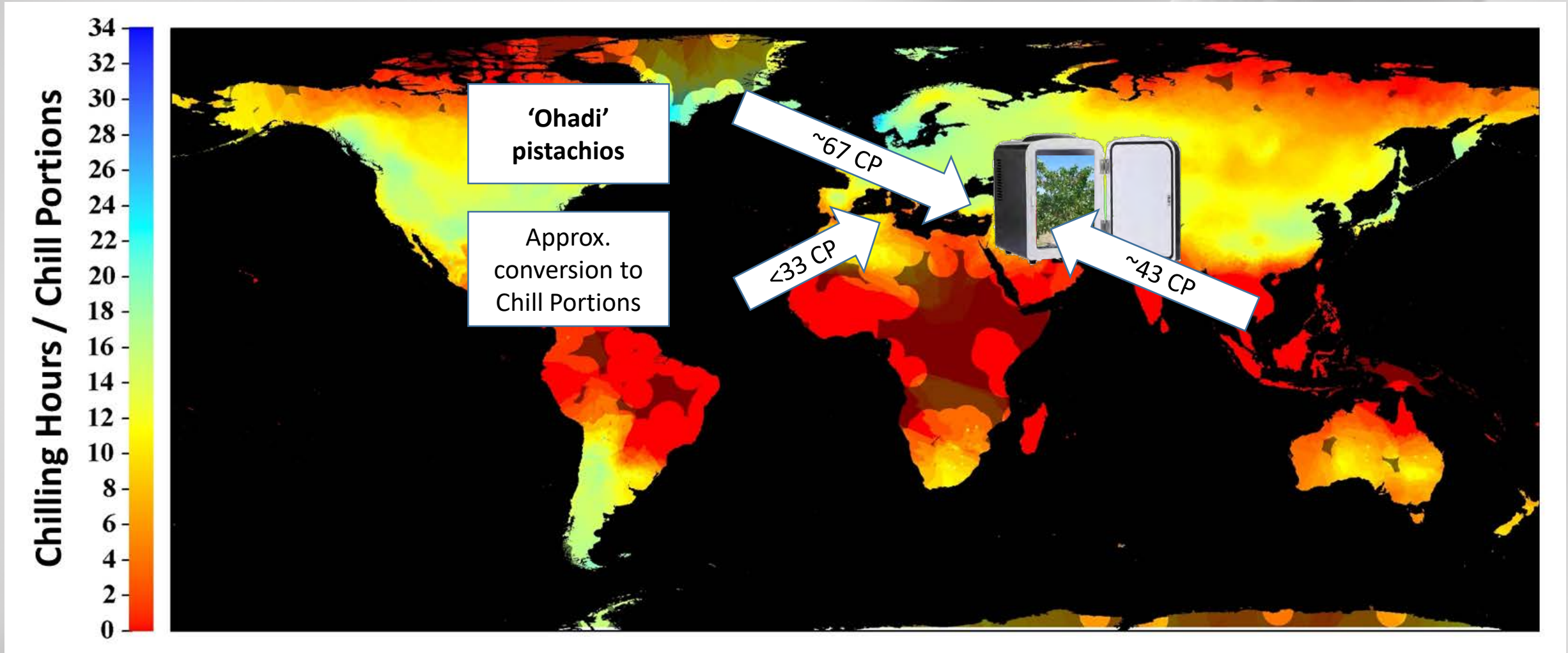
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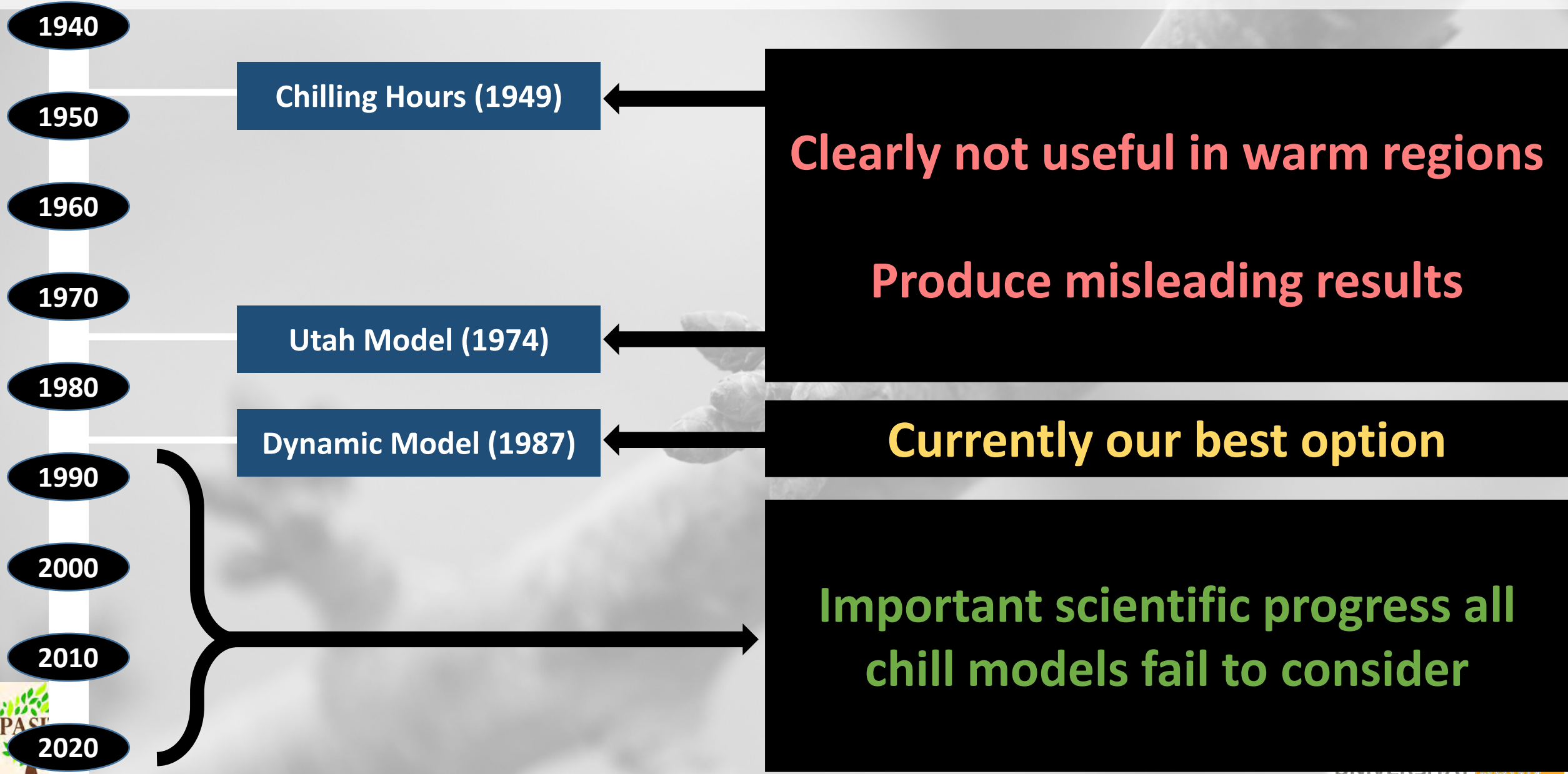
# Inconsistent responses across temp. gradients



# Inconsistent responses across temp. gradients



# Model usefulness for adaptation planning



# Towards new models

- Complete understanding of dormancy processes will remain elusive for the foreseeable future
- We need to summarize existing information, while acknowledging knowledge limitations
- Goal: Process-based probabilistic model that expresses what we know, including our uncertainties
- Means: use of decision analysis approaches for dormancy research

# Principles of decision analysis

- Incorporate all important aspects into models
- Model system using all sources of information, including expert knowledge
- Explicitly consider all uncertainties in probabilistic models
- Identify key uncertainties for measurement using 'Value of Information' analysis
- Update model, when new information becomes available



## Phenological And Social Impacts of Temperature increase

—  
advances the understanding of current and potential climate change impacts on fruit and nut farming communities in regions differing in geography, climatic threat and socio-economic conditions in Tunisia and Chile

[www.pasitproject.de](http://www.pasitproject.de)



# Thanks for your attention!

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Current vacancies at:  
<https://www.gartenbauwissenschaft.uni-bonn.de/>  
(open until 31<sup>st</sup> August)

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# How can we adapt to these changes?



## Projected chill changes

