Honeybee and Climate Change

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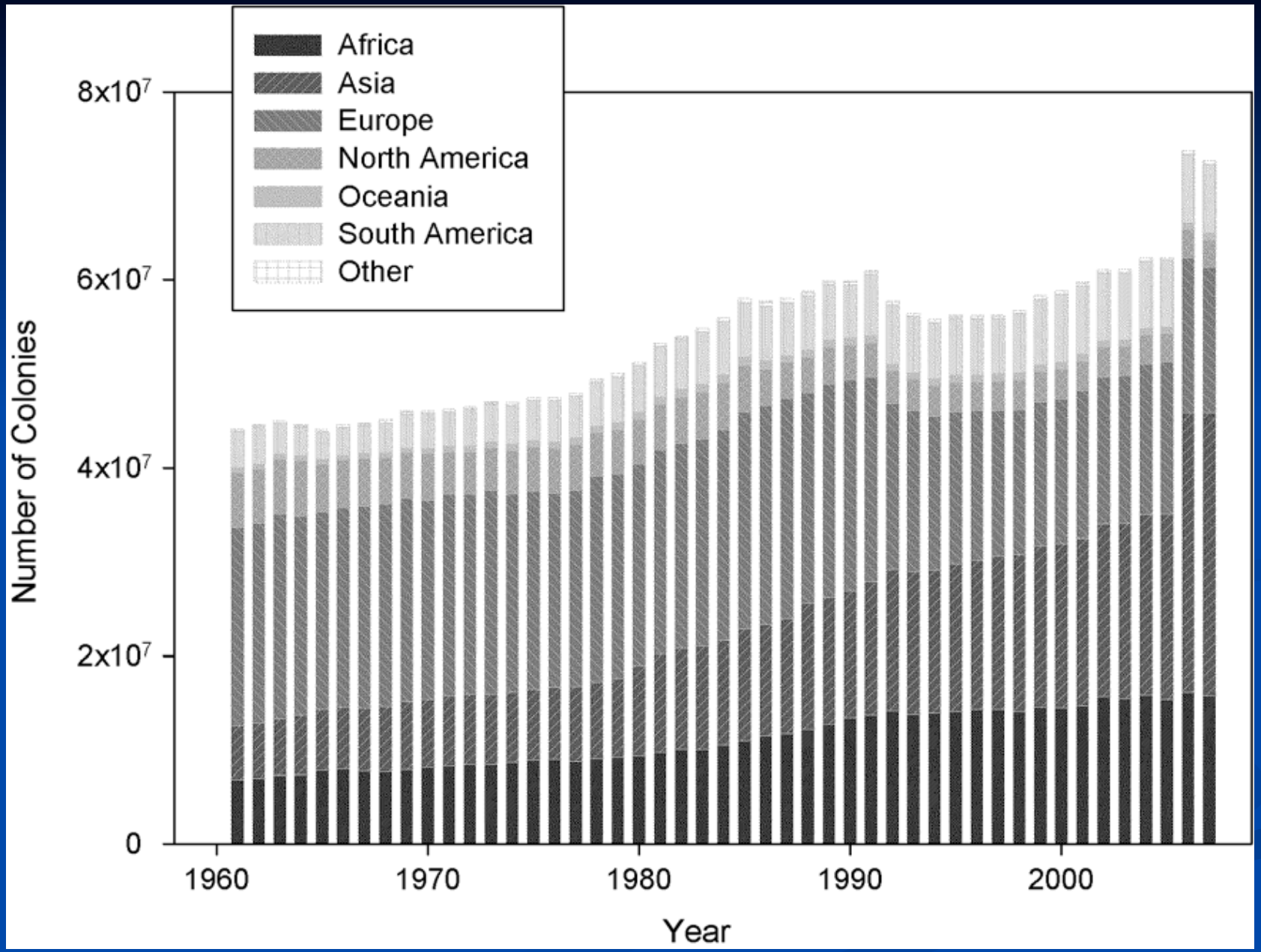
Do you agree or disagree that worldwide honeybee is declining?



* Source vanEngelsdorp & Meixner (2010)

Worldwide Statistics

- In 2013, 81.0 million colonies (FAO, 2013)
  - 11.5% increase since 2007
- In 2007, 72.6 million colonies (FAO, 2009)
  - 45-64% increase since 1961
- Details
  - Europe (-26.5%)
  - North America (-49.5%) (US and Mexico vs. Canada)
  - Asia (+426%)
  - Africa (+130%)
  - South America (+86%)
  - Oceania (+39%)

* Source vanEngelsdorp & Meixner (2010); FAOSTAT

Do you agree or disagree with the fact that honeybees are affected by weather

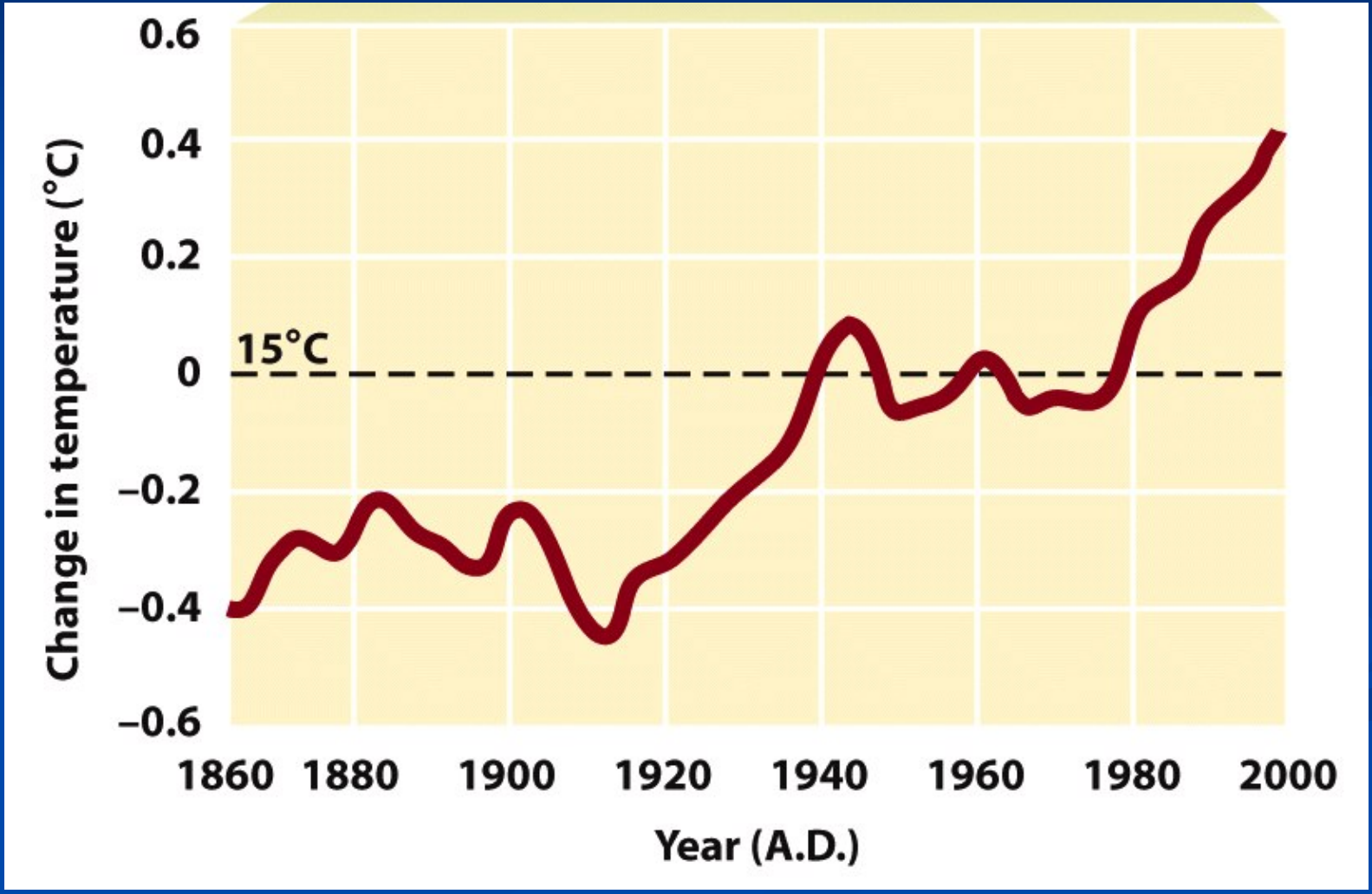
WEATHER?

- Does weather affect Honeybees?
  - Sever weather Impact survival
  - Higher temperatures lead to increase productivity
  - Rain and cool weather in summer reduce productivity
  - Drought reduce colony productivity
  - Persistent fall rains lead to poor overwintering
  - Dwindling fall pollen reserves cease brood rearing
  - Weather and pathogen loads within colonies
  - Temperature and humidity and Varroa mite
  - Cool weather in the spring and chilled brood
  - Tropical regions Vs cold (continuous vs interrupted brood)

* Source (vanEngelsdorp et al., 2008) (Harrison and Fewell, 2002); (Shuel, 1992); (Voorhies et al., 1933); (Mattila and Otis, 2007) (Harris et al., 2003) (Calis et al., 1999)

Is weather constant?

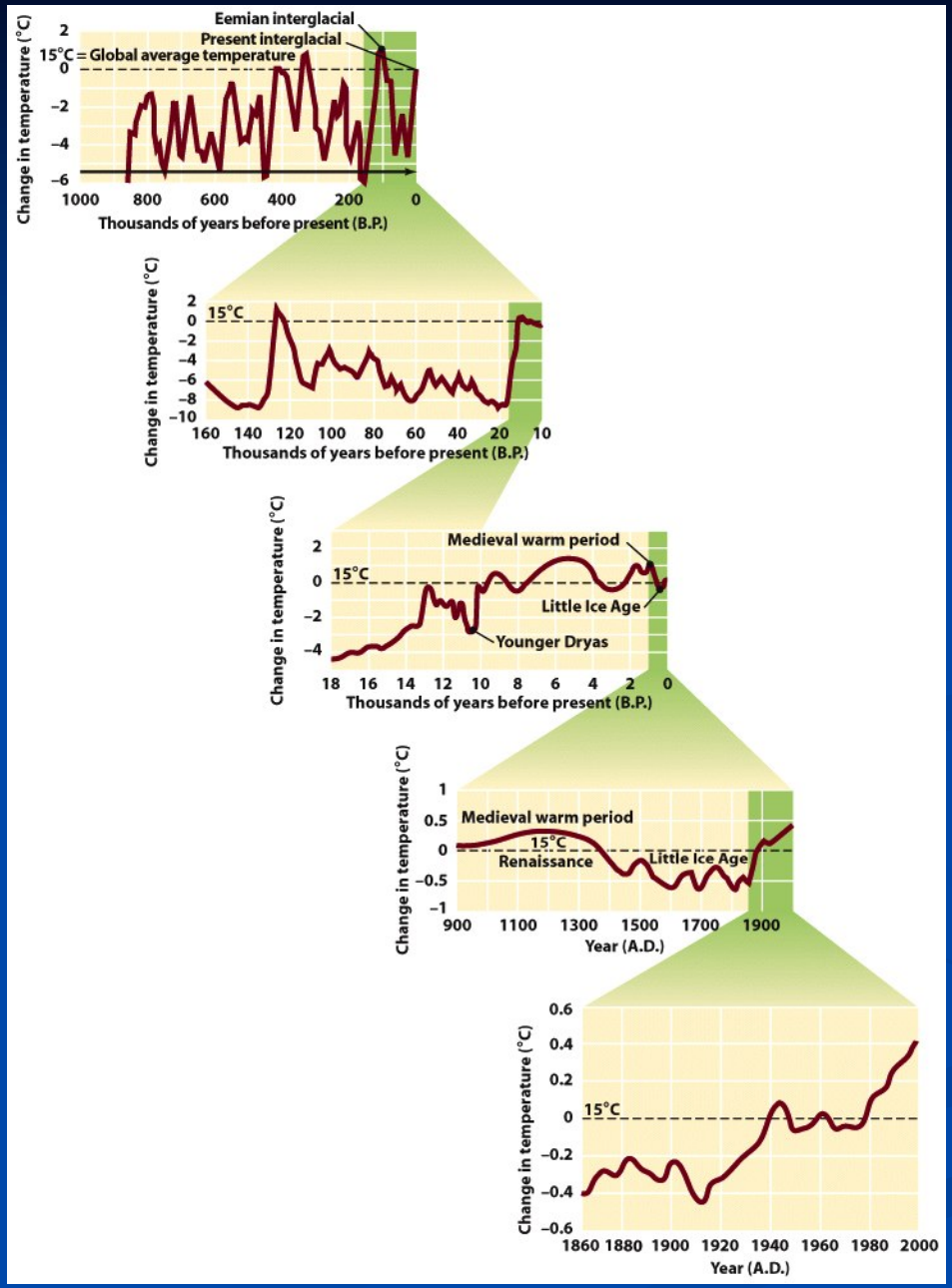
What do we know about climate change?



How long bees are there?

- *Apis* …….30–40Myr
- Stingless bees 100–130Myr
- *A. cerana–A. mellifera* group diverged within the past 1 million years (Pleistocene)

*source: Arias & Sheppard (2005) (Culliney, 1983; Engel, 1998; Ruttner, 1988) (Michener, 1979; Camargo and Wittmann,1989)


Eemian interglacial
Present interglacial
15°C = Global average temperature
Change in temperature (°C)
2
0
−2
−4
−6
1000 800 600 400 200 0
Thousands of years before present (B.P.)
15°C
2
0
−2
−4
−6
−8
−10
160 140 120 100 80 60 40 20 10
Thousands of years before present (B.P.)
Medieval warm period
Little Ice Age
Younger Dryas
18 16 14 12 10 8 6 4 2 0
Thousands of years before present (B.P.)
1
0.5
0
−0.5
−1
Medieval warm period
15°C
Renaissance
Little Ice Age
900 1100 1300 1500 1700 1900
Year (A.D.)
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
15°C
1860 1880 1900 1920 1940 1960 1980 2000
Year (A.D.)

Is it better to have a stable climate?

Climate change threatens Bees

- Climate Change and phenology shift
- Evidences
  - Theoretical approaches
  - Experiments
  - Meta-analyses
  - Observations
- All these studies depend on single or very few number of species

*Petanidou et al. 2014 Acta Oecologica

Figure 6-2 part 1 Botkin - Env. Sci. 6/e

Figure 6-1d Botkin - Env. Sci. 6/e

Figure 6-1f Botkin - Env. Sci. 6/e

Figure 6-1a Botkin - Env. Sci. 6/e

Figure 6-1b Botkin - Env. Sci. 6/e

Figure 6-1e Botkin - Env. Sci. 6/e

Figure 6-1c Botkin - Env. Sci. 6/e

Ecosystem Level Studies

- Required
  - Phenological shifts and pollination service at the larger scale of ecological communities
  - Direct or indirect interaction
  - Cascading changes would not be revealed by examining smaller subsets of species

*Petanidou et al. 2014 Acta Oecologica

Good news

Mediterranean Ecosystems

- Mediterranean communities had the highest residual connectance
  - Plant pollinator network are tightly connected
  - Mediterranean community networks are less prone to biodiversity loss than alpine, arctic, temperate, or tropical systems

*Petanidou et al. 2014 Acta Oecologica

Mediterranean Ecosystems

- High yearly colony growth of ca. 300,000–400,000 bees
- Queen egg-laying rate averaged 2000 eggs a day, with up to 3300 eggs in individual cases
- Overall average pollen uptake total 16.8 kg per colony
  - Overall mean pollen protein content was high (39.8%), and mean total FA content was 3.8%

Mediterranean Ecosystems

- Stability of pollination and bee diversity decrease from southern to northern Europe

- Mediterranean countries had more stable yields of pollinator-dependent crops across years

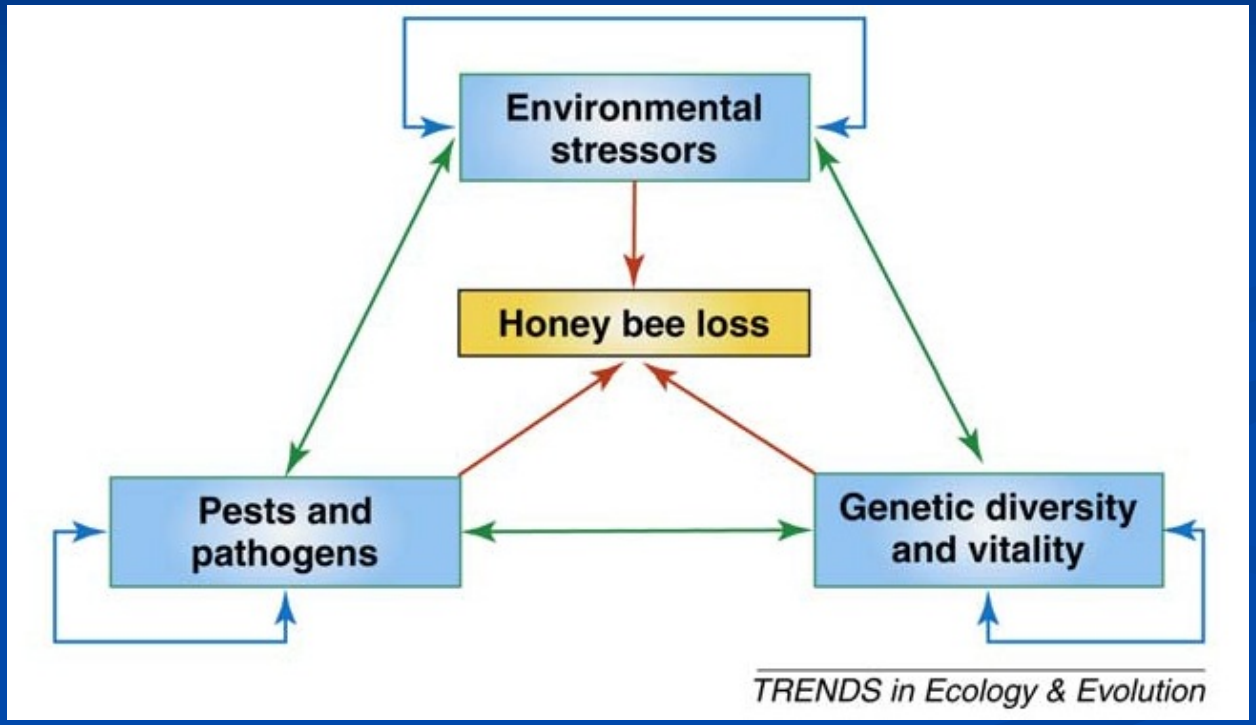
*Leonhardt et al., 2013 Basic and Applied Ecology

What is missing in climate change studies in relation to honeybees?

Giannini et al. (2012) Ecological Modelling

- Native bees are declining
- Global changes
  - habitat losses,
  - invasions of exotic species
  - climate change
- Climate change affected the distribution of 10 species of Brazilian bees using species distribution modelling
- Total area of suitable habitats decreased under the different future scenarios

Potts et al. 2010
Trends in Ecology & Evolution



Potts et al. 2010
Trends in Ecology & Evolution

- Climate change impacts on pollinators comes from butterflies
- Impacts of climate change occur at all organizational levels
  - individual level
  - population genetics
  - species level shifts
  - community level
  - What about landscape scale effect?
- Indirect effects are poorly studied
- Climate change-induced mismatches in temporal and spatial co-occurrence
  - But morphological and physiological interdependencies of differently responding animal-pollinated plants and pollinators can potentially disrupt their interactions

Marini et al., 2012
Basic and Applied Ecology

- **Landscape context**
  - Pollination studies don't evaluate the landscape context
  - Apple-dominated landscapes reduced wild bee species richness and abundance compared to landscapes dominated by either grassland or forest
  - Forest benefited richness more than grassland
  - Richness and abundance declined with increasing elevation
  - No interactive effect between temp and landscape context
  - *Apis mellifera* in the apple-dominated landscapes was two to four times higher

Chapter 3 Opener Botkin - Env. Sci. 6/e

Figure 3-3 Botkin - Env. Sci. 6/e

Figure 3-2 Botkin - Env. Sci. 6/e

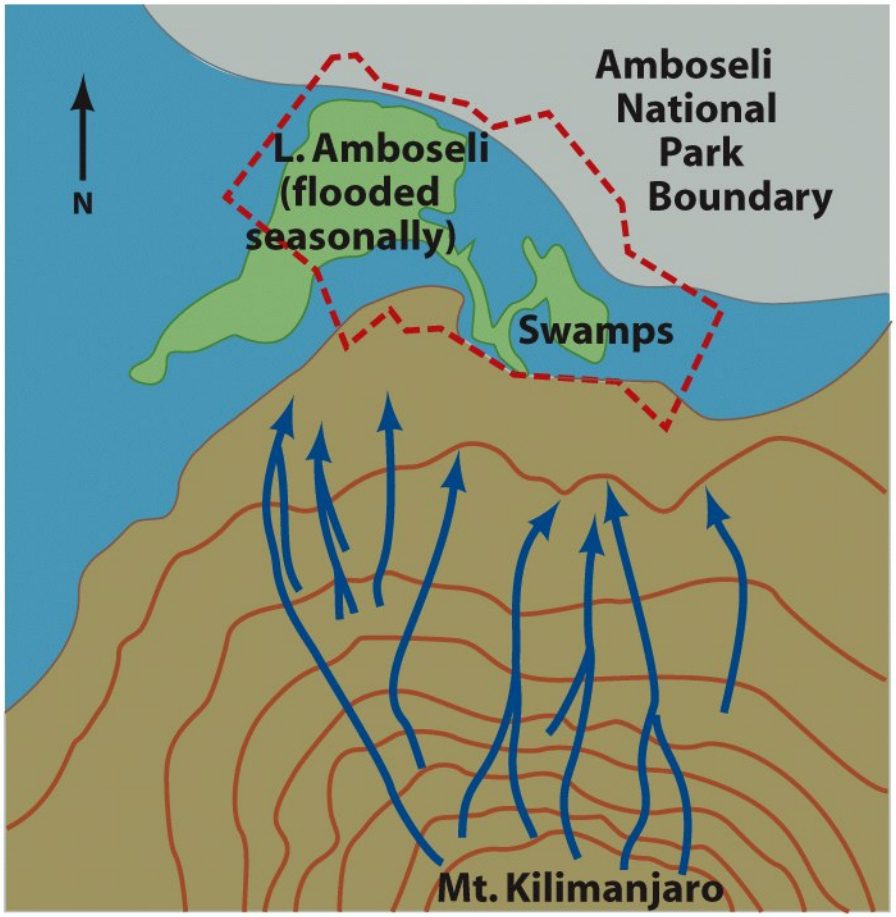


Figure 3-1 Botkin - Env. Sci. 6/e

Do all studies support climate change being negative

Pat Willmer
Current Biology (2012)

- Climate warming potentially uncouples timing of flowering from pollinator availability???

- Recent evidence might suggest this effect may be less than feared

New Scientists 2010

- Without climate change and bee decline
  - Pollination is in a downward spiral
  - And nobody knows why

- Many studies showed pollinators are falling
  - Thomson (2010) is the best evidence yet that plants' ability to reproduce is being affected.
  - Thomson's study site is pristine, local bees are not in decline and climate change does not appear to be affecting seasons at the site, leaving researchers casting around for an explanation

*James Thomson (Philosophical Transactions of the Royal Society B, vol 365, p 3187) 2010

Could it be that climate change is positive?

X. Yang et al. (2015) Agricultural and Forest Meteorology

	China	
Crop	2020	2080
Maize	2.0%	3.2%
Wheat	9.2%	14.2%
Rice	34.0%	67.4%
Average (No CO2)	18.6%	35.2%
Average (CO2 fert)	19.7%	36.8%

Y.-W. Chen et al.
Journal of Invertebrate Pathology (2012)

- Hypothesis
  - N. ceranae pathogen load are correlated with temperature changes

- Pathogen load decreases when the temperature rises

Kaloveloni et al. (2015) Ecological Modelling

- Winners and losers of climate change for the genus Merodon (Diptera: Syrphidae) across the Balkan Peninsula
- Prediction for the year 2080
- Conclusion
  - Climate generalists, Mediterranean and east Mediterranean species are expected to benefit from climate change
  - Climate specialists which are restricted to mountainous climate are expected to decline

Coulson et al. (2005) Forest Ecology and Management

- Conclusion
  - Pine forest management practices and other human activities have altered the landscape and thereby created food and habitat resources suitable for honey bees

Is it a problem to take a precaution measures?

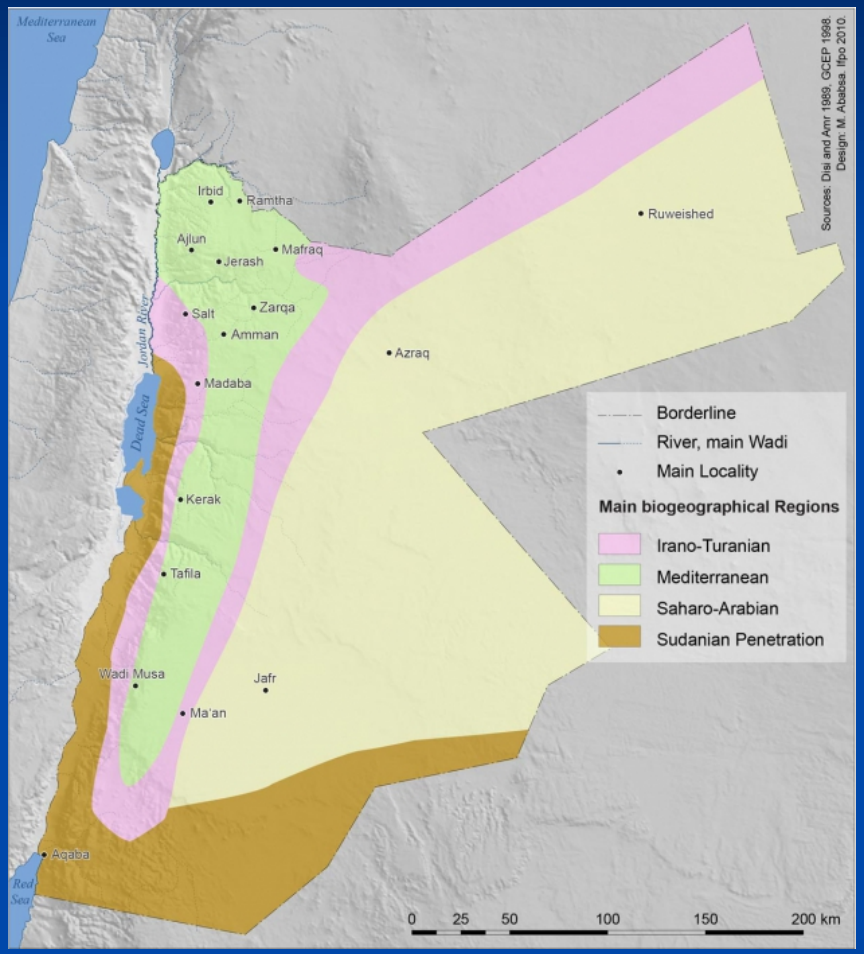
Figure 1-10 Botkin - Env. Sci. 6/e

The Bottom Line

- Ecologists Approach
  - Landscape scale studies
  - Ecological interactions
    - Direct
    - Indirect
  - Change and Ecosystem
  - Mediterranean ecosystems

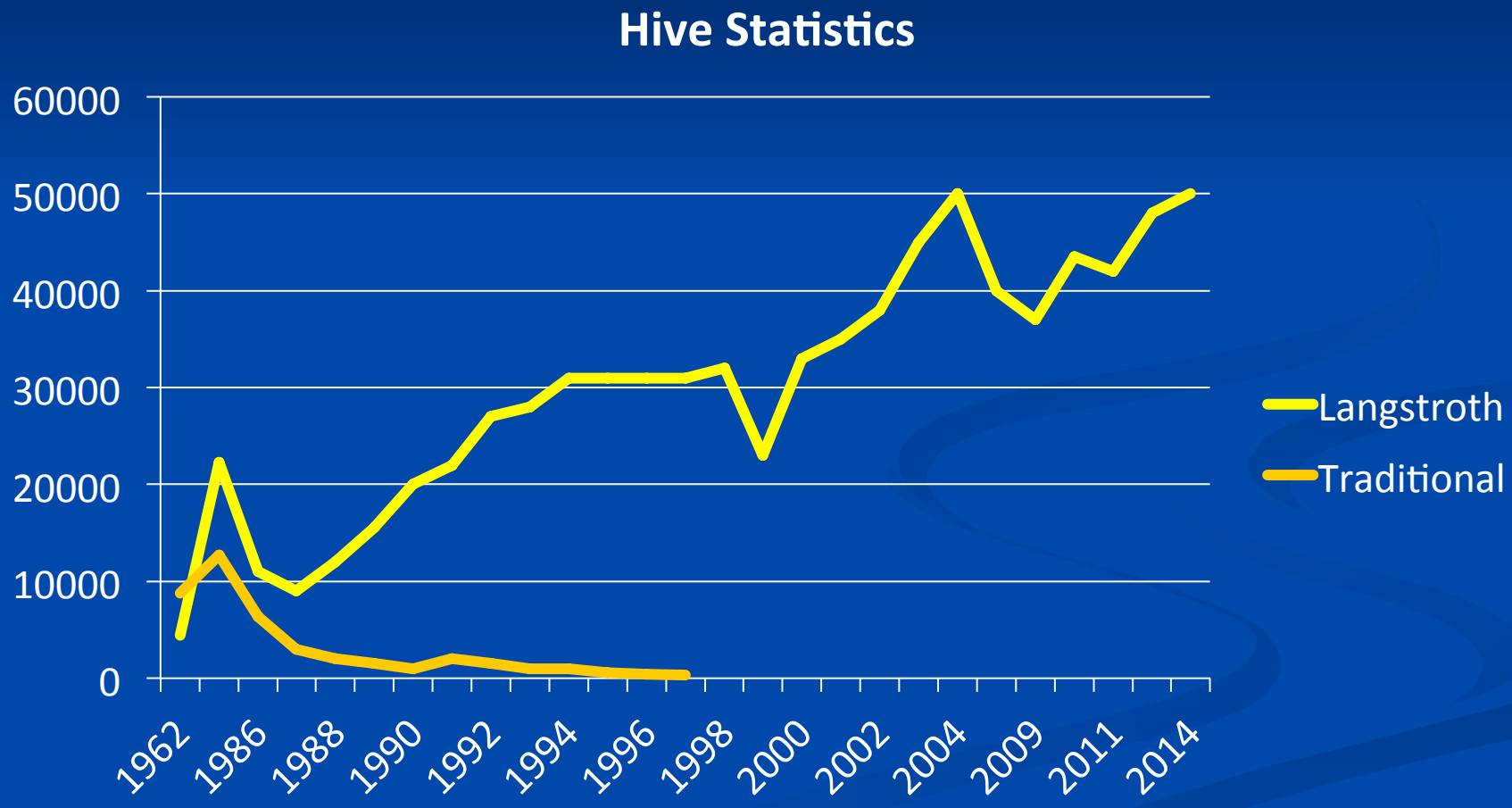
Jordan Beekeeping

Jordan Honeybee Environment



- Ancient beekeeping
- 90,000 square km
- 4 biogeographical regions
  - Mediterranean
  - Saharo Arabian
  - Irano Turanian
  - Sudanian
- 2500 flowering plant

Beekeeping Statistics



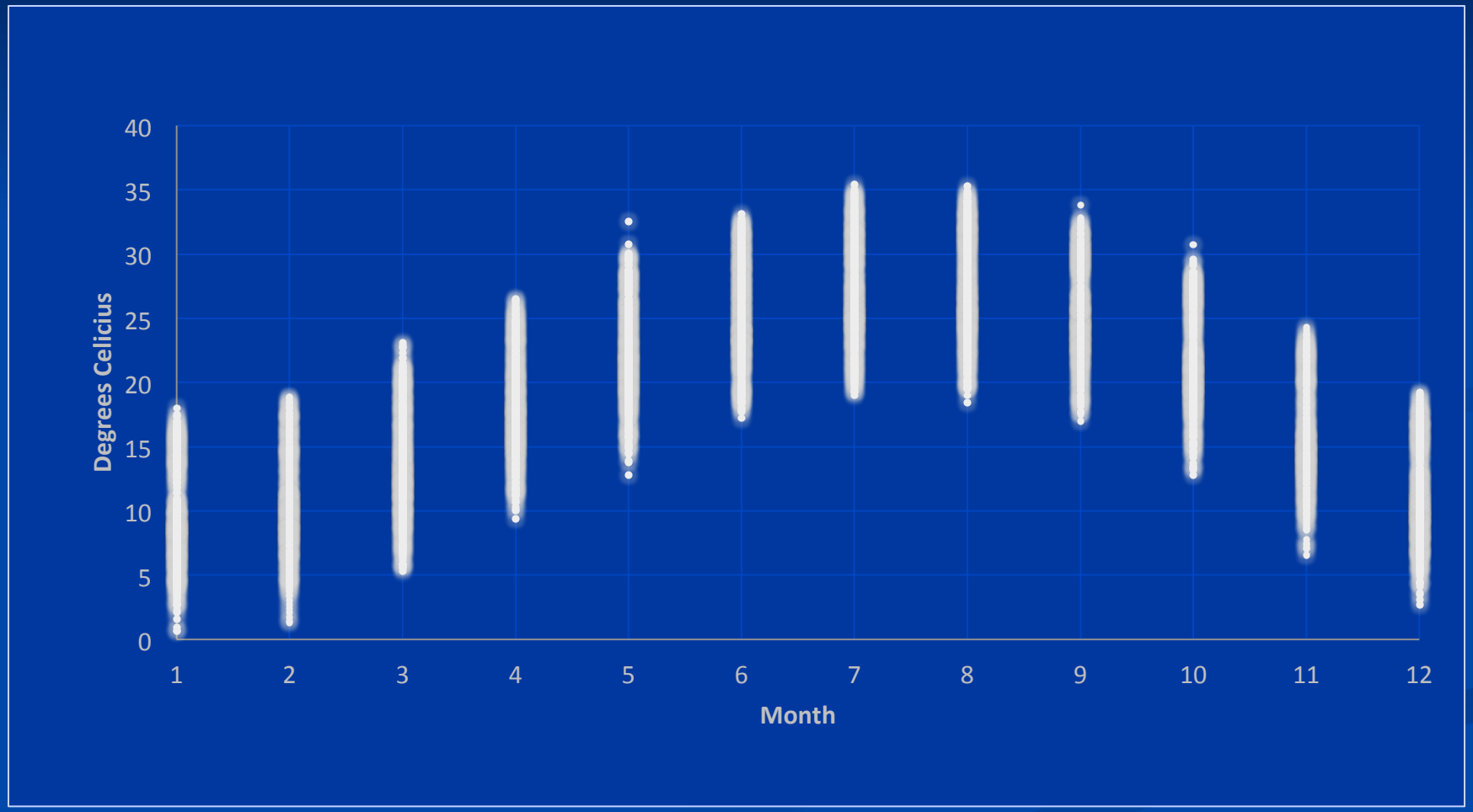
Variable Production

Year	Production of honey/tons
2008	184
2009	318
2010	186
2011	155
2013	137
2014	165

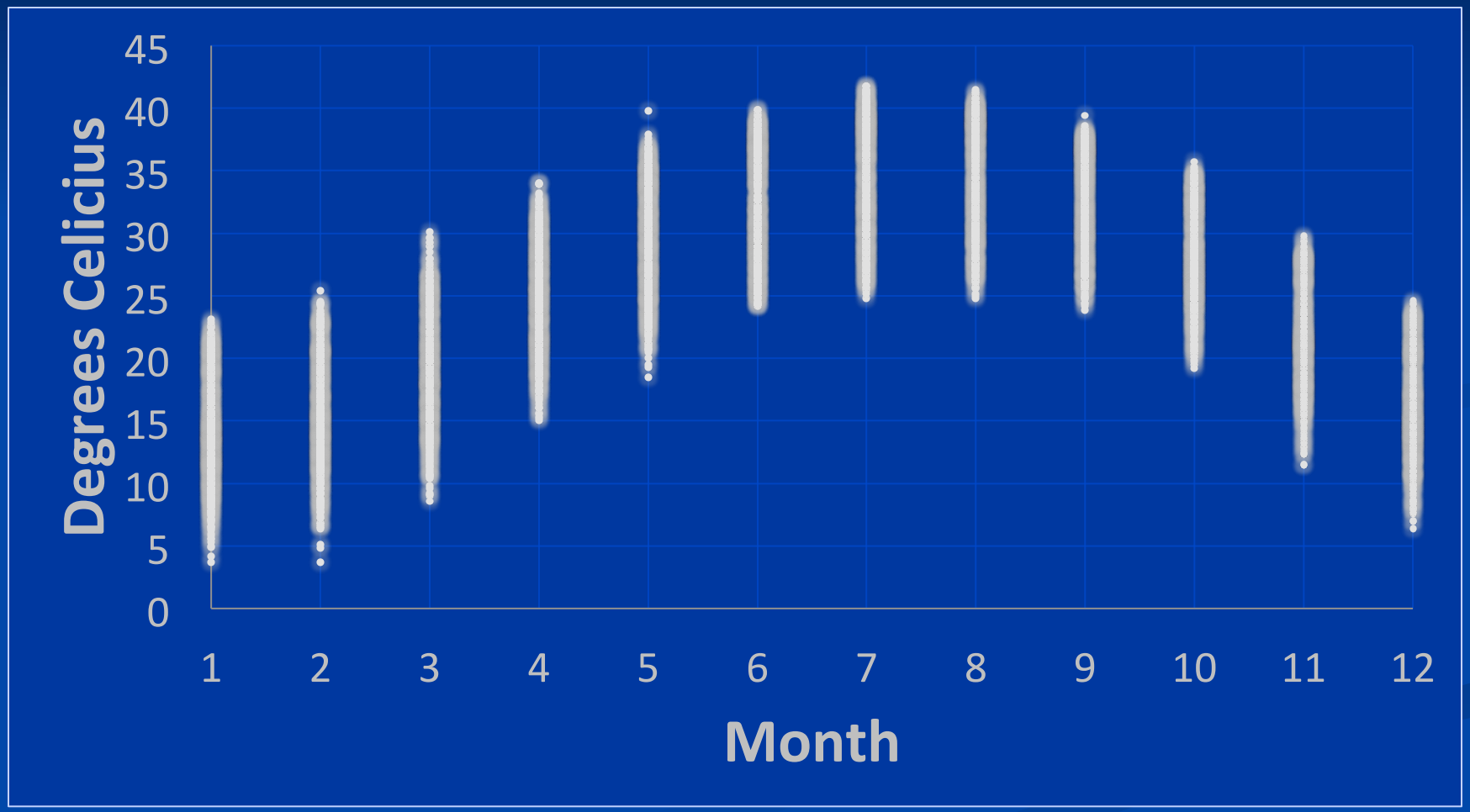
Climate Extremes
Amman as Example

	Avg High	Max High	Avg low	Min low
Winter	14.1	32.2 (40.0)	4.5	-7.5 (-14.0)
Spring	25.7	41.7 (50.0)	12.3	-2.8 (-8.0)
Summer	32.0	43.5 (48.8)	18.4	10.4 (0.4)
Autumn	22.4	38.5 (46.0)	10.8	-3.2 (-16.0)

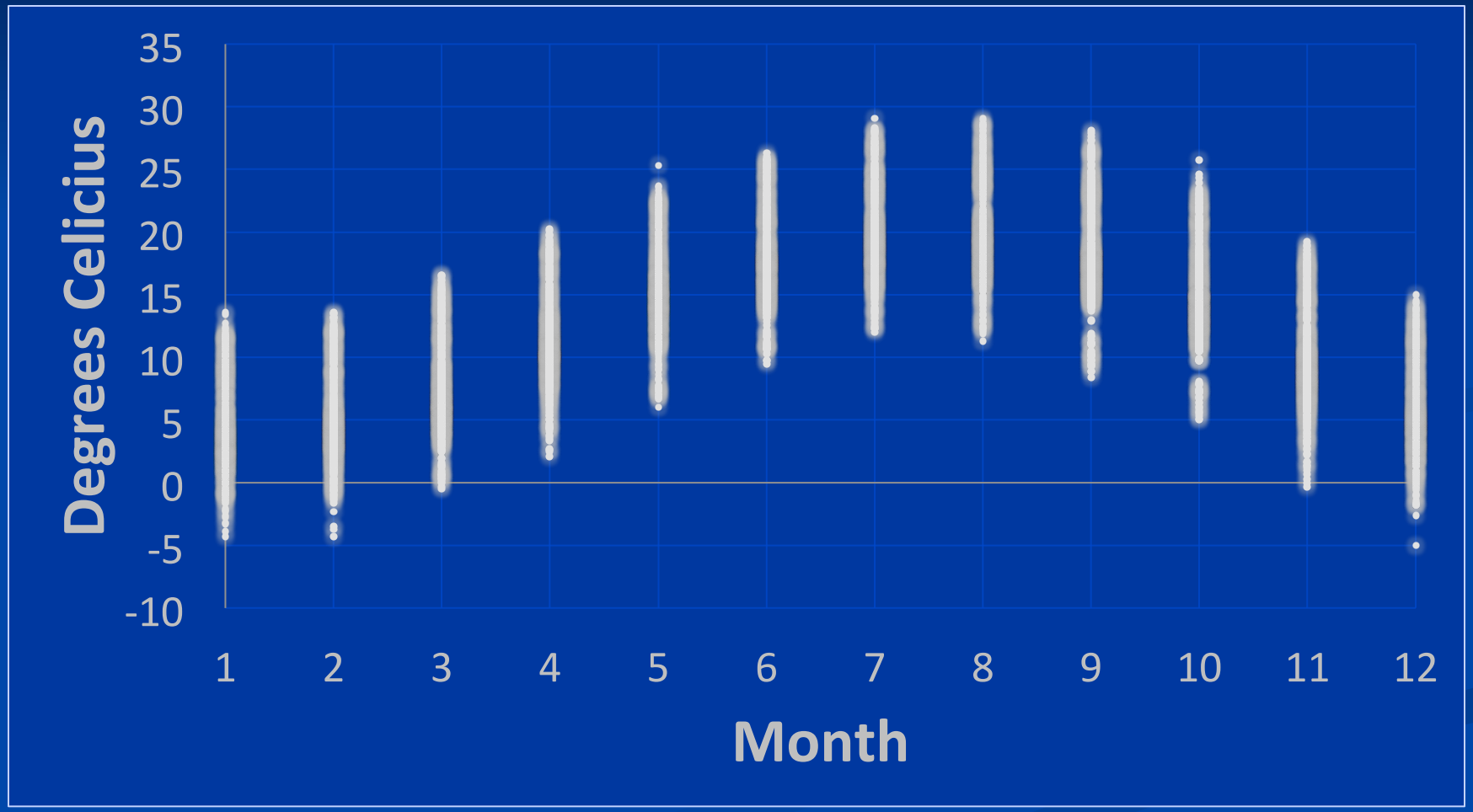
Average Temperature



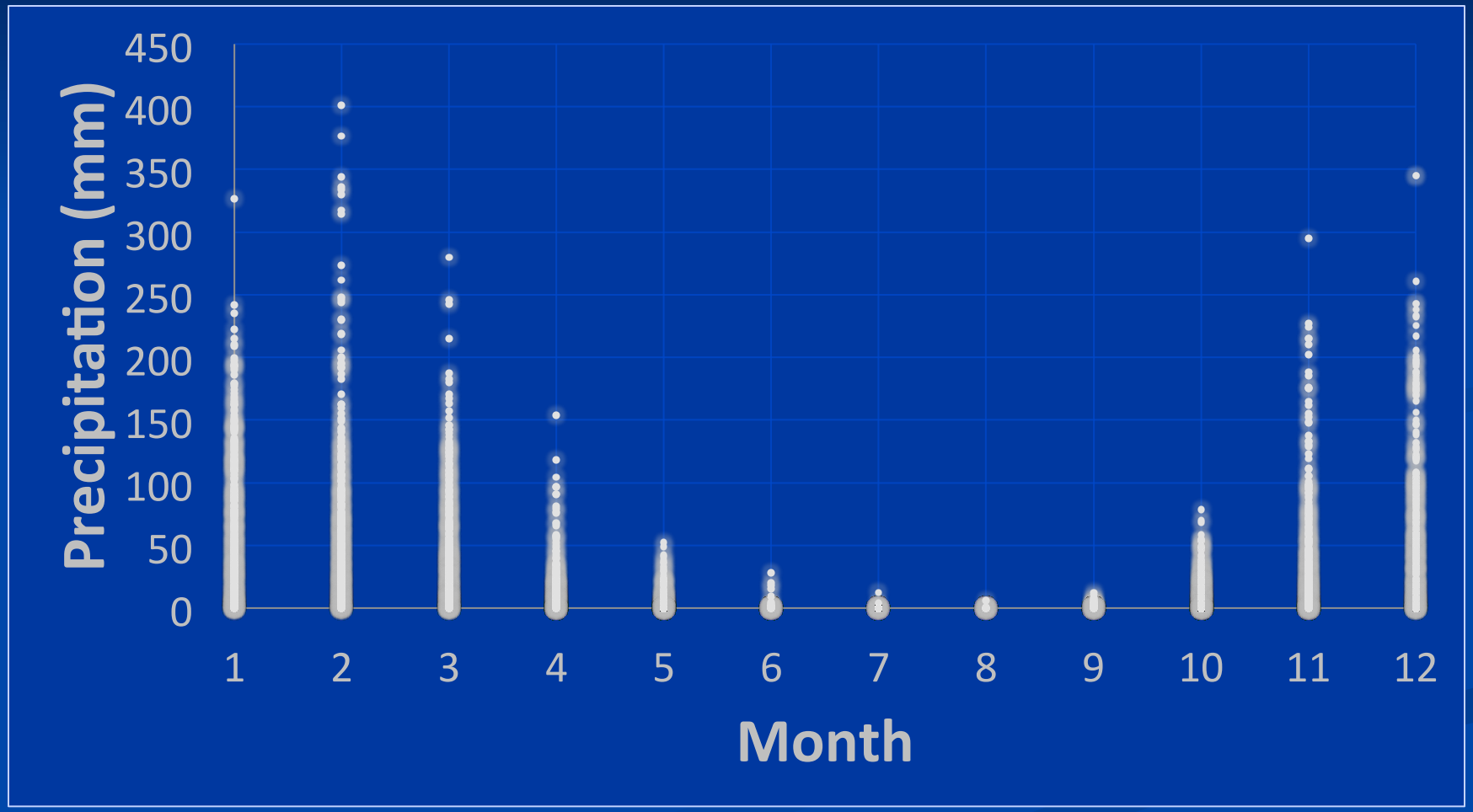
Maximum Temperature



Minimum Temperature



Precipitation



Climate and Productivity

- A significant and strong relationship between productivity and Rain

Parameters	R-Square
Total Rainfall	0.82
Rain in March	0.59
Rain in November	0.62
Rain in March & November	0.78

- No significant effect of temp on Honey productivity

Model Verification

- In the field trial on 2012
  - Prediction
    - 8.9 – 9.5 Kg honey per colony
  - The reality
    - Productivity was 9.3 kg honey per colony
- For the rest of the sites using questionnaire
  - Prediction error was 16%

Thermal Insulation Experiment

- Experiment site climate data
  - Rainfall 307 mm
  - Max Temp 38.5 C
  - Min Temp 1.5 C
  - Grass Temp -5.5 C

Thermal Insulation

Parameter	Treatment	Feb 10th	March 5th
Brood Area	Double Walled	157%	164%
	Raised	117%	132%
	Control	100%	100%
Worker Population	Double Walled	138%	150%
	Raised	109%	125%
	Control	100%	100%

Thermal Insulation

Parameter	Treatment	March 5th
Field Bee	Double Walled	153%
	Raised	101%
	Control	100%
Bee with Pollen	Double Walled	196%
	Raised	118%
	Control	100%

Thermal Insulation

Parameter	Treatment	May 16th
Fanning Bees	Double Walled	16%
	Raised	51%
	Control	100%

Thermal Insulation

Parameter	Treatment	May 16th
Honey (Kg/colony)	Double Walled	18.7 (201%)
	Raised	13.3 (143%)
	Control	100% (9.3%)

Acknowledgmnet

- JUST Deanship of Research
- Prof. Mohammad N. Alhamad
- Master student Ahmad Bdour
- Beekeepers

Thank You for Listening