PHENO 2022

e-phenology

Phenology Lab

"Tropical phenology and climate change in the crossroads"

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unesp

GLOBAL ALLIANCE BIODIVERSITY and CLIMATE CHANGE
BioGATe - A multidisciplinary approach on tropical biodiversity

CAPES

unesp PrInt PROJECT

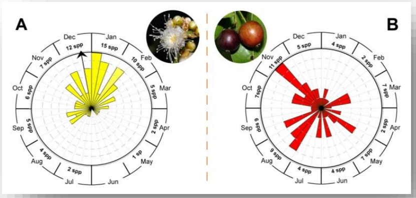
CNPq Conselho Nacional de Desenvolvimento Científico e Tecnológico

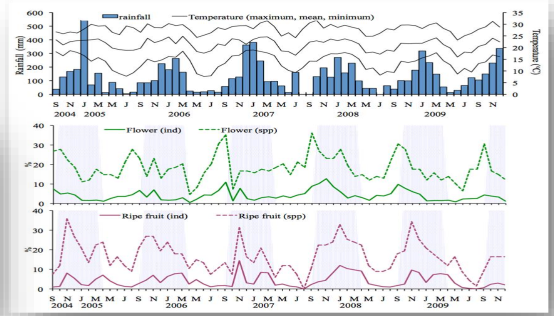
FAPESP

FAPESP MUDANÇAS CLIMATICAS

Tropical phenology and climate change in the crossroads

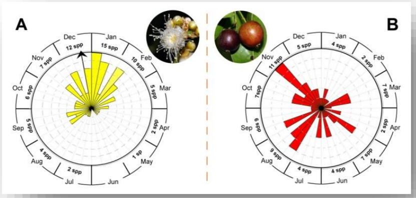
1. Phenology in highly diverse ecosystems
2. Phenology and climate change
3. Challenges to study phenology and climate change in highly diverse ecosystems
4. Final remarks

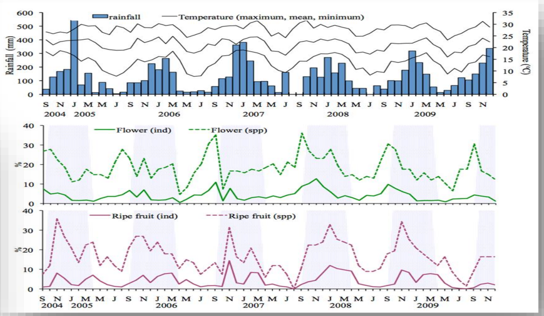




Tropical phenology and climate change in the crossroads

1. Phenology in highly diverse ecosystems
2. Phenology and climate change
3. Challenges to study phenology and climate change in highly diverse ecosystems
   I. reviews and synthesis, unlocking literature and old observations;
   II. use of herbarium records, to recover long term patterns and responses;
   III. applications of evolutionary and modelling tools to search for clade's sensitiveness to changes on their phenological niche;
   IV. combine observations and experiments to understand temporal mismatches;
   V. experiments - impose climate scenarios to tropical plants (e.g. CO_2 enrichment – FACE, drought experiments, transplants);
   VI. new technologies
   VII. networking- develop citizen science initiatives and monitoring networks to collect more comparative data over large special scales;
4. Final remarks





1. Phenology in highly diverse ecosystems

Phenology is the study of recurring life cycle events on plants and animal and its relation to climate.

Phenology has a prominent position in the current scenario of **global change research**, considered: ***the easiest and simplest way to monitor and detect plant responses and shifts to global warming***.

Listed as a **EBV** and linked to Sustainable Development Goals

nature ecology & evolution
PERSPECTIVE
https://doi.org/10.1038/s41559-018-0667-3
OPEN

Towards global data products of Essential Biodiversity Variables on species traits

W. Daniel Kissling[1*], Ramona Walls[2], Anne Bowser[3], Matthew O. Jones[4], Jens Kattge[5,6], Donat Agosti[7], Josep Amengual[8], Alberto Basset[9], Peter M. van Bodegom[10], Johannes H. C. Cornelissen[11], Ellen G. Denny[12], Salud Deudero[13], Willi Egloff[7], Sarah C. Elmendorf[14,15], Enrique Alonso García[16], Katherine D. Jones[14], Owen R. Jones[17], Sandra Lavorel[18], Dan Lear[19], Laetitia M. Navarro[6,20], Samraat Pawar[21], Rebecca Pirzl[22], Nadja Rüger[6,23], Sofia Sal[21], Roberto Salguero-Gómez[24,25,26,27], Dmitry Schigel[28], Katja-Sabine Schulz[29], Andrew Skidmore[30,31] and Robert P. Guralnick[32]

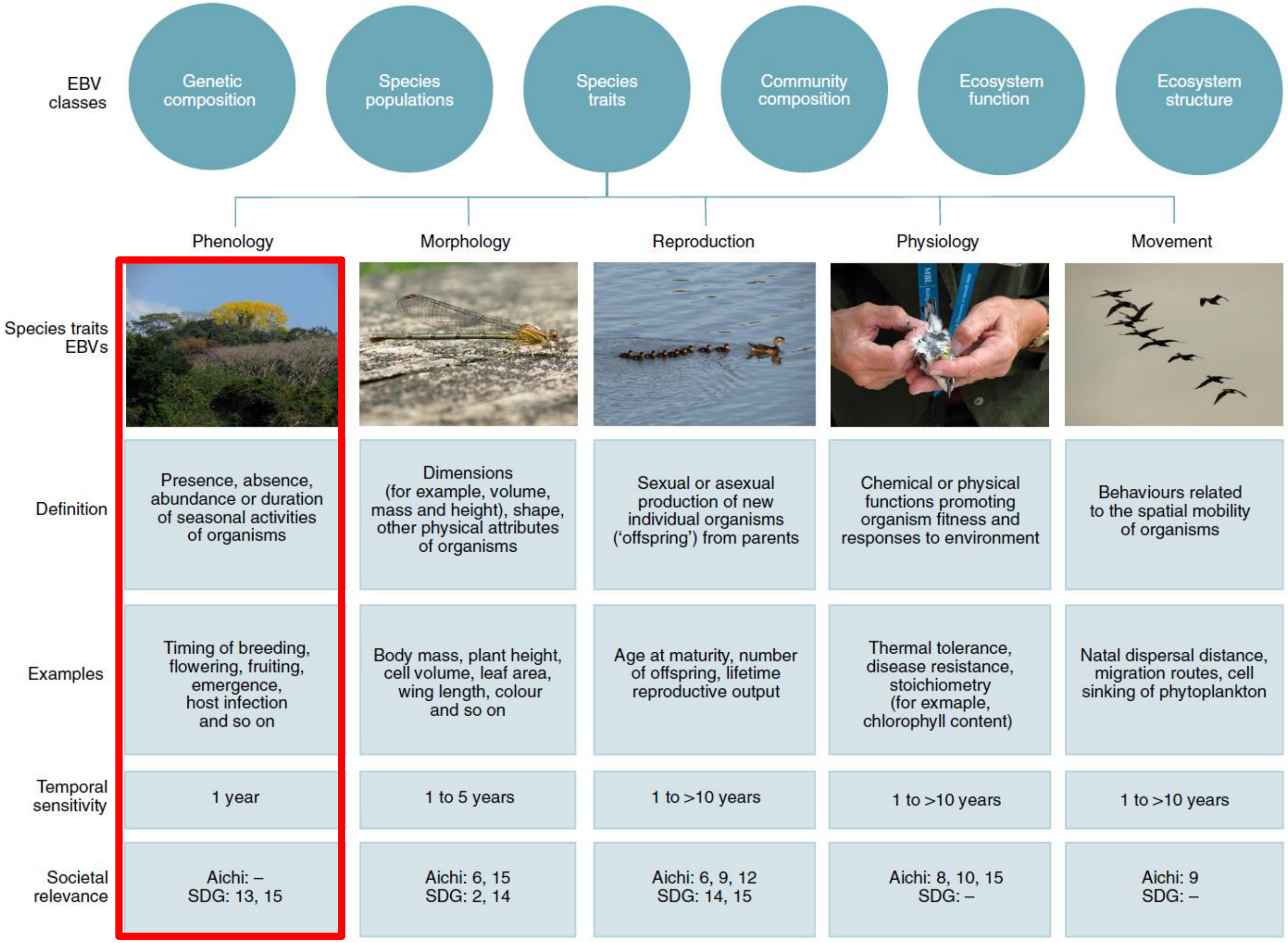
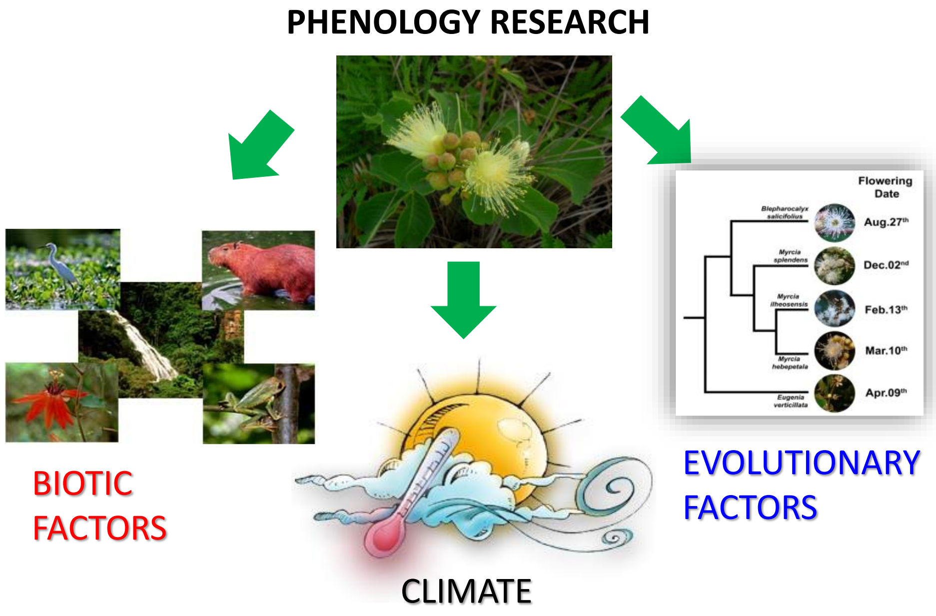


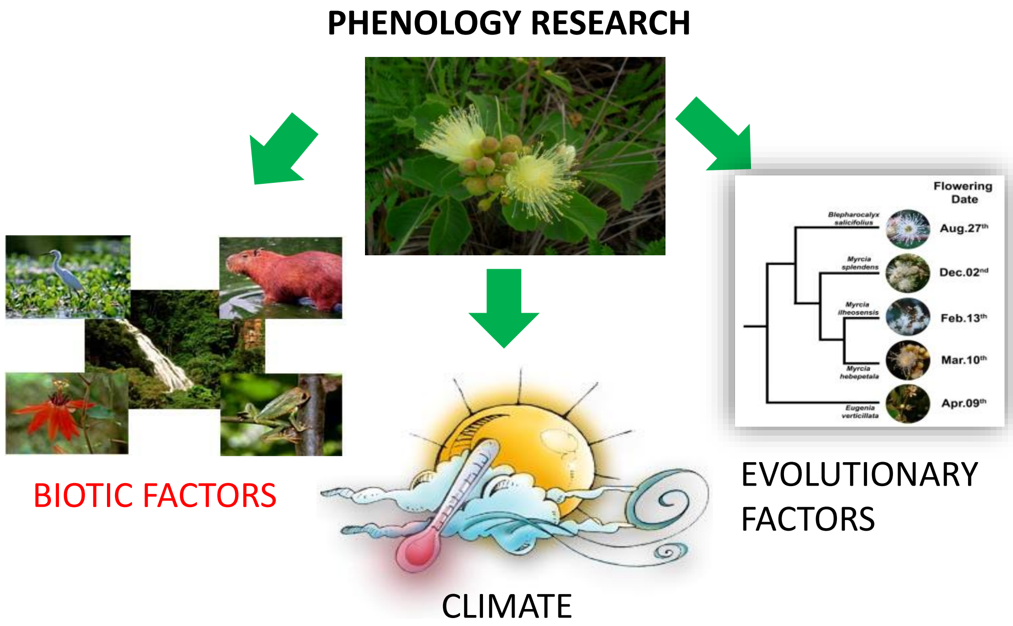
Fig. 1 | A framework for EBVs on species traits. We suggest five EBVs within the EBV class 'species traits', comprising (1) phenology, (2) morphology, (3) reproduction, (4) physiology and (5) movement. For each EBV, a definition, examples of species trait measurements, temporal sensitivity and societal relevance are given. Societal relevance refers to those Aichi Biodiversity Targets and SDGs to which the specific EBV is of highest relevance (for details on societal relevance see Supplementary Note 2 and Supplementary Table 2). Photo credits: Katja-Sabine Schulz.

1. Phenology in highly diverse ecosystems



Phenology is a multidisciplinary, Integrative science encompassing biometeorology, ecology, and evolutionary biology, and can also make a key contribution to conservation biology, management and restoration ecology

1. Phenology in highly diverse ecosystems



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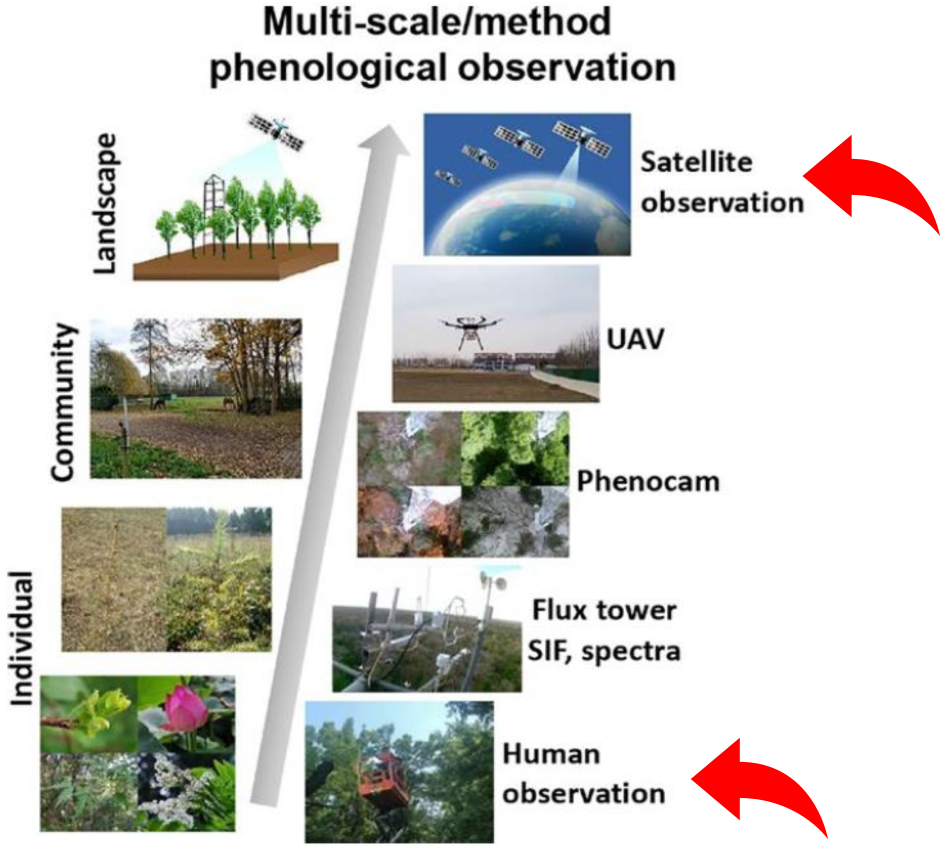
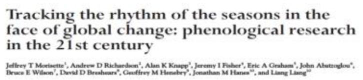



Tracking the rhythm of the seasons in the face of global change: phenological research in the 21st century

Jeffrey T Morisette[1], Andrew D Richardson[2], Alan K Knapp[3], Jeremy I Fisher[4], Eric A Graham[5], John Abatzoglou[6], Bruce E Wilson[7], David D Breshears[8], Geoffrey M Henebry[9], Jonathan M Hanes[10], and Liang Liang[10]

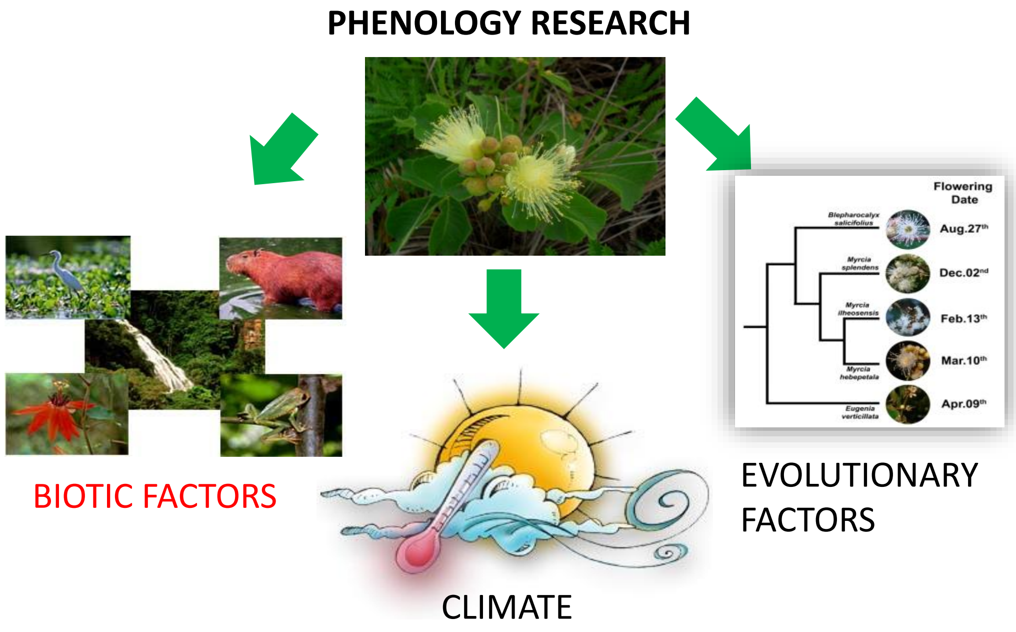

INVITED RESEARCH REVIEW

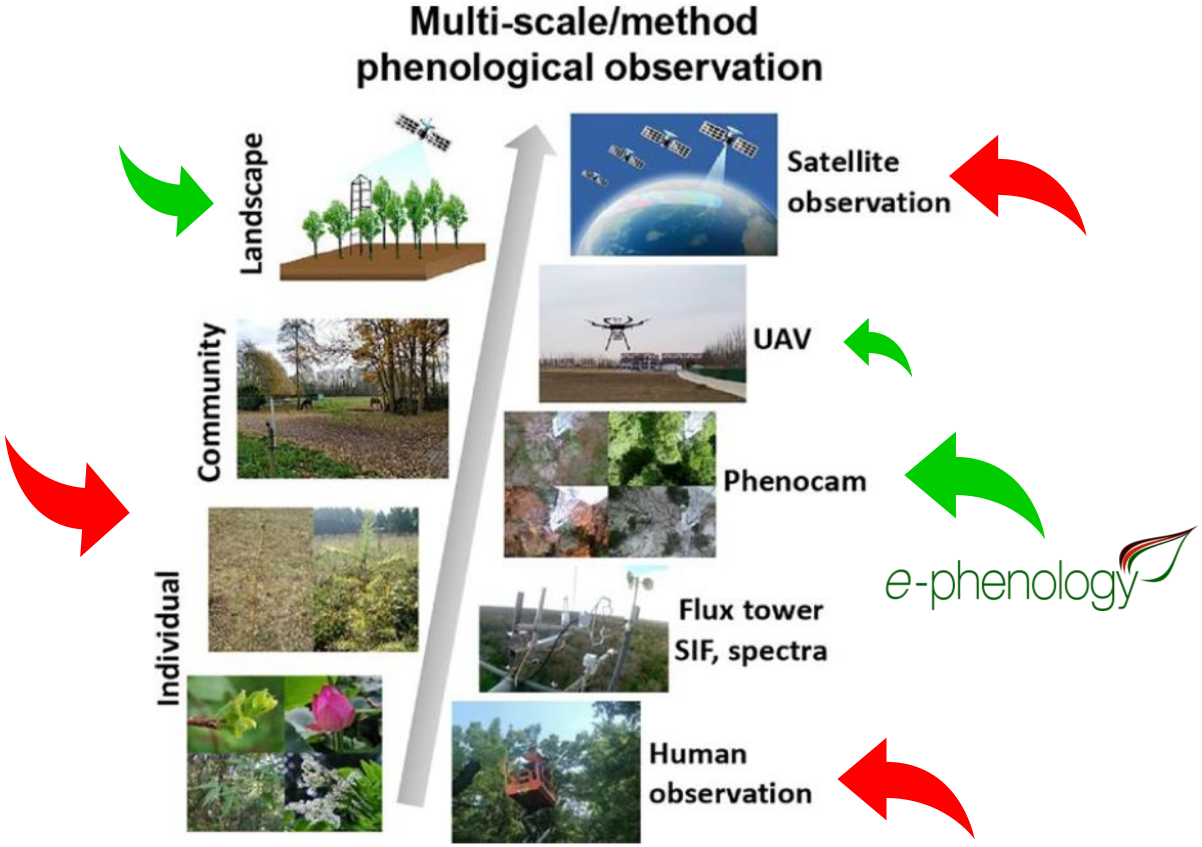
WILEY Global Change Biology

Plant phenology and global climate change: Current progresses and challenges

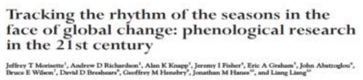
Shilong Piao[1,2,3] | Qiang Liu[1] | Anping Chen[4] | Ivan A. Janssens[5] | Yongshuo Fu[5,6] | Junhu Dai[7] | Lingli Liu[8] | Xu Lian[1] | Miaogen Shen[2,3] | Xiaolin Zhu[9]

1. Phenology in highly diverse ecosystems





Phenology is a multidisciplinary, Integrative science encompassing biometeorology, ecology, and evolutionary biology, and can also make a key contribution to conservation biology, management and restoration ecology


Tracking the rhythm of the seasons in the face of global change: phenological research in the 21st century


INVITED RESEARCH REVIEW

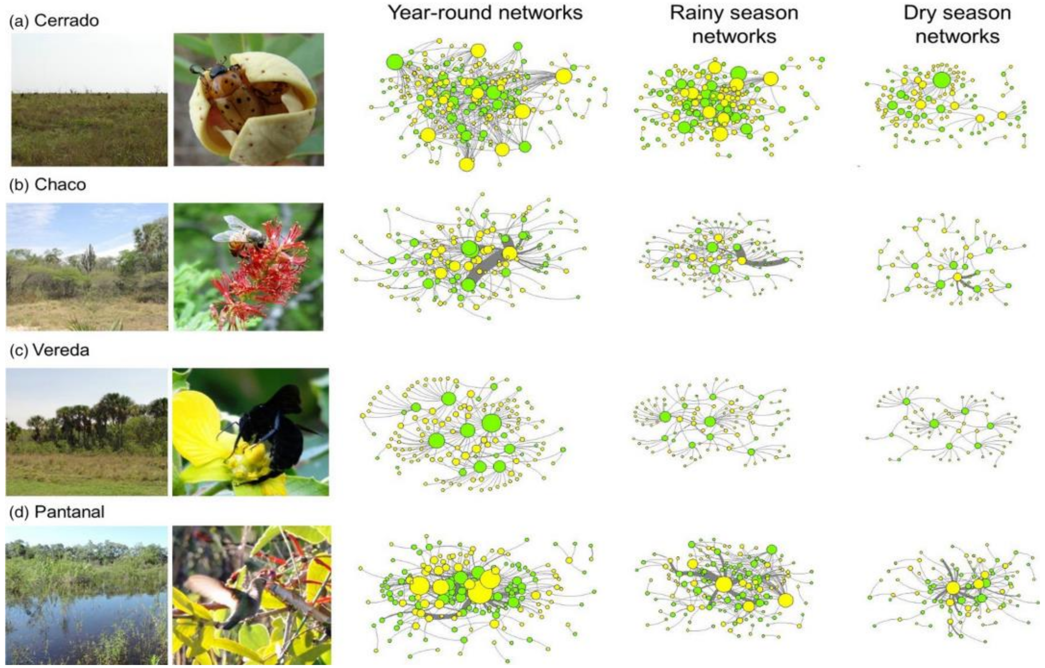
Plant phenology and global climate change: Current progresses and challenges

1. Phenology in highly diverse systems

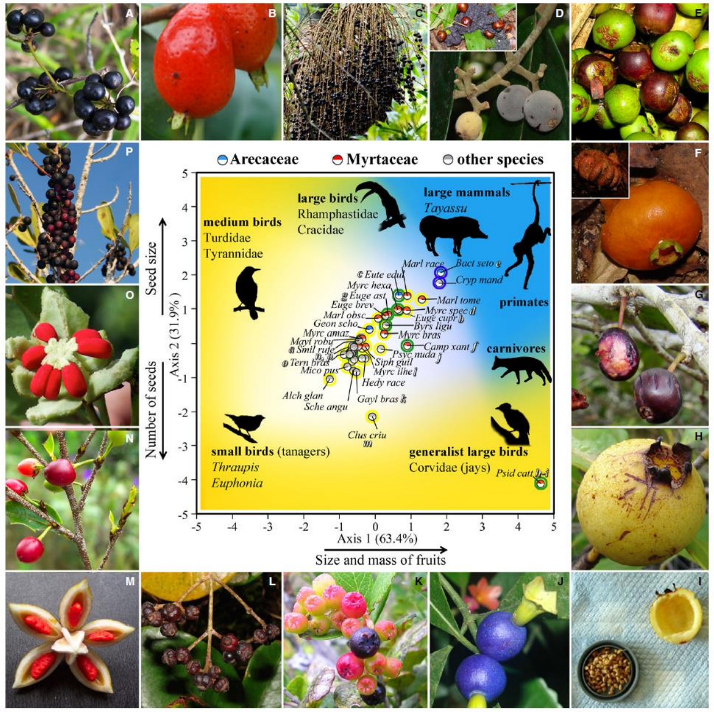
Outstanding Biodiversity

Photo ©: C.E.T. Paine

High dependence on animals for pollination and seed dispersal,



Souza et al. 2017. J. Ecology



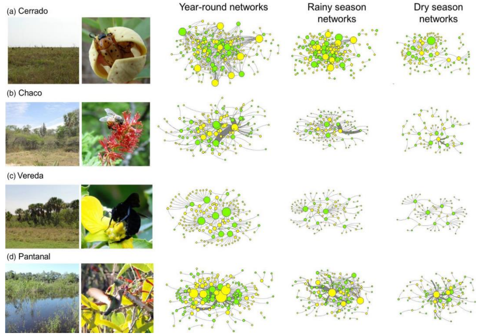
Staggemeier et al. 2017. Biotropica

BIOTIC FACTORS

1. Phenology in highly diverse systems

Outstanding Biodiversity

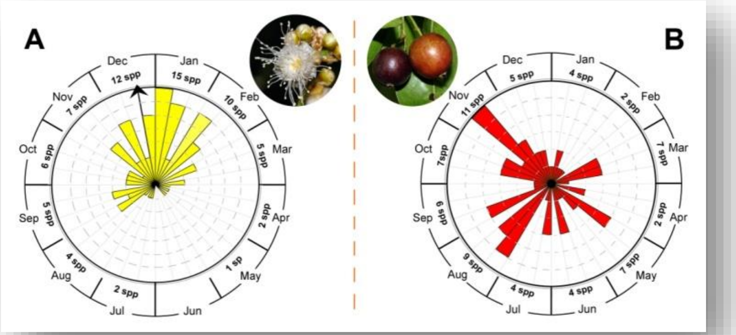
Photo ©: C.E.T. Paine

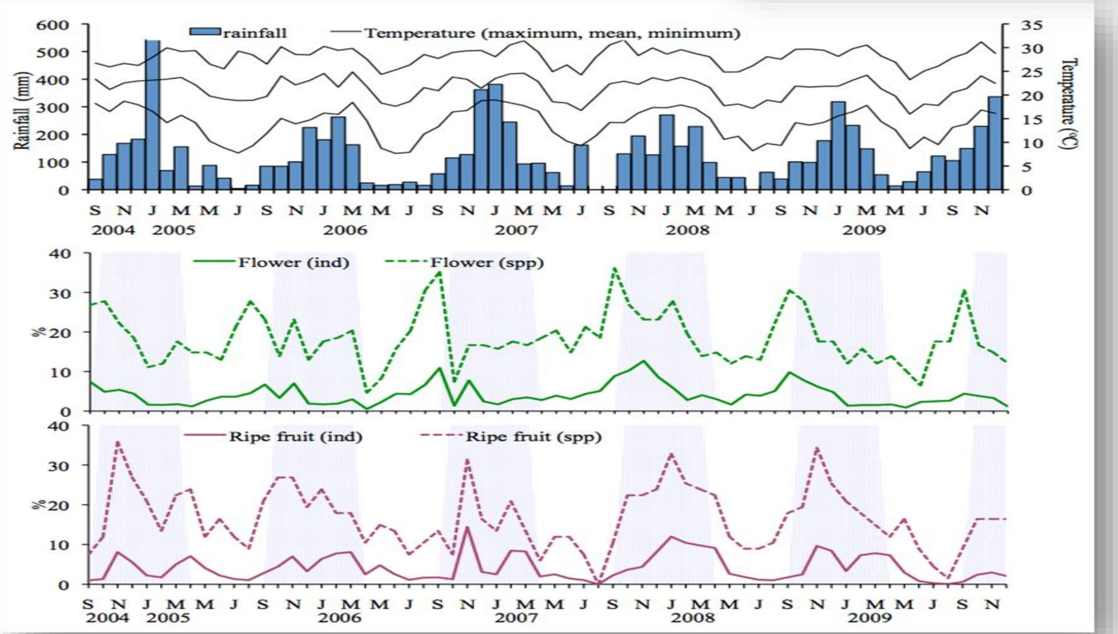


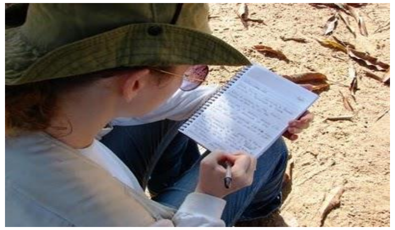
Souza et al. 2017. J. Ecology

Continuous observations on marked trees

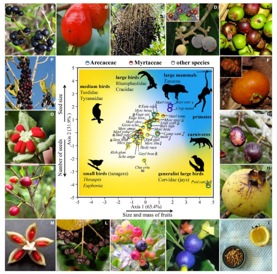
No resting season







- Data collected at individual level
- Restricted areas
- Labor of human observers



Staggemeier et al. 2017. Biotropica

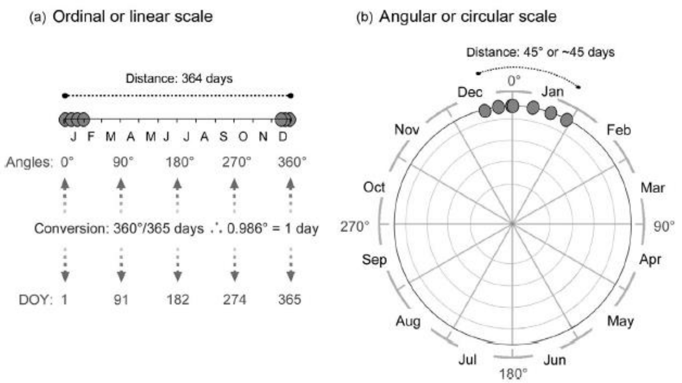
Phenology Lab

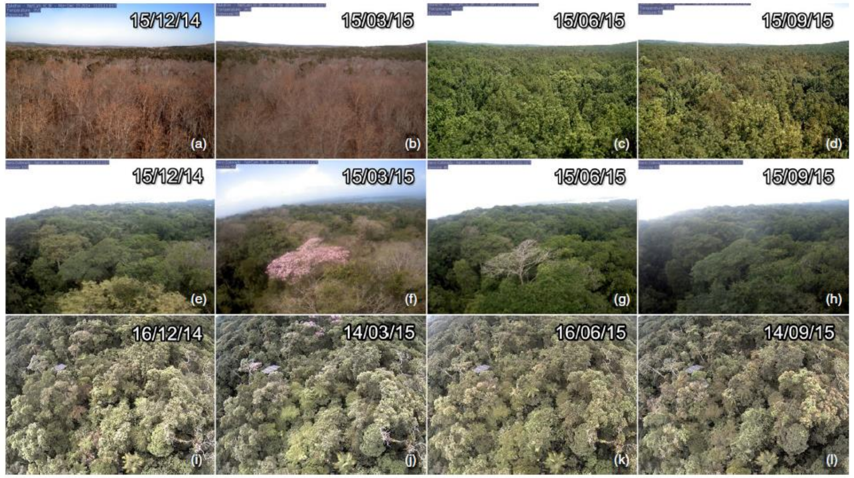
1. Phenology in highly diverse systems

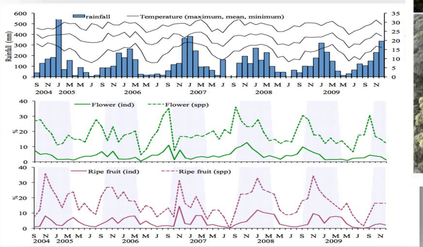
Continuous observations on marked trees – no resting season

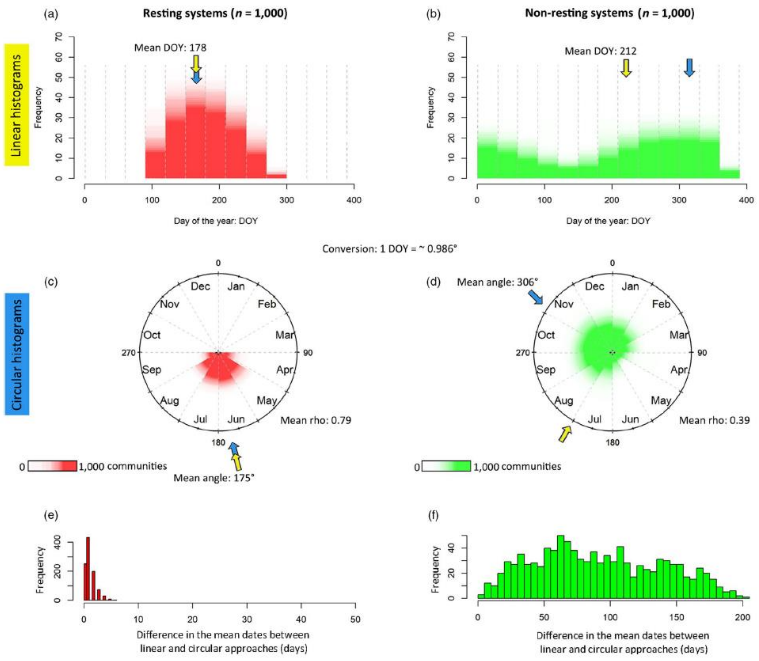
Outstanding Biodiversity

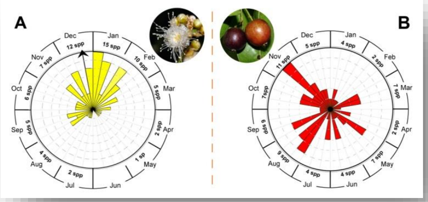
Photo ©: C.E.T. Paine

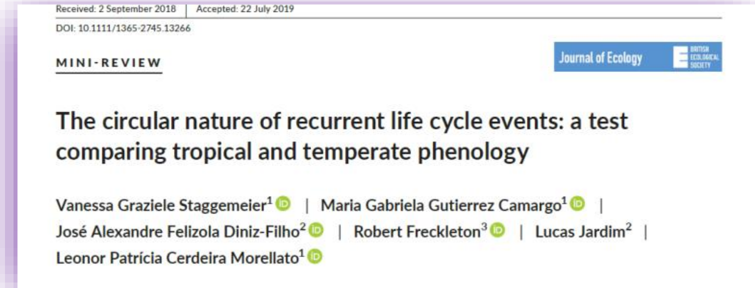










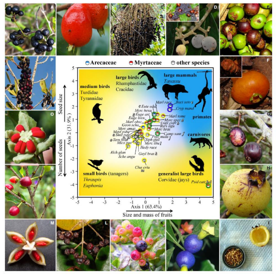

Received: 2 September 2018 | Accepted: 22 July 2019
DOI: 10.1111/1365-2745.13266

MINI-REVIEW

Journal of Ecology

The circular nature of recurrent life cycle events: a test comparing tropical and temperate phenology

Vanessa Graziele Staggemeier[1] | Maria Gabriela Gutierrez Camargo[1] | José Alexandre Felizola Diniz-Filho[2] | Robert Freckleton[3] | Lucas Jardim[2] | Leonor Patrícia Cerdeira Morellato[1]



Staggemeier et al. 2017. Biotropica

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1. Phenology in highly diverse systems

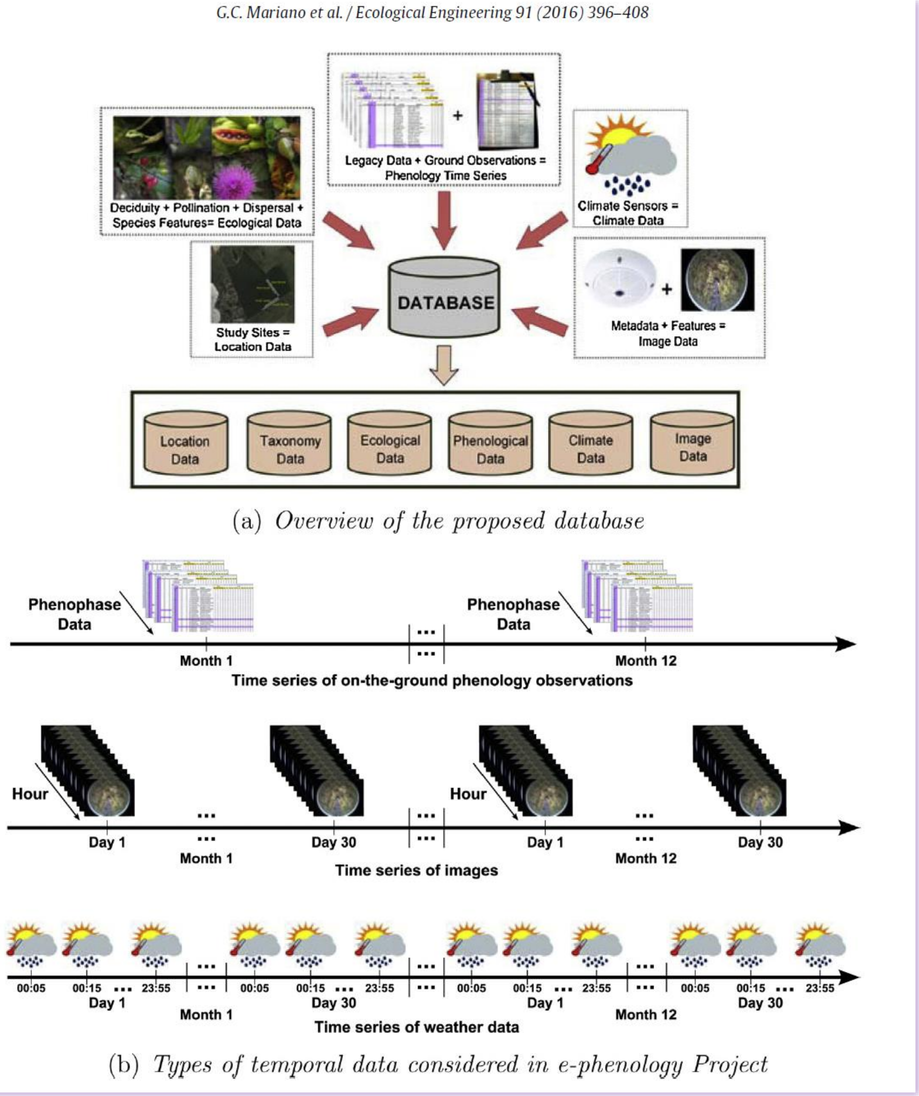
Develop databases and bigdata tolls

Outstanding Biodiversity

Photo ©: C.E.T. Paine

eScience

Data-intensive science



Ecological Engineering 91 (2016) 396–408

Contents lists available at ScienceDirect

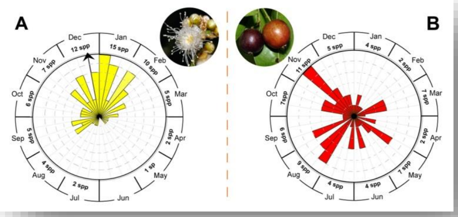
Ecological Engineering

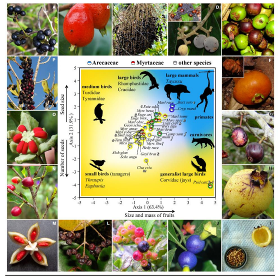
journal homepage: www.elsevier.com/locate/ecoleng

Modeling plant phenology database: Blending near-surface remote phenology with on-the-ground observations

Greice C. Mariano[a,*], Leonor Patricia C. Morellato[b], Jurandy Almeida[a,c], Bruna Alberton[b], Maria Gabriela G. de Camargo[b], Ricardo da S. Torres[a]

[a] Institute of Computing, University of Campinas (UNICAMP), 13083-970 Campinas, SP, Brazil
[b] Institute of Biosciences, Universidade Estadual Paulista (UNESP), 13506-900 Rio Claro, SP, Brazil
[c] Institute of Science and Technology, Federal University of São Paulo (UNIFESP), 12247-014 São José dos Campos, SP, Brazil





Staggemeier et al. 2017. Biotropica

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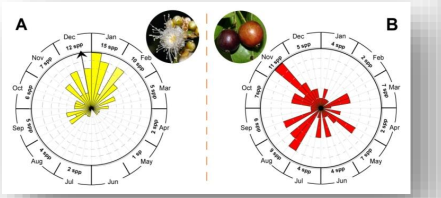
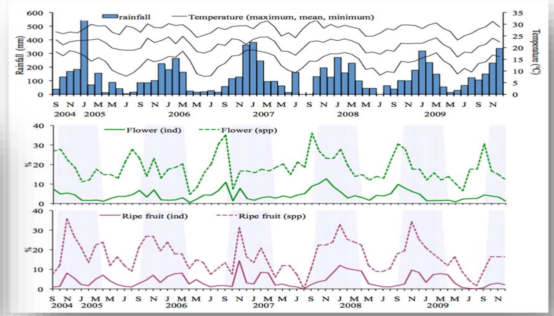
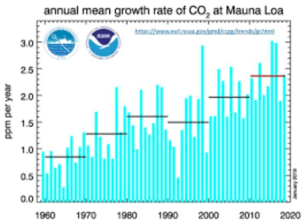
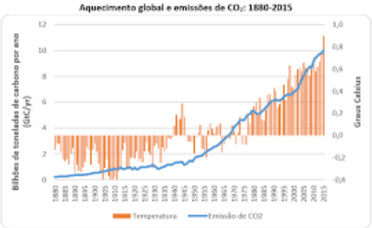




2. Phenology and climate change





Fonte: Global Carbon Project http://cdiac.ornl.gov/GCP/ e NOAA http://www.ncdc.noaa.gov/

SIXTH ASSESSMENT REPORT
Working Group I – The Physical Science Basis

INTERGOVERNMENTAL PANEL ON climate change — ipcc — WMO — UNEP

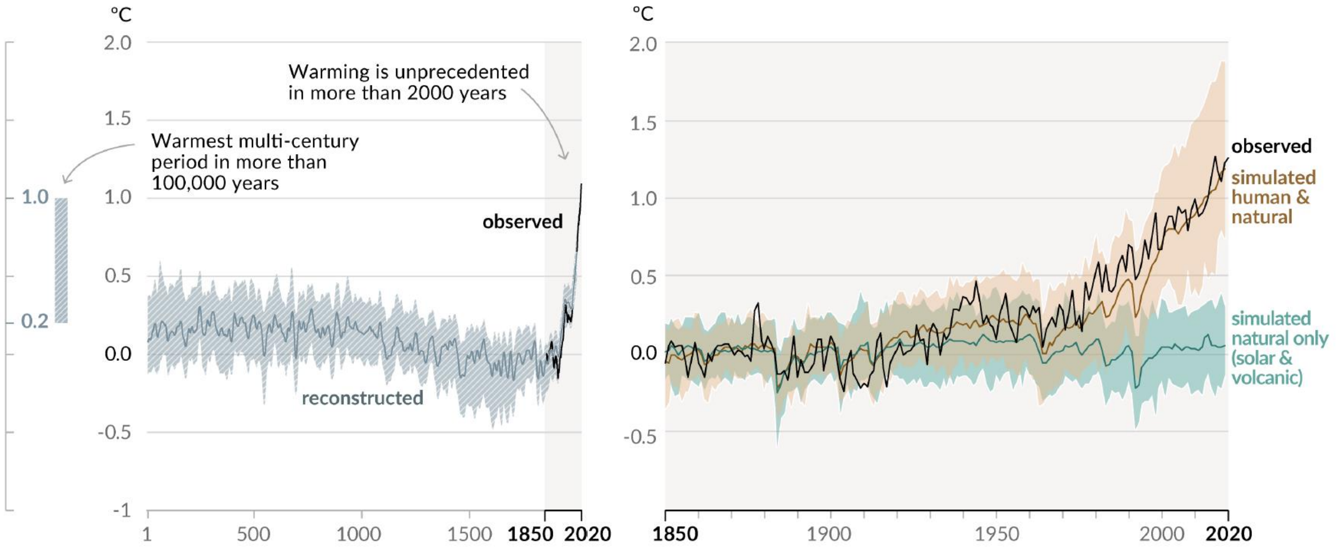
Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years

Figure SPM.1

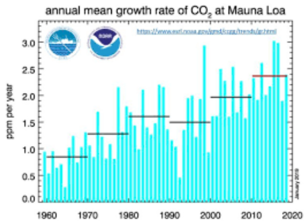
Changes in global surface temperature relative to 1850-1900

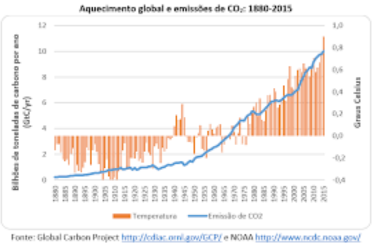
a) Change in global surface temperature (decadal average) as reconstructed (1-2000) and **observed** (1850-2020)

b) Change in global surface temperature (annual average) as **observed** and simulated using human & natural and only natural factors (both 1850-2020)



2. Phenology and climate change





The great acceleration of plant phenological shifts

Vitasse, Y

NATURE CLIMATE CHANGE | VOL 12 | APRIL 2022 | 300–304 | www.nature.com/natureclimatechange

- ✓Long-term observation series/programs
- ✓species driven
- ✓ one-to-few punctual events
- ✓Short observations – unmarked

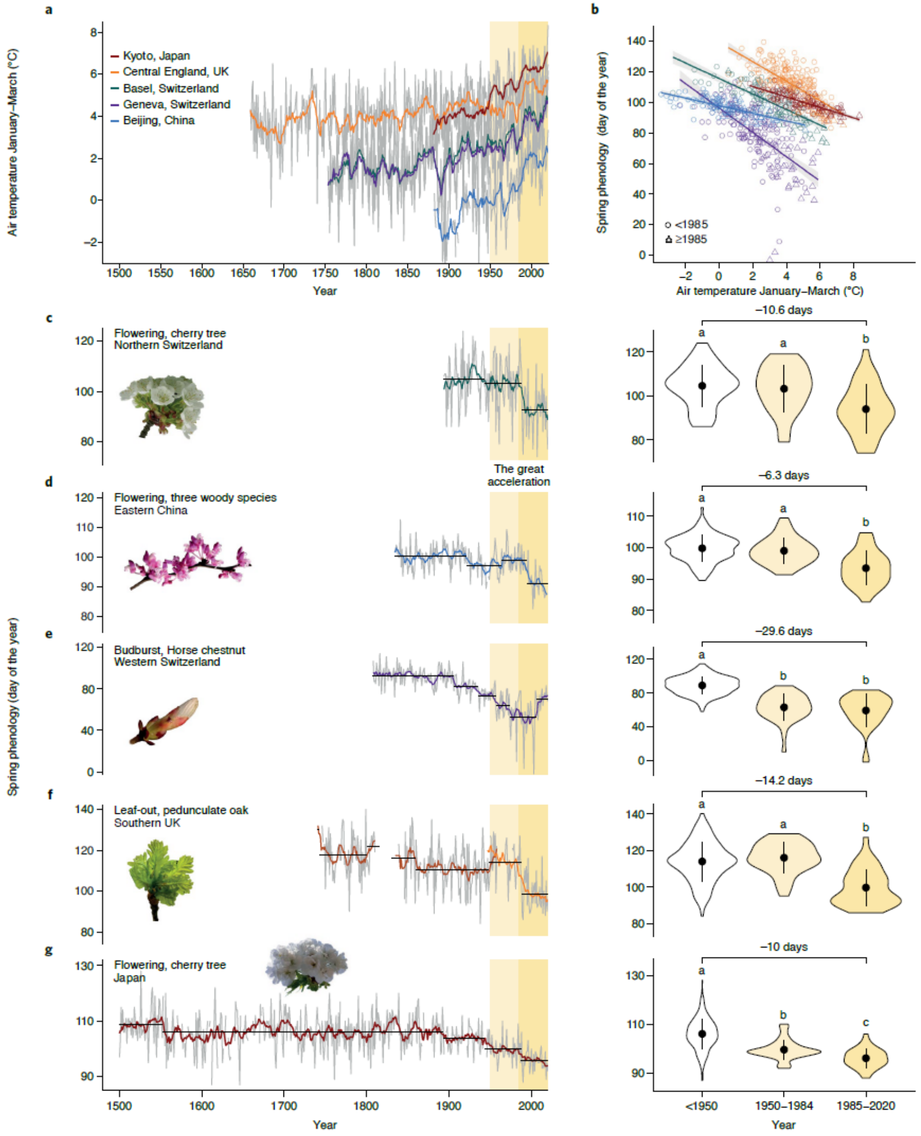


Fig. 1 | The world's longest phenological time series with the associated spring temperatures.

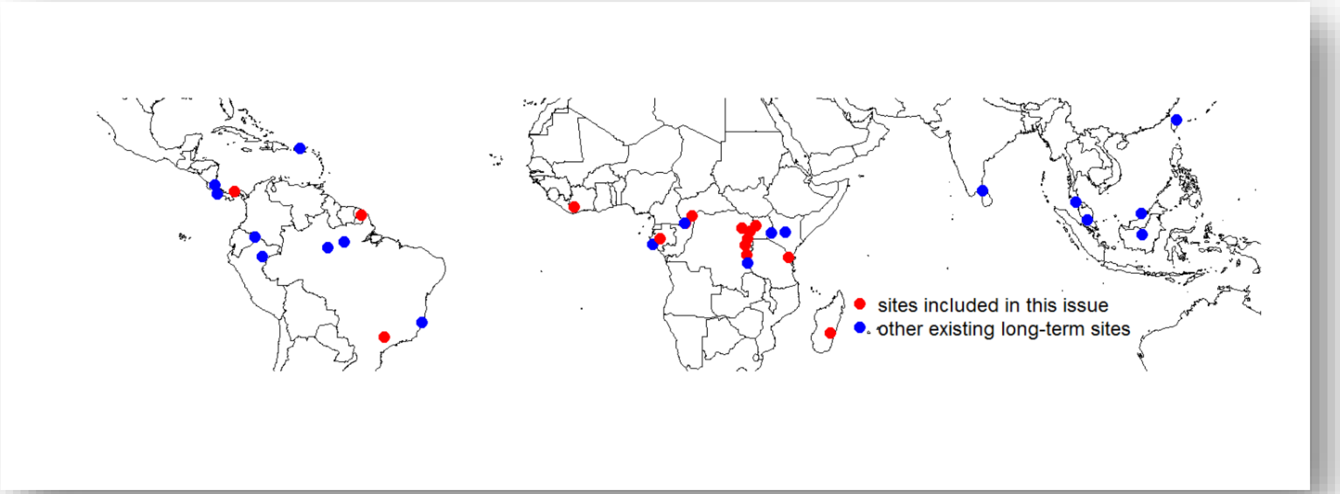
Phenology Lab

2. Phenology and climate change

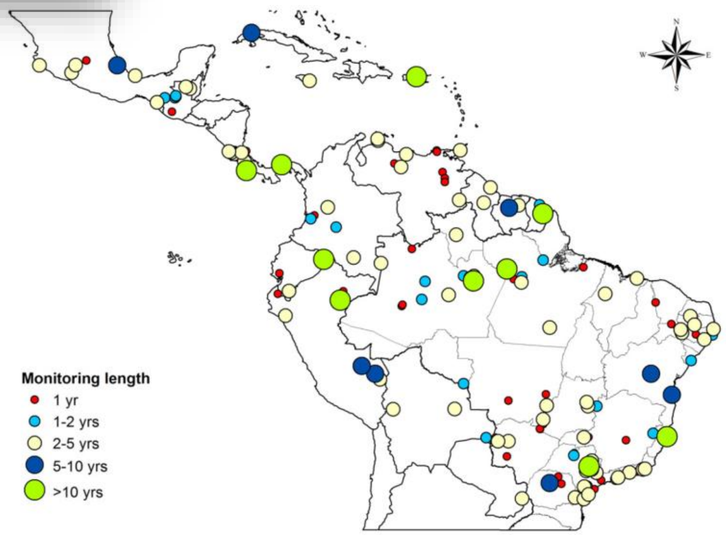
✓Long-term observation programs

Bulk of evidence of **phenology** shifts comes from temperate regions.

"The **short time series** and the **high species diversity** make it difficult tracking phenology and detect cues and shifts in the tropics."



Albernethy et al. 2018. Biotropica



Mendoza, Peres, Morellato 2017. GPC 148:227-241

2. Phenology and climate change

Phenology Lab

SIXTH ASSESSMENT REPORT

Working Group I – The Physical Science Basis

ipcc INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

With every increment of global warming, changes get larger in regional mean temperature, precipitation and soil moisture

Figure SPM.5

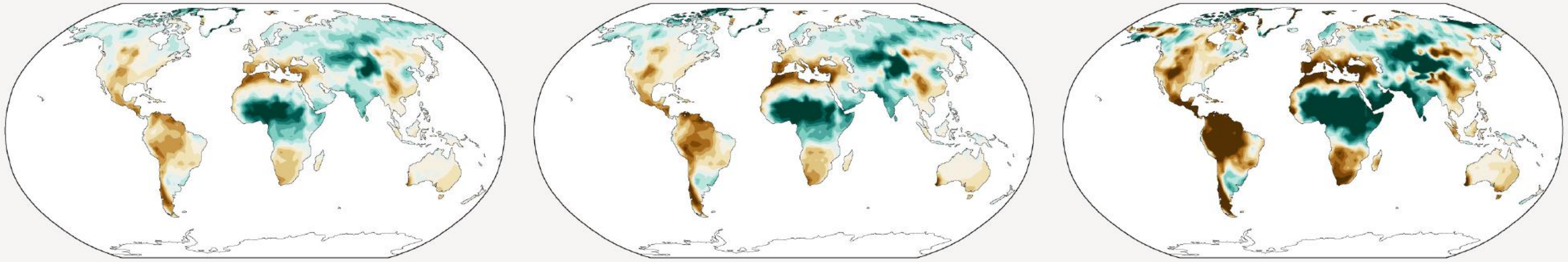
d) Annual mean total column soil moisture change (standard deviation)

Across warming levels, changes in soil moisture largely follow changes in precipitation but also show some differences due to the influence of evapotranspiration.

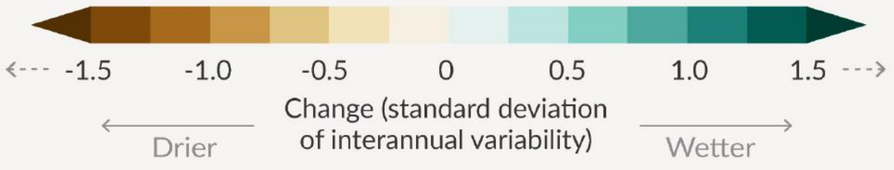
Simulated change at **1.5 °C** global warming

Simulated change at **2 °C** global warming

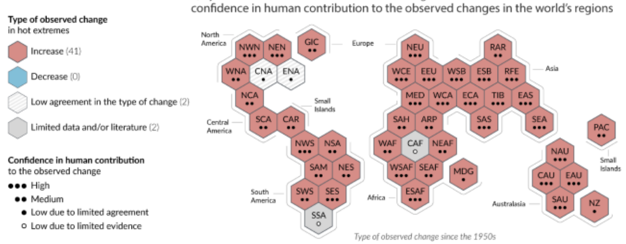
Simulated change at **4 °C** global warming



Relatively small absolute changes may appear large when expressed in units of standard deviation in dry regions with little interannual variability in baseline conditions



a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions



2. Phenology and climate change

IPBES-IPCC CO-SPONSORED WORKSHOP

BIODIVERSITY AND CLIMATE CHANGE

WORKSHOP REPORT

Making Peace with Nature

A scientific blueprint to tackle the climate, biodiversity and pollution emergencies

3.1. Relative global impact of direct drivers on major ecosystems

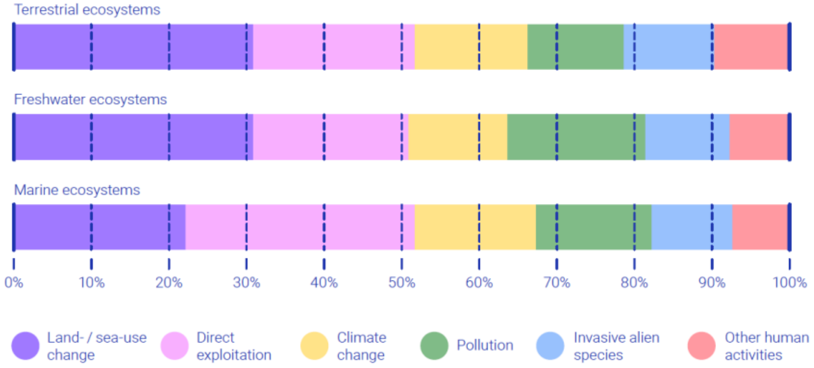


Figure 3.1: Relative global impact of direct drivers on major ecosystems, ranking the past and current causes of declines in biodiversity.
Source: IPBES 2019a, GA SPM, Figure SPM.2

3.4. Land degradation world maps

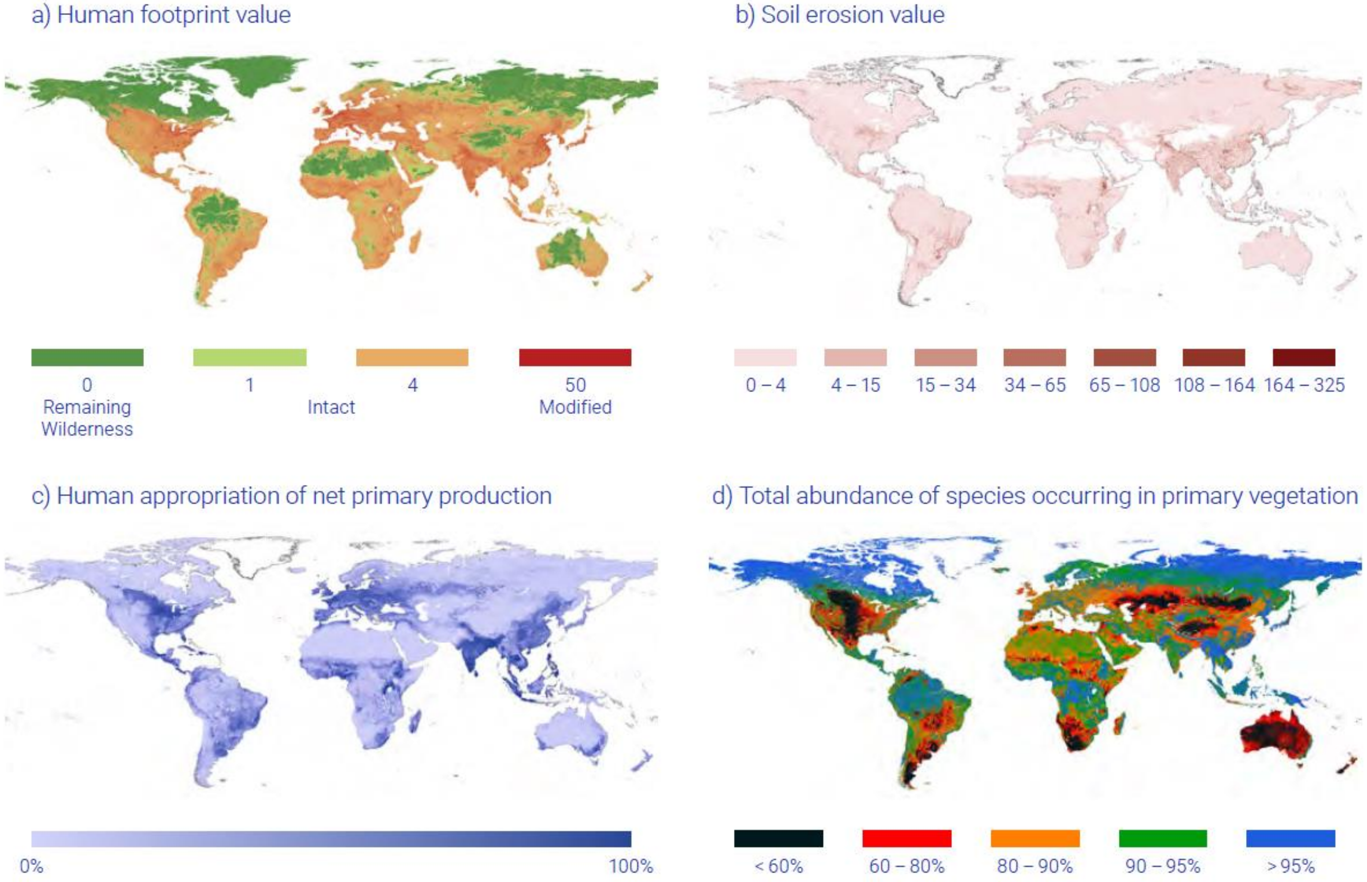


Figure 3.4: Human activities have modified the land surface of the planet as shown through the human footprint value indicating the intactness of terrestrial ecosystems (panel a) the soil erosion value (panel b), the human appropriation of net primary production (panel c) and the total abundance of originally occurring species as a percentage of their total abundance in minimally disturbed primary vegetation, expressed as the Biodiversity Intactness Index (panel d).

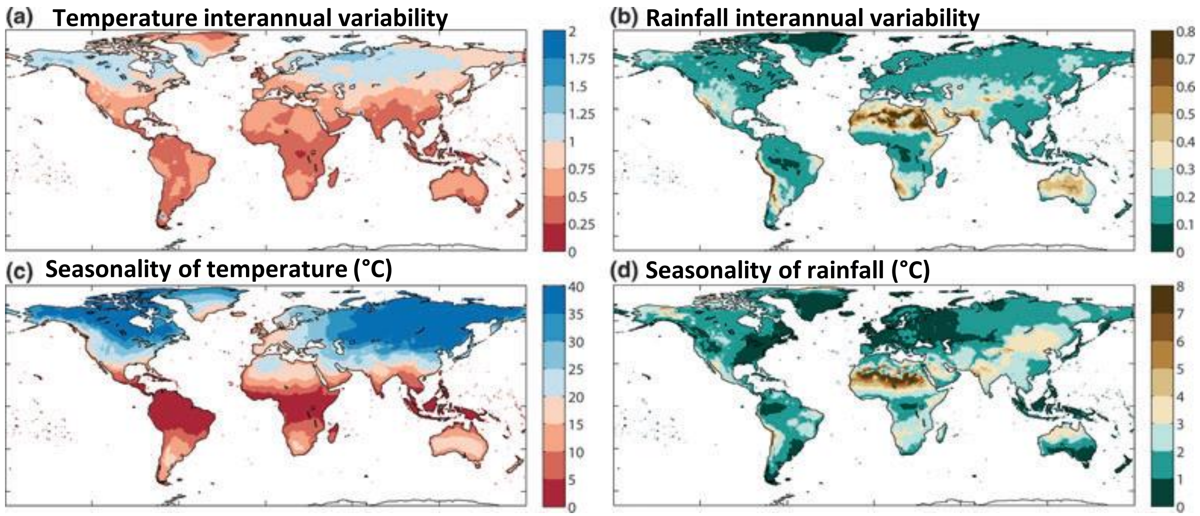
Data sources: a) Brooke, *et al.* (2020), b) Borrelli *et al.* (2007), c) Newbold *et al.* (2016), d) Haberl *et al.* (2007)

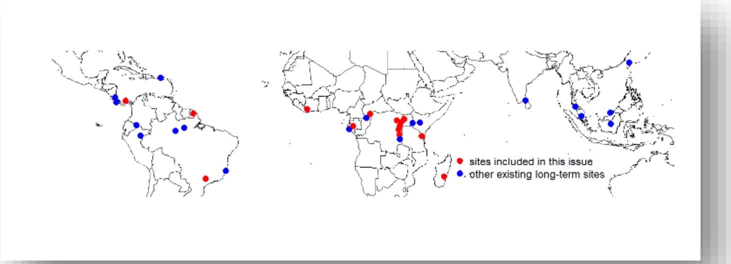
Data compiled and plotted by Emily Zhang

Phenological responses to climate change in the tropics

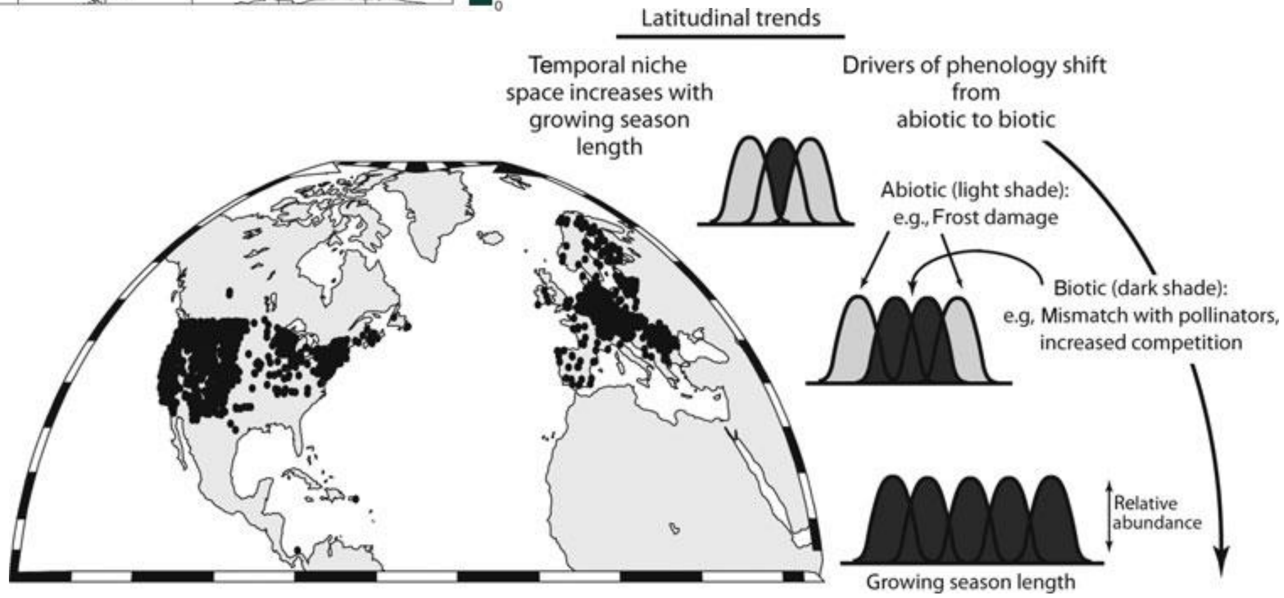
Some predictions can be made considering variability in **temperature**, **precipitation** and **length of growing season**

Phenology responses and shifts should differ depending on the length of growing season - ***Long-term observations***





Albernethy et al. 2018. Biotropica



Pau et al, 2011. GCB

Phenological responses to climate change in the tropics

Phenology Lab

✓Long-term observation programs

OPEN ACCESS Freely available online PLOS | ONE

Phenological Changes in the Southern Hemisphere

Lynda E. Chambers[1*], Res Altwegg[2,15], Christophe Barbraud[3], Phoebe Barnard[2,16], Linda J. Beaumont[4], Robert J. M. Crawford[5], Joel M. Durant[6], Lesley Hughes[4], Marie R. Keatley[7], Matt Low[8], Patricia C. Morellato[9], Elvira S. Poloczanska[10], Valeria Ruoppolo[11,12], Ralph E. T. Vanstreels[12], Eric J. Woehler[13], Anton C. Wolfaardt[14]

October 2013 | Volume 8 | Issue 10 | e75514

The El Nino Southern Oscillation, Variable Fruit Production, and Famine in a Tropical Forest

S. Joseph Wright

Ecology, Vol. 80,

LETTERS nature climate change

PUBLISHED ONLINE: 7 JULY 2013 | DOI: 10.1038/NCLIMATE1934

Clouds and temperature drive dynamic changes in tropical flower production

Stephanie Pau[1,2*], Elizabeth M. Wolkovich[3], Benjamin I. Cook[4,5], Christopher J. Nytch[6], James Regetz[2], Jess K. Zimmerman[6] and S. Joseph Wright[7]

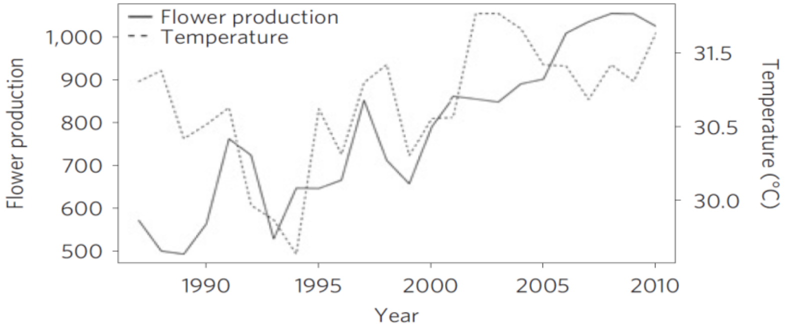


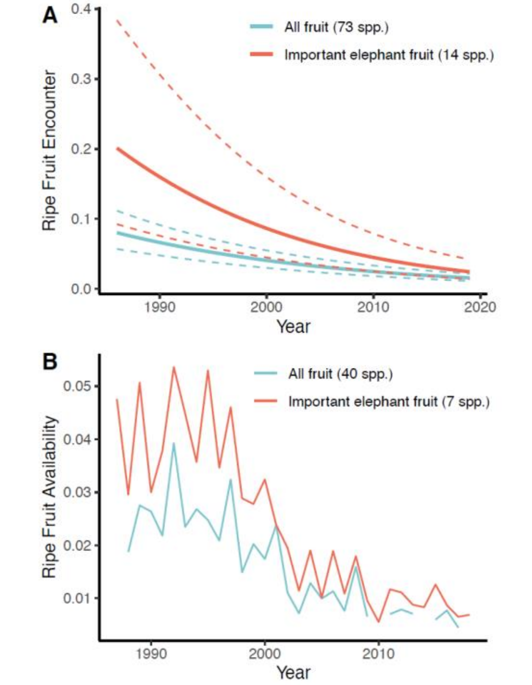
Figure 2 | Long-term trends in flower production (solid line) and maximum temperature (dotted line) at BCI from 1987 to 2009. Flower

biotropica THE SCIENTIFIC JOURNAL OF THE ATBC

Special Section 2018: Long-term trends of tropical plant phenology: consequences for plants and consumers

Long-term collapse in fruit availability threatens Central African forest megafauna§

Emma R. Bush1,2†, Robin C. Whytock1,3*†, Laila Bahaa-el-din4, Stephanie Bourgeois3, Nils Bunnefeld1, Anabelle W. Cardoso5,6, Jean Thoussaint Dikangadissi3, Pacome Dimbonda3,Edmond Dimoto3, Josue Edzang Ndong3, Kathryn J. Jeffery1, David Lehmann3, Loic Makaga3, ... hite1,8,9,



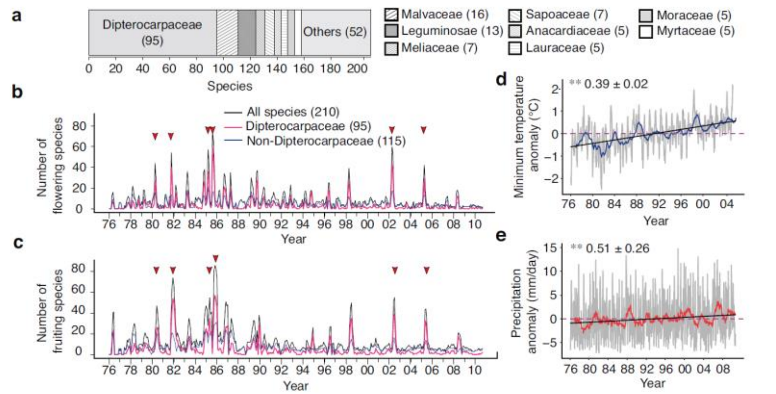
communications biology

ARTICLE

https://doi.org/10.1038/s42003-022-03245-8 OPEN

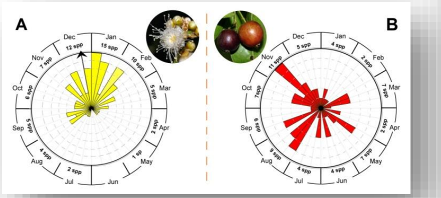
Impacts of climate change on reproductive phenology in tropical rainforests of Southeast Asia

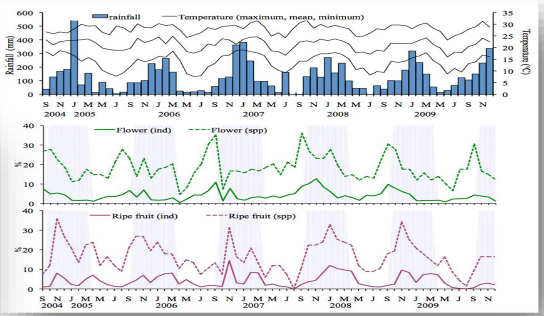
Shinya Numata[1], Koharu Yamaguchi[2], Masaaki Shimizu[2], Gen Sakurai[3], Ayaka Morimoto[1], Noraliza Alias[4], Nashatul Zaimah Noor Azman[4], Tetsuro Hosaka[5] & Akiko Satake[6]



Tropical phenology and climate change in the crossroads

1. Phenology in highly diverse ecosystems
2. Phenology and climate change
3. Challenges to study phenology and climate change in highly diverse ecosystems
   - I. reviews and synthesis, unlocking literature and old observations;
   - II. use of herbarium records, to recover long term patterns and responses;
   - III. applications of evolutionary and modelling tools to search for clade's sensitiveness to changes on their phenological niche;
   - IV. combine observations and experiments to understand temporal mismatches;
   - V. experiments - impose climate scenarios to tropical plants (e.g. CO_2 enrichment – FACE, drought experiments, transplants);
   - VI. new technologies
   - VII. networking- develop citizen science initiatives and monitoring networks to collect more comparative data over large special scales;
4. Final remarks





3. to detect temporal responses in highly diverse ecosystems

Phenology Lab

I. reviews and synthesis, unlocking literature and old observations

Chapter 2.5

SOUTH AMERICA

L. Patrícia C. Morellato
Departamento de Botânica, Plant Phenology and Seed Dispersal Research Group, Universidade Estadual Paulista, São Paulo, Brasil

Acta bot. bras. 18(1): 99-108. 2004

Métodos de amostragem e avaliação utilizados em estudos fenológicos de florestas tropicais[1]

Fernanda F. d'Eça-Neves[2] e L. Patrícia C. Morellato[3,4]

OPEN ACCESS Freely available online PLOS ONE

Phenological Changes in the Southern Hemisphere

Lynda E. Chambers[1*], Res Altwegg[2,15], Christophe Barbraud[3], Phoebe Barnard[2,16], Linda J. Beaumont[4], Robert J. M. Crawford[5], Joel M. Durant[6], Lesley Hughes[4], Marie R. Keatley[7], Matt Low[8], Patricia C. Morellato[9], Elvira S. Poloczanska[10], Valeria Ruoppolo[11,12], Ralph E. T. Vanstreels[12], Eric J. Woehler[13], Anton C. Wolfaardt[14]

Chapter 6
A Review of Plant Phenology in South and Central America

L. Patrícia C. Morellato, Maria Gabriela G. Camargo, and Eliana Gressler

Contents lists available at ScienceDirect
Global and Planetary Change
journal homepage: www.elsevier.com/locate/gloplacha
ELSEVIER

Invited review article

Continental-scale patterns and climatic drivers of fruiting phenology: A quantitative Neotropical review

Irene Mendoza [a,*], Carlos A. Peres [b], Leonor Patrícia C. Morellato [a]
[a] Universidade Estadual Paulista, Departamento de Botânica, Laboratório de Fenologia, Av. 24A, 1515, 13506-900 Rio Claro, SP, Brazil

Restoration Ecology
THE JOURNAL OF THE SOCIETY FOR ECOLOGICAL RESTORATION

OPINION ARTICLE

Plant phenological research enhances ecological restoration

Elise Buisson[1,2], Swanni T. Alvarado[3,4], Soizig Le Stradic[4,5], Leonor Patricia C. Morellato[5]

Biological Conservation 195 (2016) 60–72
Contents lists available at ScienceDirect
Biological Conservation
journal homepage: www.elsevier.com/locate/bioc
ELSEVIER

Perspective

Linking plant phenology to conservation biology

Leonor Patrícia Cerdeira Morellato [a,*], Bruna Alberton [a,b], Swanni T. Alvarado [c], Bruno Borges [a,b], Elise Buisson [d], Maria Gabriela G. Camargo [a], Leonardo F. Cancian [a], Daniel W. Carstensen [a], Diego F.E. Escobar [a,e], Patrícia T.P. Leite [a,e], Irene Mendoza [a], Nathália M.W.B. Rocha [a], Natalia C. Soares [a,e], Thiago Sanna Freire Silva [c], Vanessa G. Staggemeier [a], Annia Susin Streher [b,c], Betânia C. Vargas [a,e], Carlos A. Peres [f]

Contents lists available at ScienceDirect
Ecological Engineering
journal homepage: www.elsevier.com/locate/ecoleng
ELSEVIER

Modeling plant phenology database: Blending near-surface remote phenology with on-the-ground observations

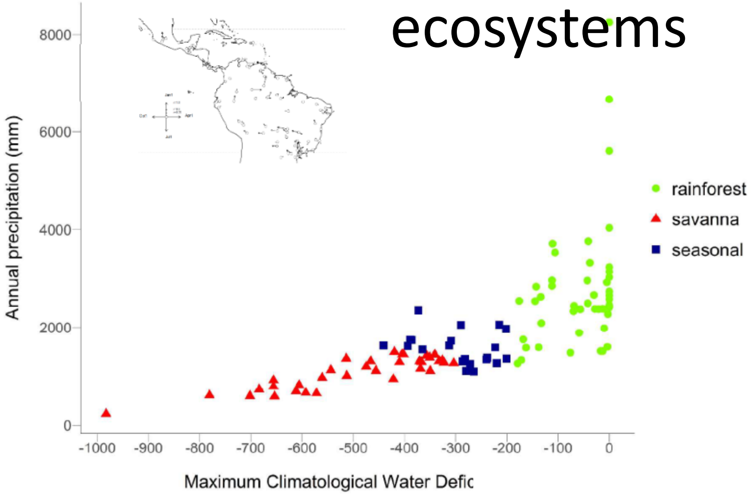
Greice C. Mariano [a,*], Leonor Patricia C. Morellato [b], Jurandy Almeida [a,c], Bruna Alberton [b], Maria Gabriela G. de Camargo [b], Ricardo da S. Torres [a]

Revista Brasil. Bot., V.25, n.3, p.269-275, set. 2002

Comparação de dois métodos de avaliação da fenologia de plantas, sua interpretação e representação[1]

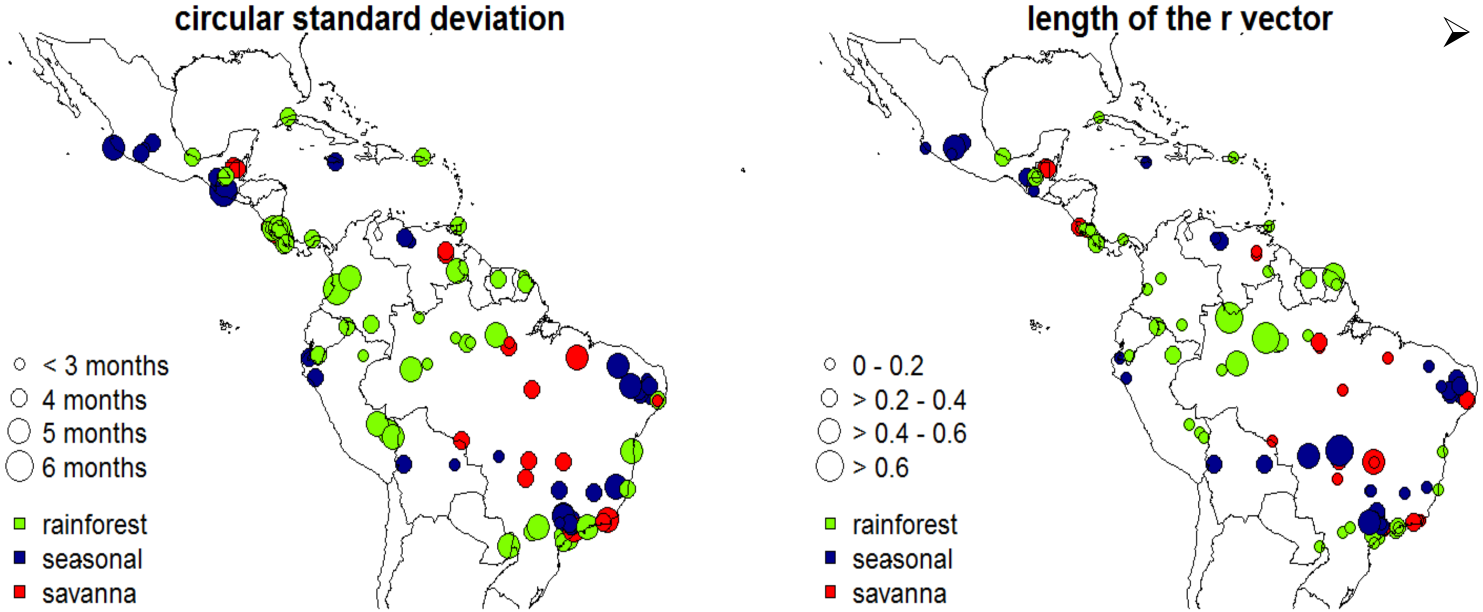
CINARA S.C. BENCKE[2,3] e L. PATRÍCIA C. MORELLATO[2,4]

3. Challenges to detect temporal responses in highly diverse ecosystems



Fruiting availability is sensible to climate change scenarios.

- Reduced fruiting season length as consequence of future climatic conditions may have a very detrimental effect for resident frugivores.



- Half of analyzed Neotropical sites were subjected to some degree of fruiting seasonality.

Mendoza, I., Peres, C. A., Morellato, L.P.C. in prep. Large-scale climatic predictors of fruiting seasonality across the Neotropics.

3. Challenges to detect temporal responses in highly diverse ecosystems

II. use of herbarium records, to recover long term patterns and responses;

Trends in Ecology & Evolution

Review

Old Plants, New Tricks: Phenological Research Using Herbarium Specimens

Charles G. Willis,[1,*] Elizabeth R. Ellwood,[2,*]
Richard B. Primack,[3] Charles C. Davis,[1] Katelin D. Pearson,[2]
Amanda S. Gallinat,[3] Jenn M. Yost,[4] Gil Nelson,[2]
Susan J. Mazer,[5] Natalie L. Rossington,[5] Tim H. Sparks,[6,7]
and Pamela S. Soltis[8]

herbarium specimens in a stage of early leaf-out demonstrated that trees now leaf-out earlier than a century ago and leaf-out earlier in warm years [18]. A surprising finding was that annual variation in temperature was far greater in determining leaf-out dates than geographical variation in temperature and that differences among species in leaf-out times were not significant. Further, the geographic variation in leaf-out dates determined using herbarium specimens was significantly correlated with geographic variation in leaf-out dates determined using remote sensing data provided by satellites. This correlation provides independent confirmation that remote sensing, a rapidly growing tool in climate change research, is accurately measuring leaf-out times over large geographic areas. The study also showed that, on average, herbarium specimens show later leaf-out dates than remote sensing dates, perhaps because remote sensing instruments are sensitive to ground cover, the shrub layer, and the very first tree leaves.

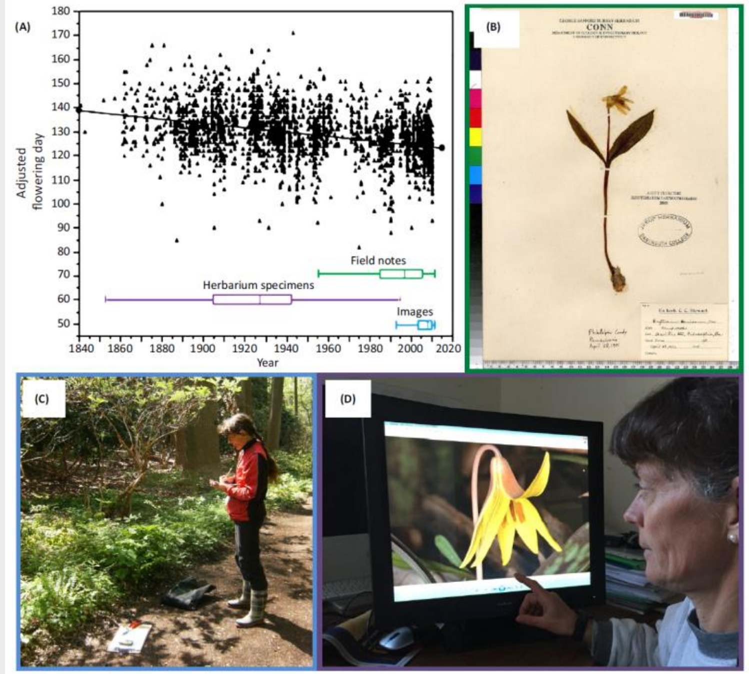


Figure I. Example of Integrated Historical Data Sources. (A) Plot of flowering day over time for 28 species in the Philadelphia area based on a combination of

Analysis of flowering patterns from herbarium specimens: relationships with the climate and long-term shifts in flowering times

1 Identify species with conspicuous flowers

(Tabebuia aurea)

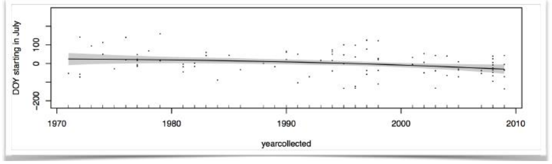
Photography and collector note indicating the presence of flowers

2 Search online databases for herbarium records of target species

GBIF speciesLink

3 Use machine learning to retain reliable records of specimens with flowers

4 Model the derived long term time series to identify changes in flowering times and relationships with the climate for several species

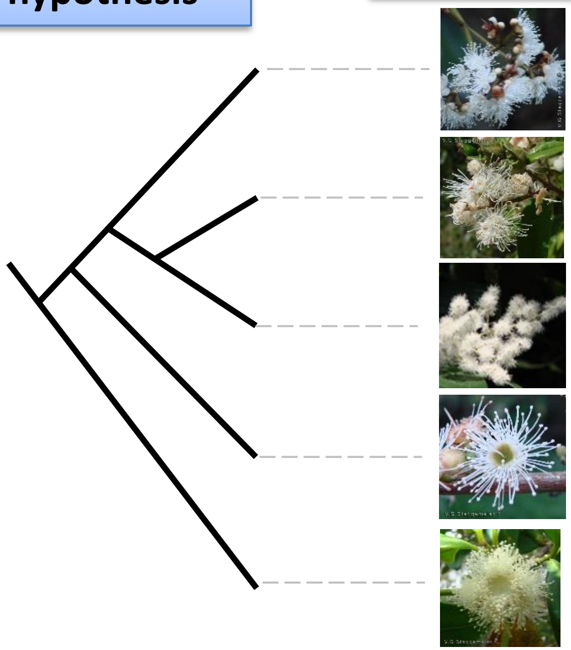


3. Challenges to detect temporal responses in highly diverse ecosystems

III. applications of evolutionary and modelling tools to search for clade's sensitiveness to changes on their phenological niche;

- ✓ Detect trends, sensitivities and shifts to climate change
- ➢ Phylogeny, Modeling and forecasting phenology

Phylogenetic hypothesis ✚ **Phenology**



Journal of Ecology
British Ecological Society
Journal of Ecology doi: 10.1111/j.1365-2745.2010.01717.x

The shared influence of phylogeny and ecology on the reproductive patterns of Myrteae (Myrtaceae)

Vanessa Graziele Staggemeier[1]*, José Alexandre Felizola Diniz-Filho[2] and Leonor Patrícia Cerdeira Morellato[1]

Contents lists available at ScienceDirect
Perspectives in Plant Ecology, Evolution and Systematics
journal homepage: www.elsevier.com/locate/ppees
ELSEVIER

Research article

Clade-specific responses regulate phenological patterns in Neotropical Myrtaceae

Vanessa G. Staggemeier[a,*], José Alexandre F. Diniz-Filho[a], Valesca B. Zipparro[b], Eliana Gressler[b], Everaldo Rodrigo de Castro[c], Fiorella Mazine[d], Itayguara Ribeiro da Costa[e], Eve Lucas[f], Leonor Patrícia C. Morellato[b]

PHENO 2022

Phenology Lab

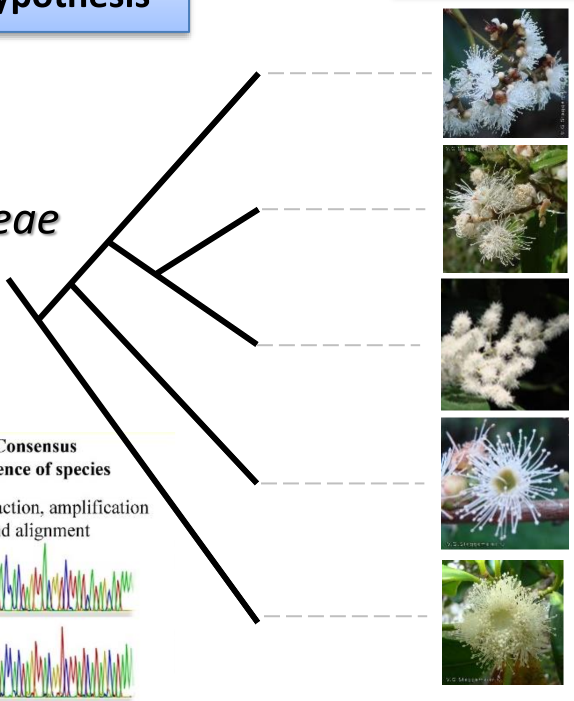
3. Challenges to detect temporal responses in highly diverse ecosystems

III. applications of evolutionary and modelling tools to search for clade's sensitiveness to changes on their phenological niche;

✓ Detect trends, sensitivities and shifts to climate change

Phylogenetic hypothesis ✚ **Phenology**

Myrtaceae



21. Oct

25. Oct

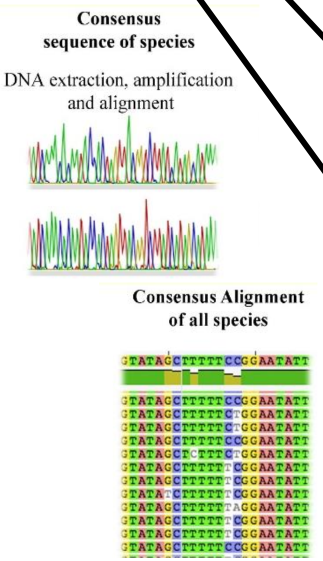
23. Oct

13.Mar

05.Jan

Prediction

Closely related species would exhibit similar phenological patterns because of their common ancestry



Monthly systematic collection in the field

Contents lists available at ScienceDirect

Perspectives in Plant Ecology, Evolution and Systematics

journal homepage: www.elsevier.com/locate/ppees

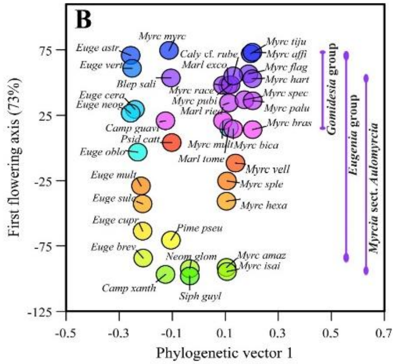
Research article

Clade-specific responses regulate phenological patterns in Neotropical Myrtaceae

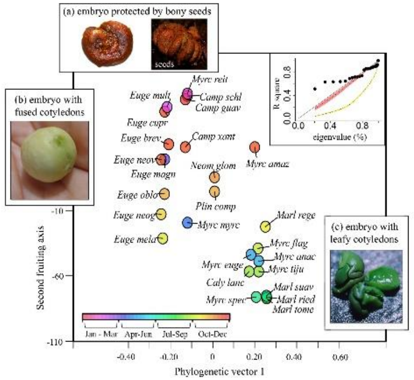
Vanessa G. Staggemeier[a,*], José Alexandre F. Diniz-Filho[a], Valesca B. Zipparro[b], Eliana Gressler[b], Everaldo Rodrigo de Castro[c], Fiorella Mazine[d], Itayguara Ribeiro da Costa[e], Eve Lucas[f], Leonor Patrícia C. Morellato[b]

Useful for:

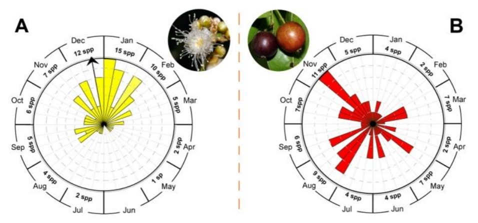
- Identify groups with conservative phenology (potentially less resilient face to global warming)

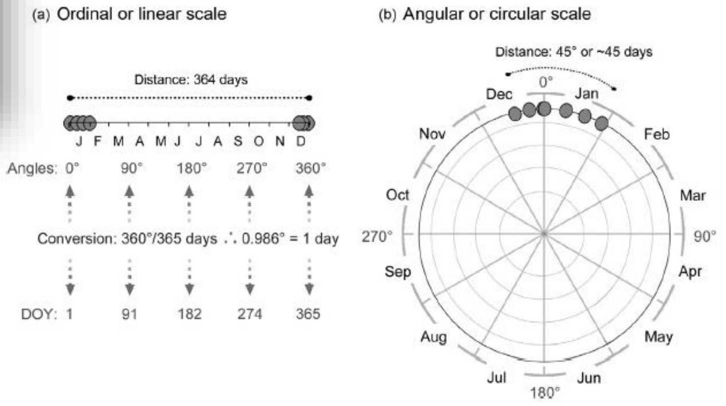


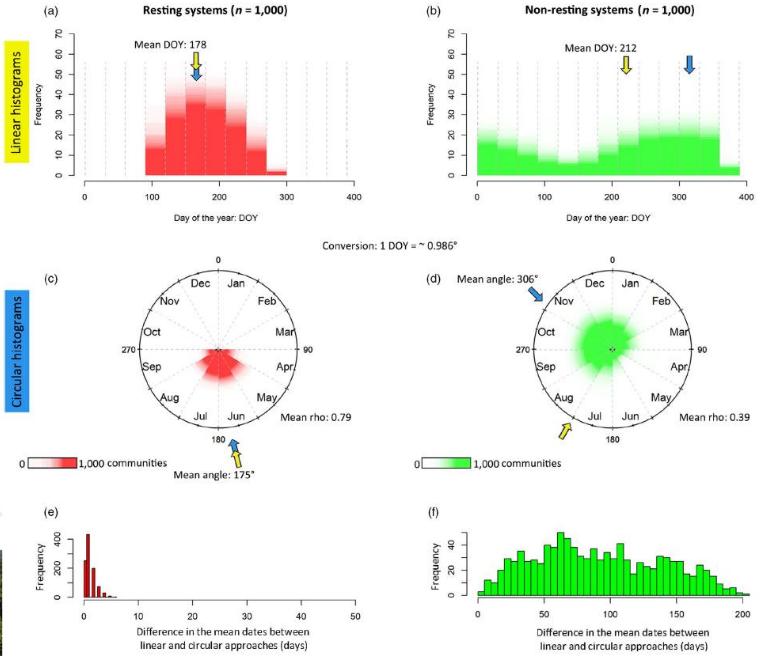
- Understand the evolution of phenological strategies on plants

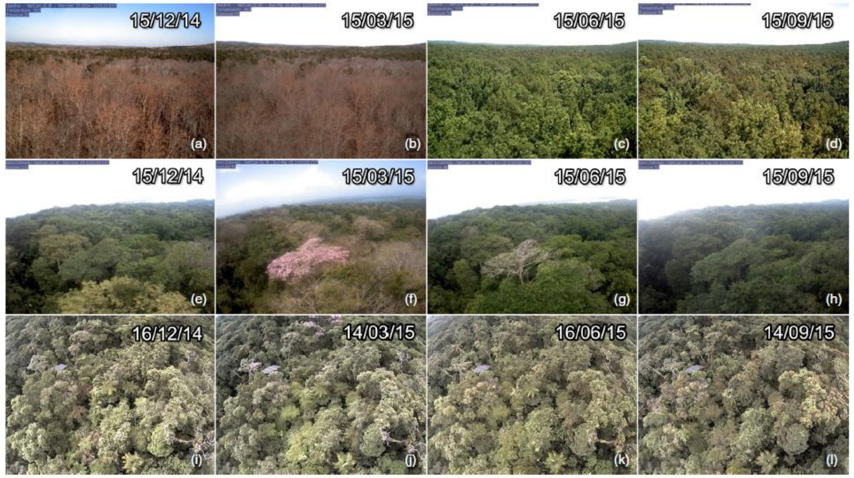


III. applications of evolutionary and modelling tools to search for clade's sensitiveness to changes on their phenological niche;









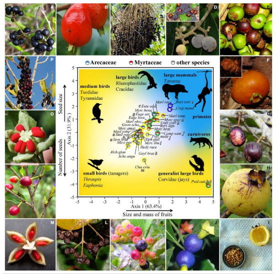
DOI: 10.1111/1365-2745.13266

Journal of Ecology BRITISH ECOLOGICAL SOCIETY

MINI-REVIEW

The circular nature of recurrent life cycle events: a test comparing tropical and temperate phenology

Vanessa Graziele Staggemeier[1] | Maria Gabriela Gutierrez Camargo[1] | José Alexandre Felizola Diniz-Filho[2] | Robert Freckleton[3] | Lucas Jardim[2] | Leonor Patrícia Cerdeira Morellato[1]

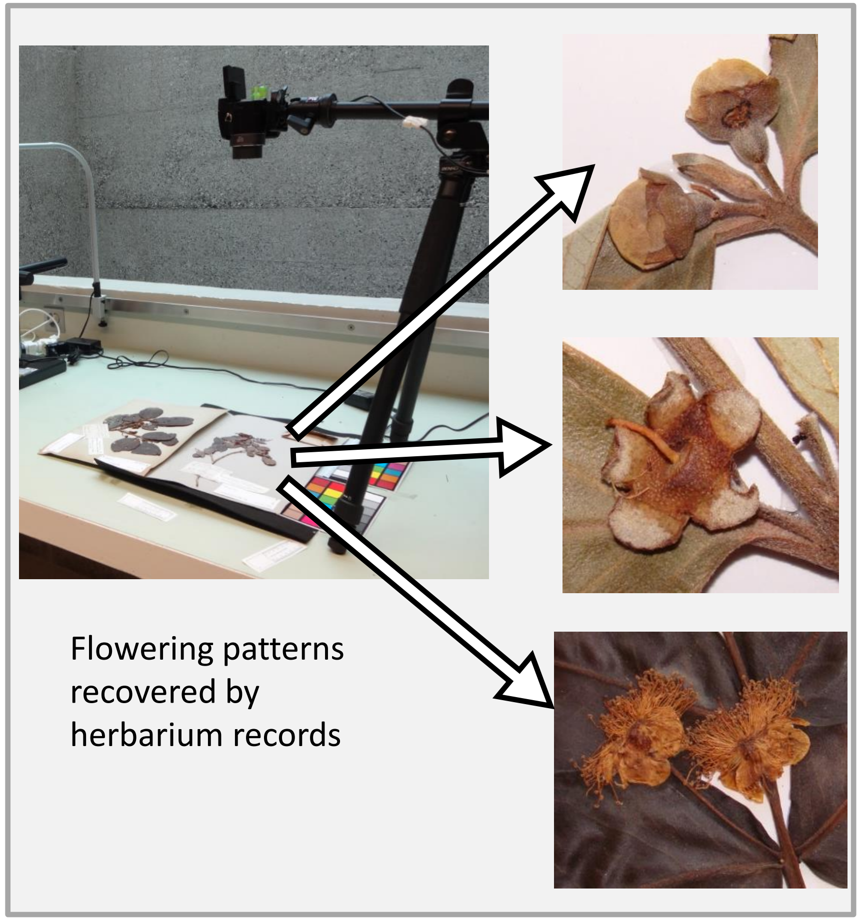


ggemeier et al. 2017. Biotropica

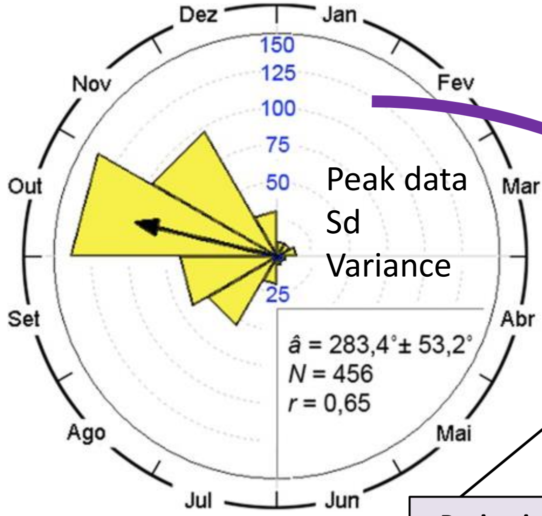
3. Challenges: detect temporal responses in highly diverse ecosystems

II. use of herbarium records, to recover long term patterns and responses;

III. applications of evolutionary and modelling tools to search for clade's sensitiveness to changes on their phenological niche;



Phenograms: best time for flowering

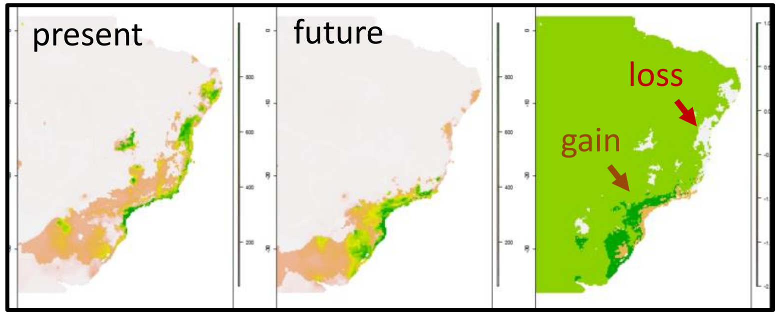


Climatic variables (reproductive niche)

Temp, rainfall

Projections in the geographical space

=predictions




Received: 2 September 2018 | Accepted: 22 July 2019
DOI: 10.1111/1365-2745.13266

MINI-REVIEW

Journal of Ecology

The circular nature of recurrent life cycle events: a test comparing tropical and temperate phenology

Vanessa Graziele Staggemeier[1] | Maria Gabriela Gutierrez Camargo[1] | José Alexandre Felizola Diniz-Filho[2] | Robert Freckleton[3] | Lucas Jardim[2] | Leonor Patrícia Cerdeira Morellato[1]

➢ Phylogeny, Modeling and forecasting phenology

3. Challenges: detect temporal responses in highly diverse ecosystems

V. experiments - impose climate scenarios to tropical plants (e.g. CO2 enrichment – FACE, drought experiments, transplants);

FACE experiments aim to investigate how terrestrial ecosystems respond to elevated atmospheric CO2 concentration

AMAZONFACE
Assessing the effects of increased atmospheric CO_2 on the ecology and resilience of the Amazon forest.

NEWS IN FOCUS

Experiment aims to steep rainforest in carbon dioxide

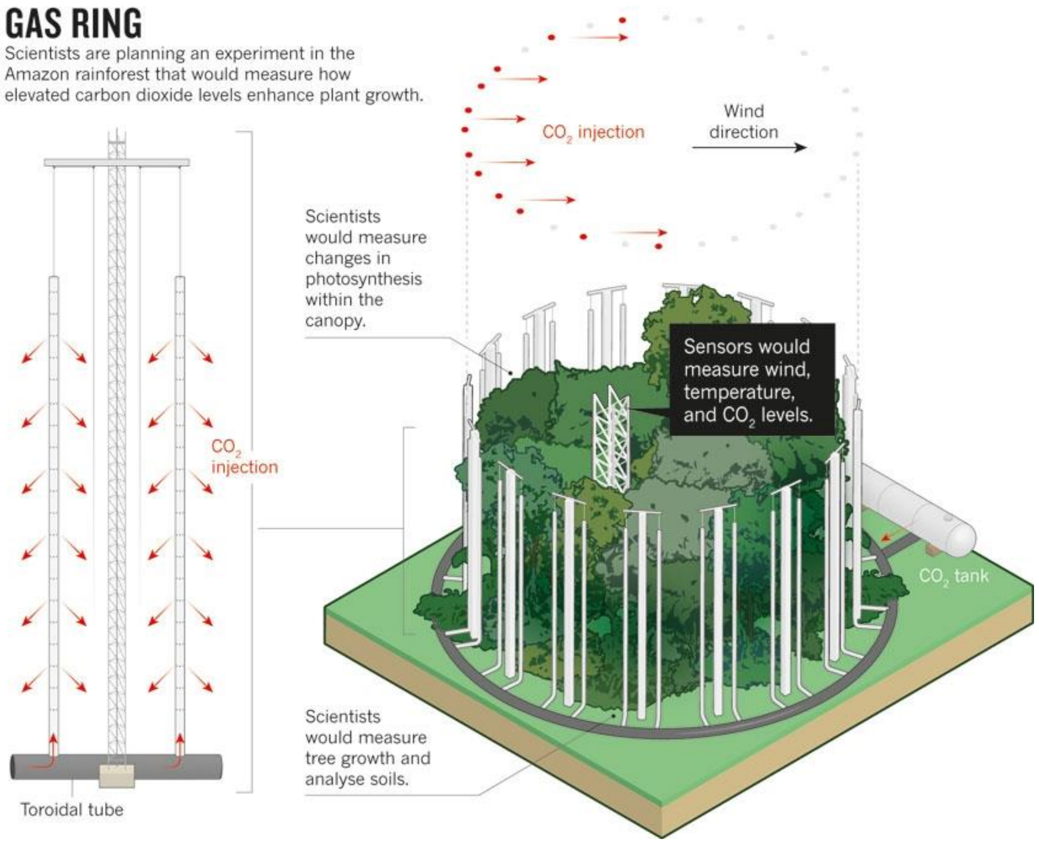
Sensor-studded plots in the Amazon forest will r

NATURE | VOL 496 | 25 APRIL 2013

PERSPECTIVE — nature climate change
PUBLISHED ONLINE: 21 MAY 2015 | DOI: 10.1038/NCLIMATE2621

Using ecosystem experiments to improve vegetation models

Belinda E. Medlyn[1,2*], Sönke Zaehle[3], Martin G. De Kauwe[1], Anthony P. Walker[4], Michael C. Dietze[5], Paul J. Hanson[4], Thomas Hickler[6], Atul K. Jain[7], Yiqi Luo[8], William Parton[9], I. Colin Prentice[1,10], Peter E. Thornton[4], Shusen Wang[11], Ying-Ping Wang[12], Ensheng Weng[13], Colleen M. Iversen[4], Heather R. McCarthy[8], Jeffrey M. Warren[4], Ram Oren[14,15] and Richard J. Norby[4]



Info: http://amazonface.inpa.org.br/
Dr David Lapola – UNICAMP Brazil

3. Challenges: detect temporal responses in highly diverse ecosystems

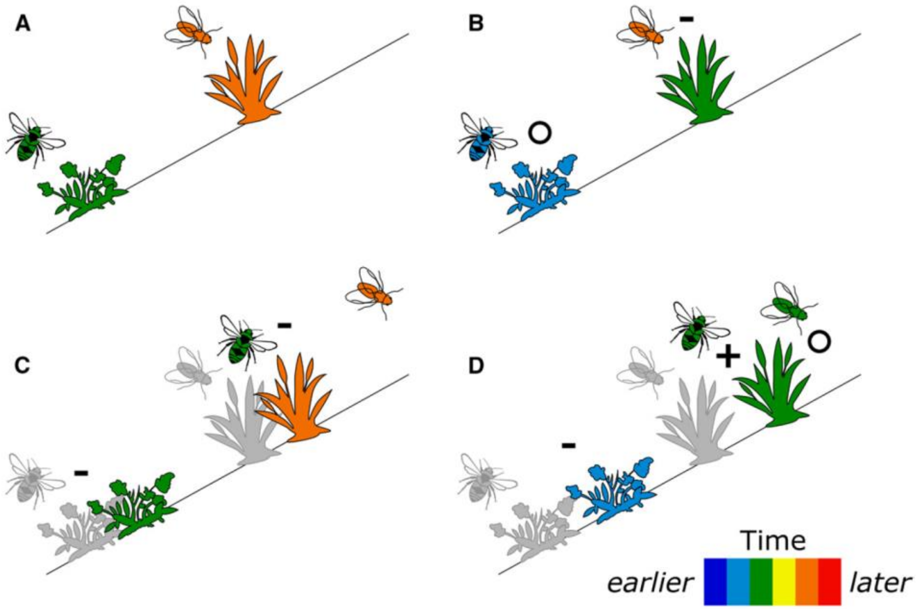
V. experiments - impose climate scenarios to tropical plants (e.g. CO2 enrichment – FACE, drought experiments, transplants);

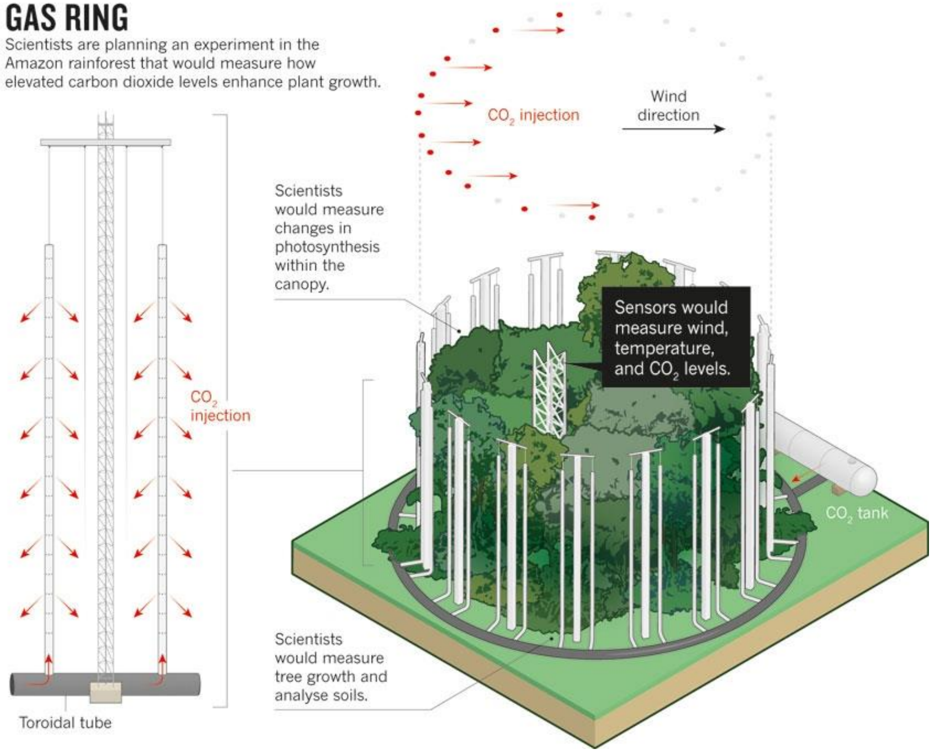
AMAZONFACE

Assessing the effects of increased atmospheric CO_2 on the ecology and resilience of the Amazon forest.

Plant–pollinator interactions under climate change: The use of spatial and temporal transplants[1]

Eva M. Morton[2,3,4] and Nicole E. Rafferty[2,3,5]





3. Challenges: detect temporal responses in highly diverse ecosystems

Phenology Lab

VI. new technologies which may maximize our understanding at large scales

→ Light Detection And Ranging (LiDAR), radar, etc.

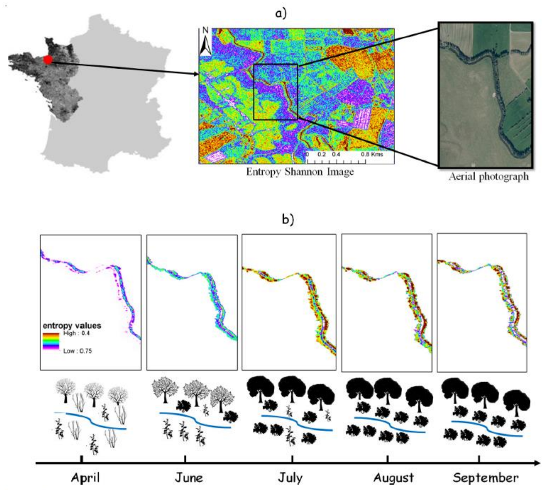


Figure 7
Riparian vegetation monitoring, with the Shannon Entropy parameter derived from TerraSAR-X images (Dual-polarization): a) Riparian vegetation extracted from the image registered in July and b) Evolution of the intra-annual riparian vegetation during the year 2012.

Trends in
Ecology & Evolution

CellPress

Review

Scale gaps in landscape phenology: challenges and opportunities

Daniel S. Park[1,5,*], Erica A. Newman[2,3,5] and Ian K. Breckheimer[4,5]

Dufour *et al.* (2013)

Time will tell: resource continuity bolsters ecosystem services

Nancy A Schellhorn[1], Vesna Gagic[1,2], and Riccardo Bommarco[2]

[1] CSIRO, GPO Box 2583, Brisbane, QLD, 4001, Australia
[2] Swedish University of Agricultural Sciences, Department of Ecology, Uppsala 75007, Sweden

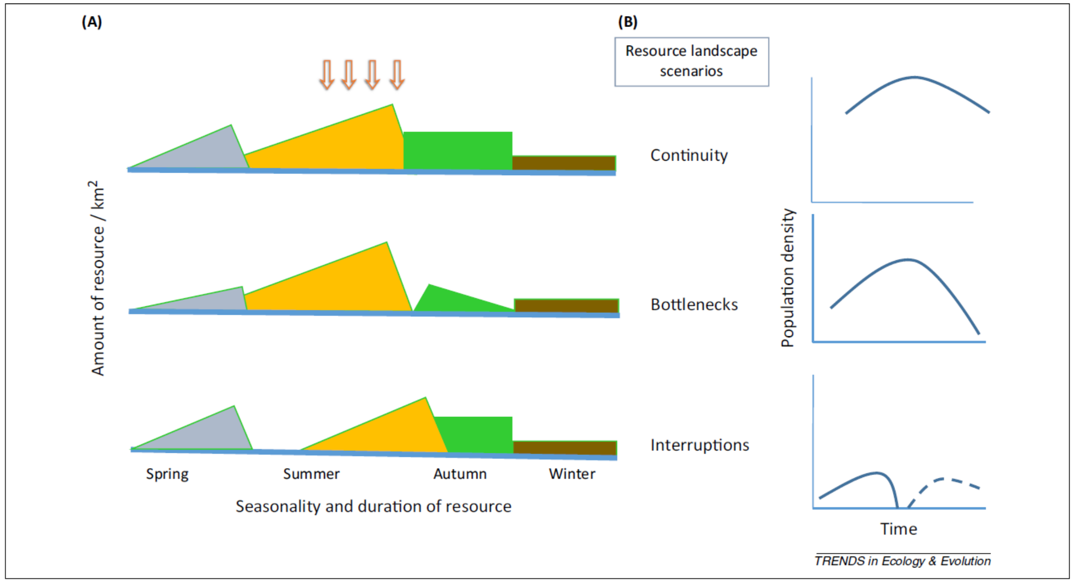


Figure 1. Scenarios of resource availability over time. Hypothetical schematic **(A)** depicting resource amount (per km^2; 'Y' axis), against time of year when available, and duration (X axis). Examples show resource continuity (top), discontinuity as bottlenecks (middle), and as interruptions (bottom), as related to the resource needs of a target organism. Panel **(B)** depicts implications for population dynamics for each respective resource situation. Colours represent types of resources. The top left continuity example shows resources to be available throughout the year, although in different amounts, and corresponding population densities (top right) are sustained at high and more constant levels. The bottleneck and interruption scenarios exemplify extreme limitation or absence of resources, respectively; peaks in population densities will be lower and changes in density will occur faster. The four arrows represent the sampling period of data collection of typical snapshot landscape ecology studies.

3. Challenges: detect temporal responses in highly diverse ecosystems

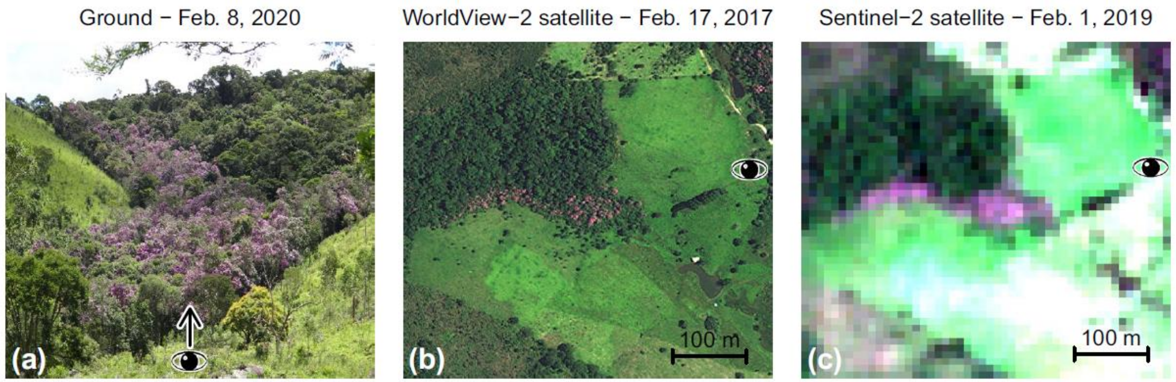
Phenology Lab

scientific reports

VI. new technologies which may maximize our understanding at large scales

Check for updates

OPEN **The flowering of Atlantic Forest *Pleroma* trees**



High resolution images are allowing to map individuals or groups of the same tree species, at special and temporal scales.

Wagner (2020) used **high-resolution images with 10 m** of spatial resolution to map the ***Pleroma*** trees **(Sentinel-2 satellites - Copernicus Sentinel-2)**. The **frequency** of revisit is of **five days** at the Equator and enables to **monitor Earth's surface changes.** The blooming of *Pleroma* forest patches are visible, their colours rendering them detectable and separable from the forest and other landcover (Fig. 1c)**,** showing **local landscape changes and plant phenology shifts**.

3. Challenges: detect temporal responses in highly diverse ecosystems

Phenology Lab

scientific reports

VI. new technologies which may maximize our understanding at large scales

Check for updates

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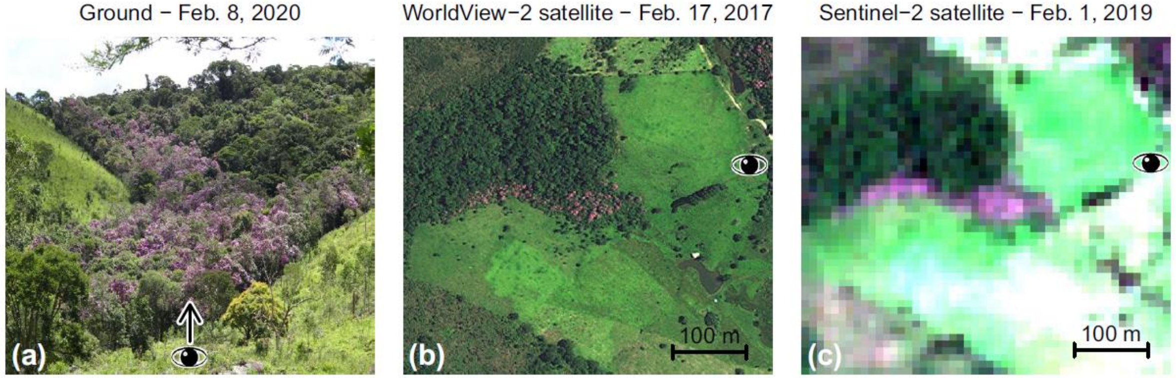


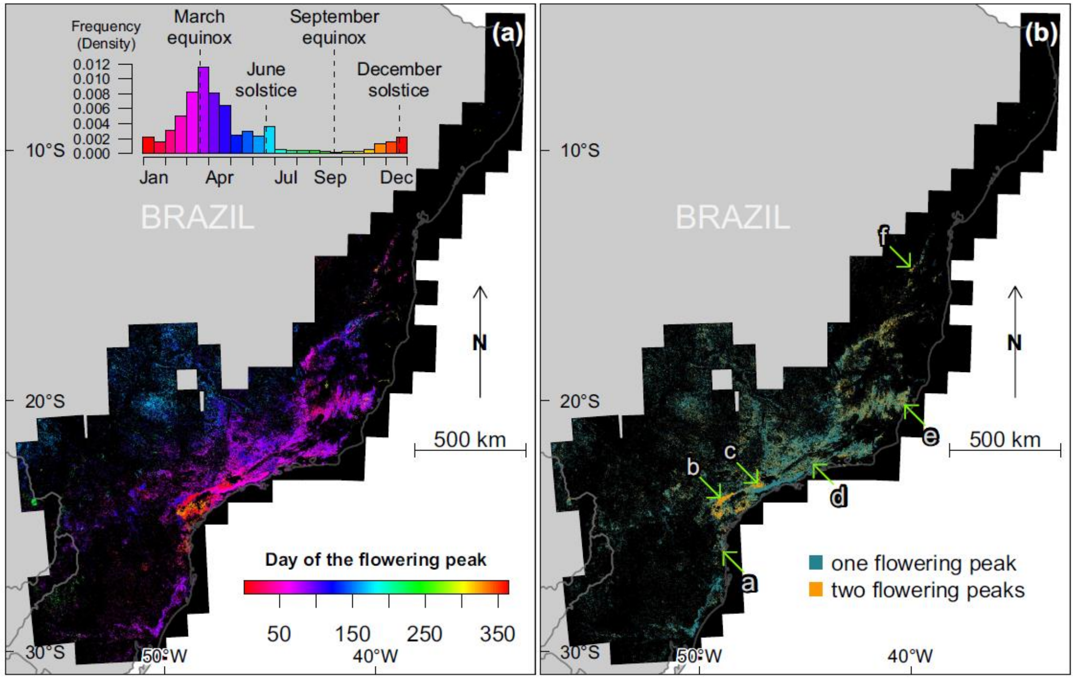


Figure 7. Day of the flowering peak (a) estimated from the mean monthly detection time series and Fourier transform signal decomposition (see Methods). For the pixel showing two flowering peaks in per year in (a), only the highest peak is represented. Number of flowering peaks per year (**b**). Subset images of locations indicated by arrows are given in Fig. 8. The flowering peaks on the map are mainly from trees of the genus *Pleroma* and in a lesser proportion from large trees of the genus *Handroanthus* that can be also detected.

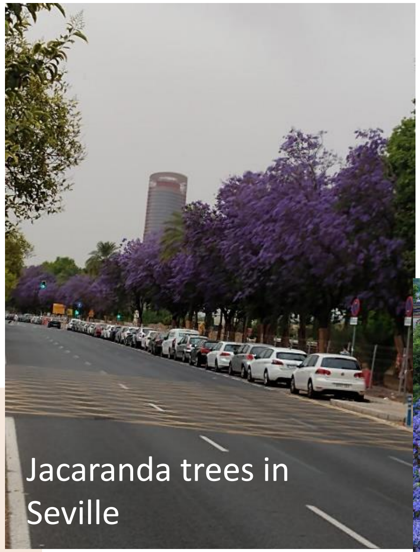
3. Challenges to detect temporal responses in highly diverse ecosystems

Phenology Lab

VII. networking- develop citizen science initiatives and monitoring networks to collect more comparative data over large special scales;

Citizen Science – Citizen Phenology

Phenological monitoring and citizen science


Jacaranda trees in Seville


...randa trees in Yunnan, China


Jacaranda trees in Buenos Aires


Jacaranda trees in Pretoria

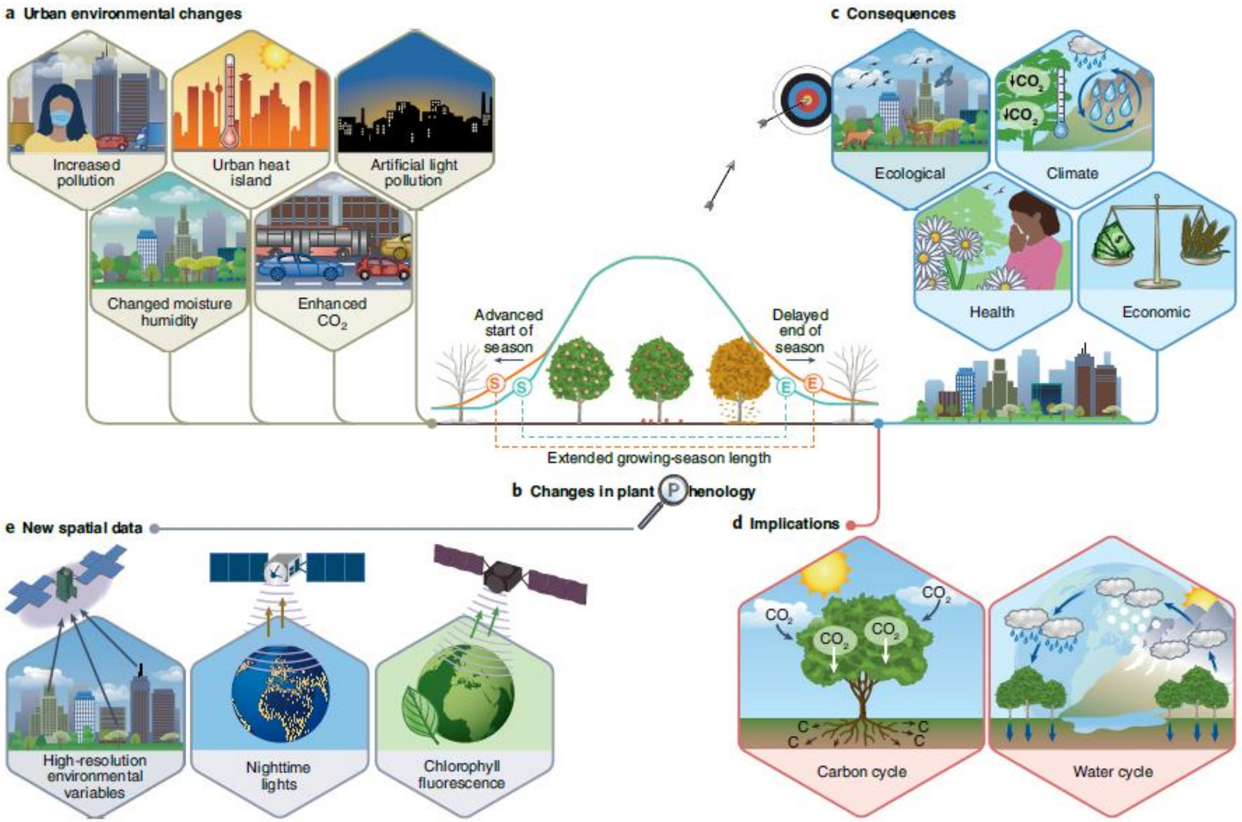

Jacaranda trees in Brazil

3. Challenges: detect temporal responses in highly diverse ecosystems

Phenology Lab

VII. networking- develop citizen science initiatives and monitoring networks to collect more comparative data over large special scales;

Understanding urban plant phenology for sustainable cities and planet



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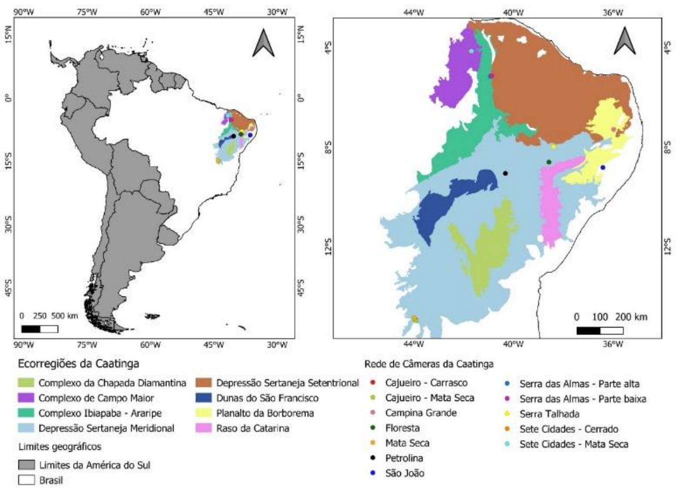
3. Challenges: detect temporal responses in highly diverse ecosystems

Phenology Lab

VII. networking- develop citizen science initiatives and monitoring networks to collect more comparative data over large special scales;

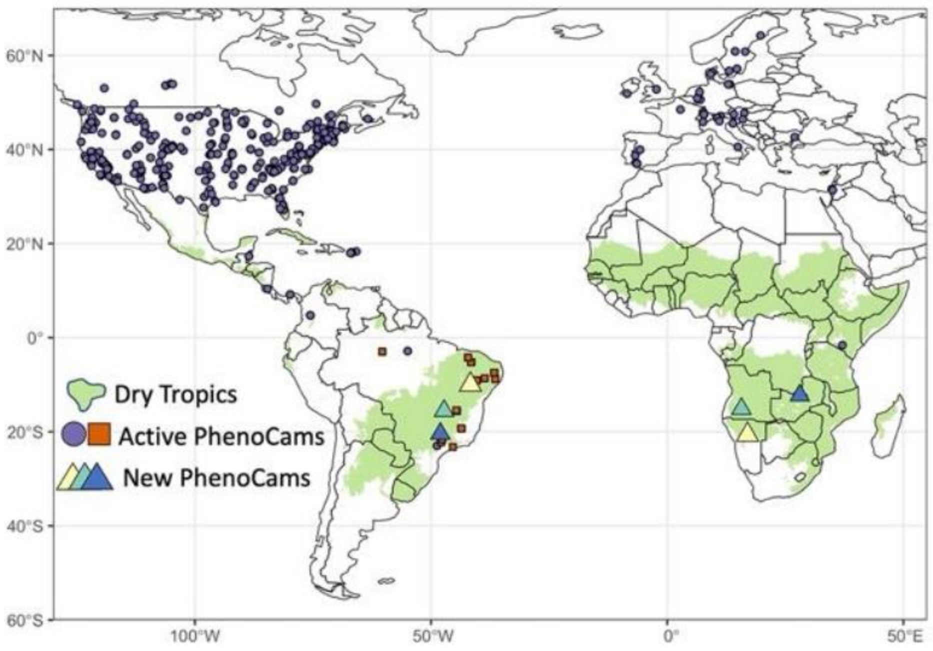
Caatinga SDTFW Ecoregions

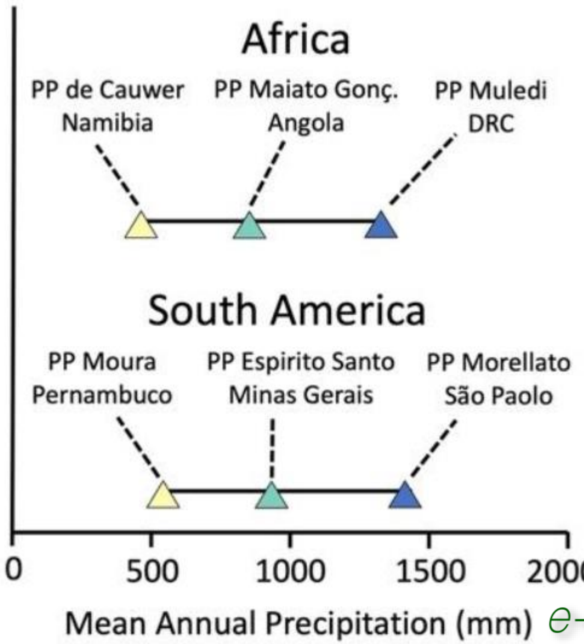


Phenological monitori
- Vegetation types
- Soil
- Climate

~48 tree species
~320 individuals

Seasonally dry vegetations e-phenology Phenocam Network





e-phenology

SECO: Resolving the current and future carbon dynamic of the dry tropics

FAPESP | UKRI Natural Environment Research Council | The University of Edinburgh | University of Exeter | University of Leeds | The University of Sheffield

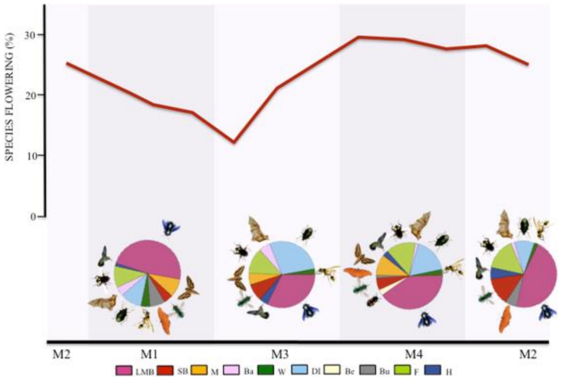
4. Remarks

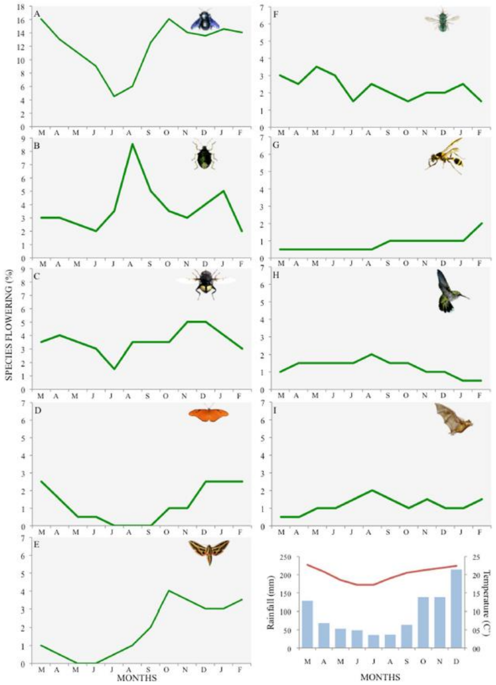
VIII. *Biodiversity Conservation and restoration*;

Biodiversity Conservation and restoration

The organization of flowering and fruiting phenology directly affects the structure and availability of plant resources over time and the maintenance of pollinators and seed dispersers

Genini et al. 2021 The Sience of Nature






Biological Conservation 195 (2016) 60–72

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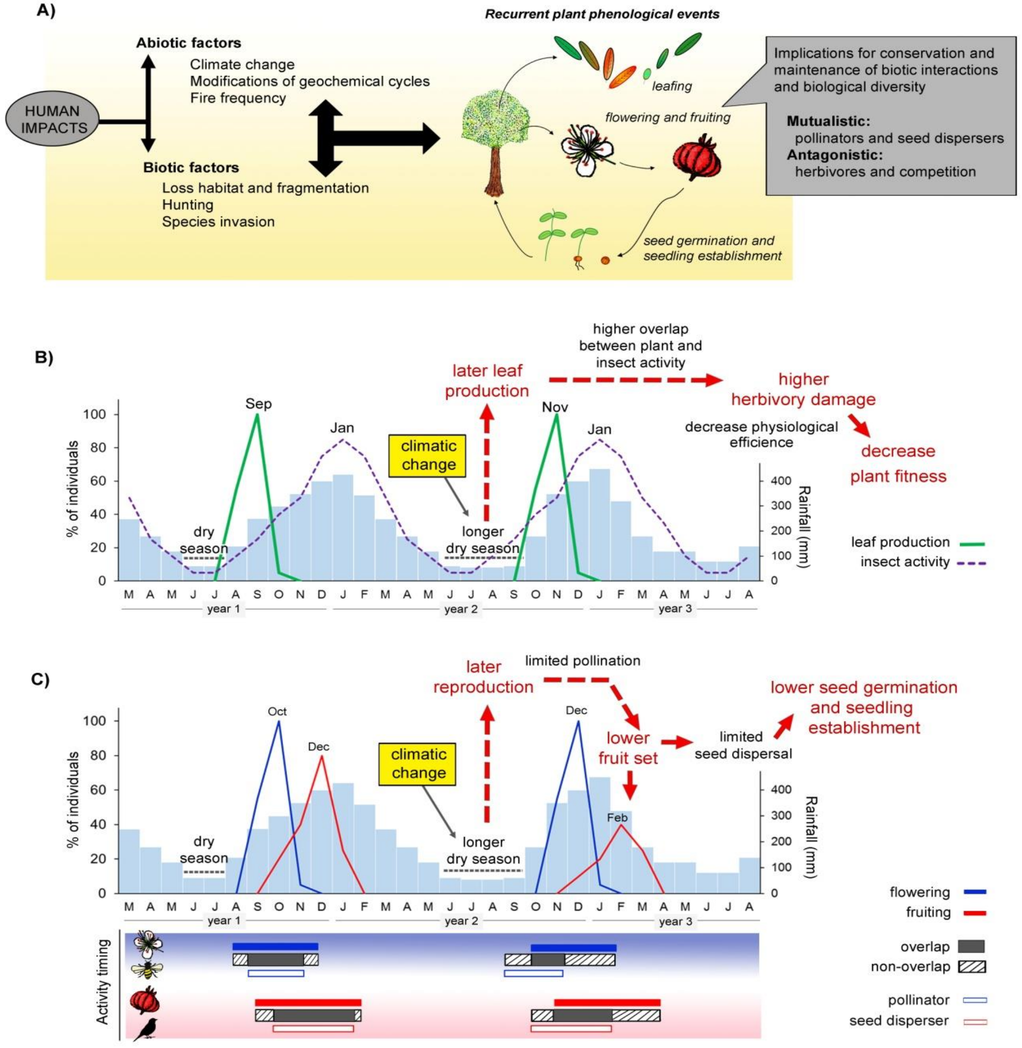
Perspective

Linking plant phenology to conservation biology

Leonor Patrícia Cerdeira Morellato [a,*], Bruna Alberton [a,b], Swanni T. Alvarado [c], Bruno Borges [a,b], Elise Buisson [d], Maria Gabriela G. Camargo [a], Leonardo F. Cancian [a], Daniel W. Carstensen [a], Diego F.E. Escobar [a,e], Patrícia T.P. Leite [a,e], Irene Mendoza [a], Nathália M.W.B. Rocha [a], Natalia C. Soares [a,e], Thiago Sanna Freire Silva [c], Vanessa G. Staggemeier [a], Annia Susin Streher [b,c], Betânia C. Vargas [a,e], Carlos A. Peres [f]



Morellato et al. 2016 Biol. Cons

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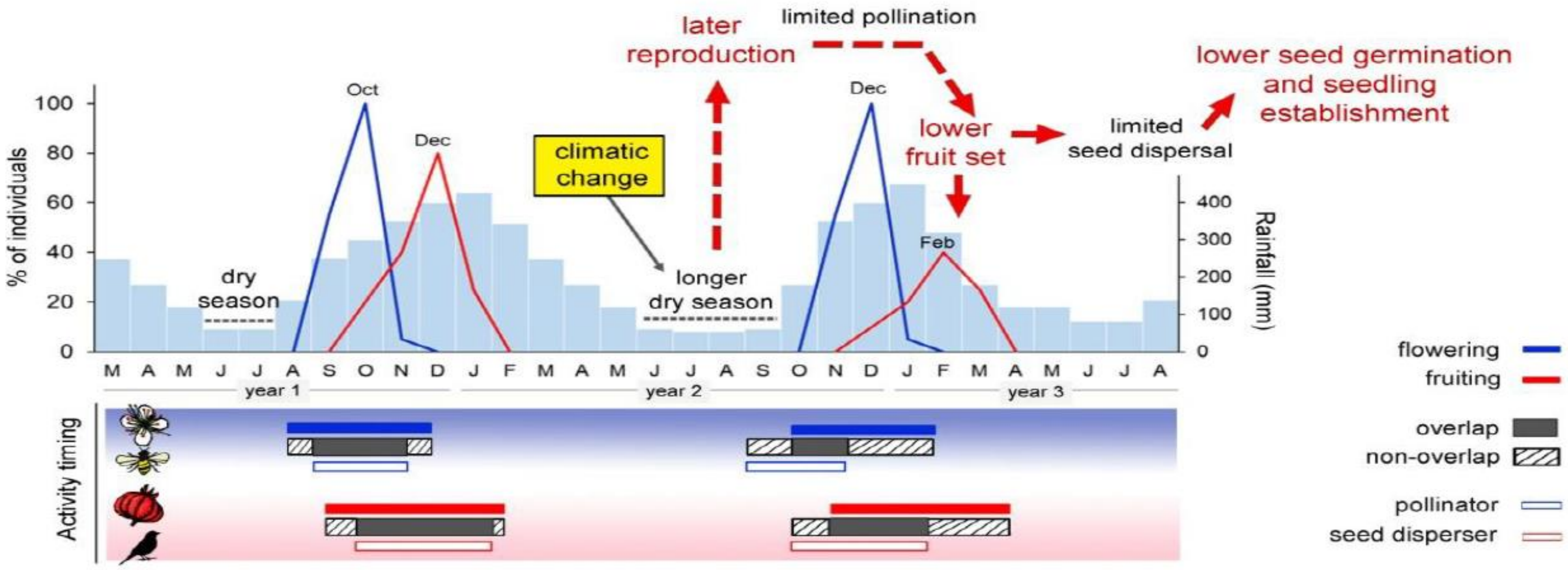
4. Remarks

Phenological shifts and mismatches

VIII. ***Biodiversity Conservation and restoration***;

Flowering and pollinators ***Fruiting and frugivory***

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Phenology

Climate change is shifting the rhythm of nature

Frontiers 2022

EMERGING ISSUES OF ENVIRONMENTAL CONCERN

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Phenology

Climate change is shifting the rhythm of nature

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4. Remarks

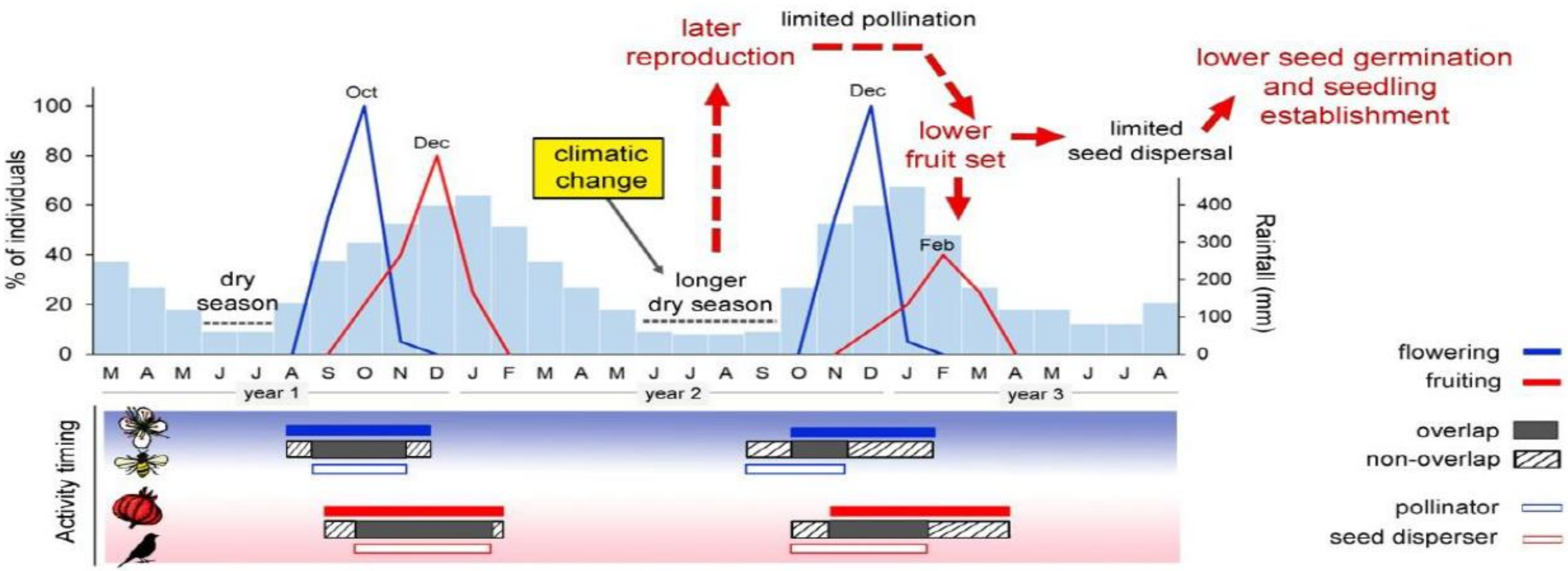
Phenological shifts and mismatches

Flowering and pollinators

Fruiting and frugivory

Phenology

Climate change is shifting the rhythm of nature



Ecology Letters, (2007) **10**: 710–717 doi: 10.1111/j.1461-0248.2007.01061.x

LETTER

Global warming and the disruption of plant–pollinator interactions

Ecology Letters, (2009) **12**: 184–195 doi: 10.1111/j.1461-0248.2008.01269.x

REVIEW AND SYNTHESES

How does climate warming affect plant-pollinator interactions?

Variable flowering phenology and pollinator use in a community suggest future phenological mismatch

Theodora Petanidou [a, *], Athanasios S. Kallimanis [b], Stefanos P. Sgardelis [c], Antonios D. Mazaris [c], John D. Pantis [c], Nickolas M. Waser [d]

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EMERGING ISSUES OF ENVIRONMENTAL CONCERN

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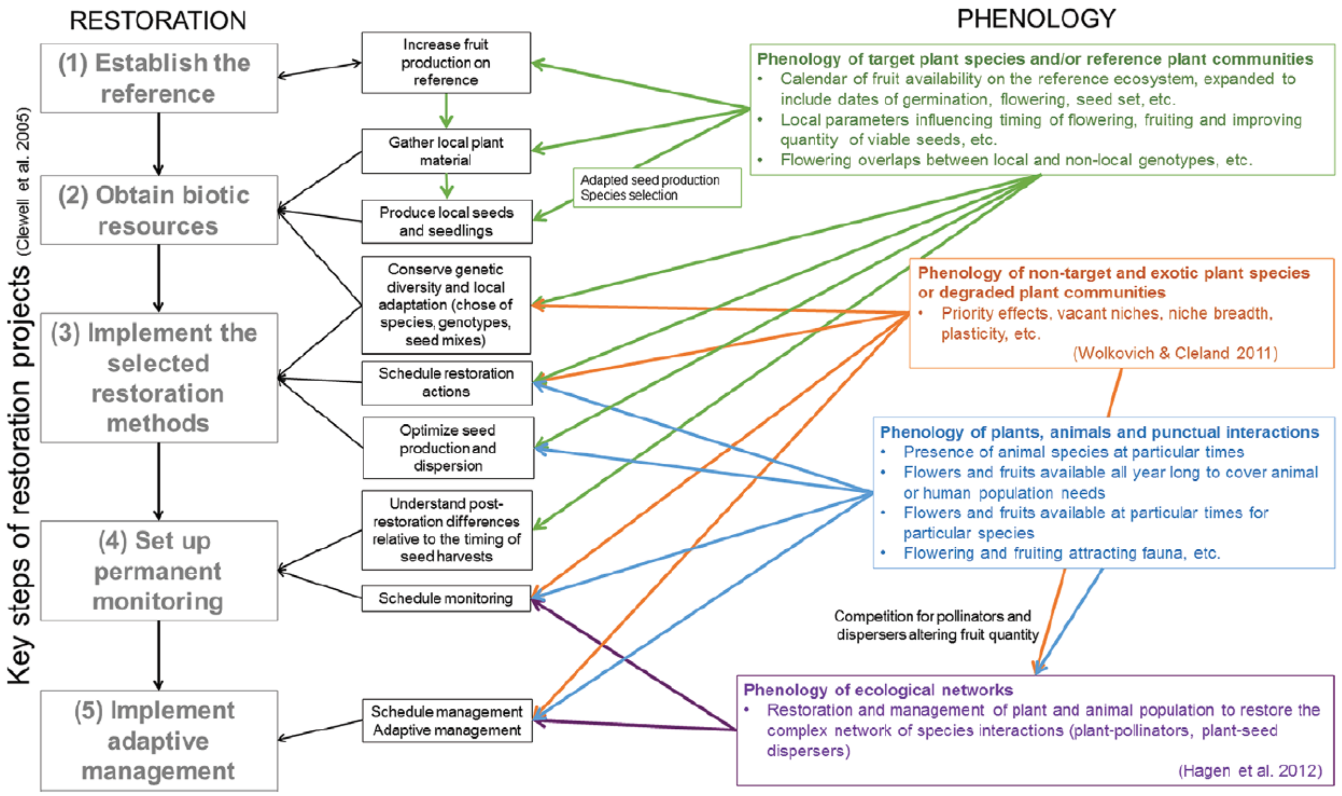
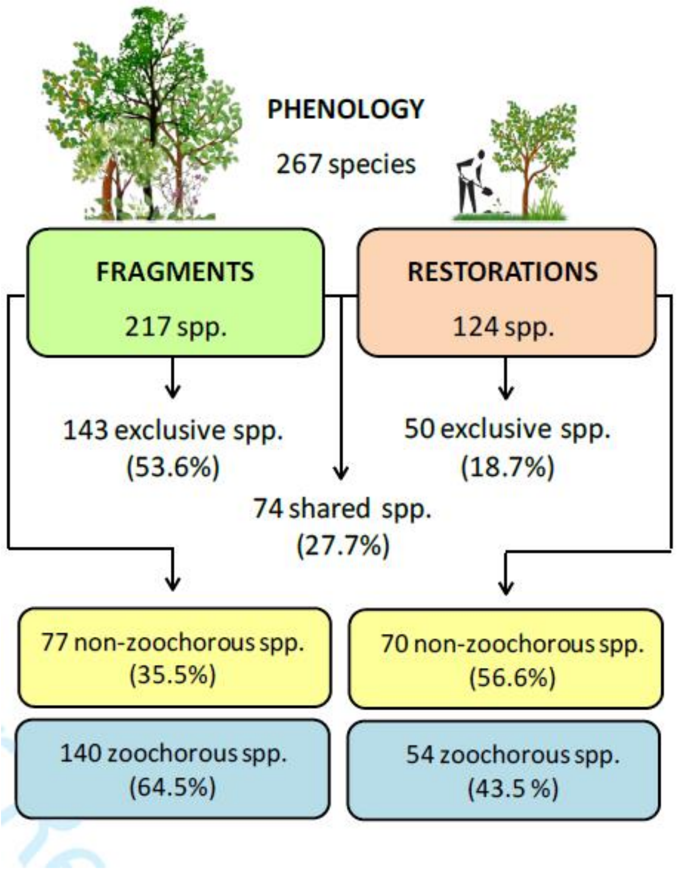


Figure 1. Conceptual framework showing where phenology can contribute to restoration. Numbers 1–5 are five major key steps of restoration projects (Clewell et al. 2005). Phenological information that may be collected for restoration projects are found in boxes on the right-hand side of the figure. Arrows show how specific phenological information can contribute to specific restoration steps.




Restoration Ecology
OPINION ARTICLE
Plant phenological research enhances ecological restoration
Elise Buisson[1,2], Swanni T. Alvarado[3,4], Soizig Le Stradic[4,5], Leonor Patricia C. Morellato[5]


RESTORATION ECOLOGY
UN DECADE ON ECOSYSTEM RESTORATION
RESEARCH ARTICLE
Comparing the potential reproductive phenology between restored areas and native tropical forest fragments in Southeastern Brazil
Débora C. Rother[1,2,3], Igor L. F. de Sousa[4], Eliana Gressler[4], Ana P. Liboni[2,5], Vinícius C. Souza[2], Ricardo R. Rodrigues[2], L. Patrícia C. Morellato[4]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