



A new research framework for evaluating natural medicinal resources and their exposure to global change

Spyros Theodoridis



SENCKENBERG
world of biodiversity

GOETHE
UNIVERSITÄT
FRANKFURT AM MAIN

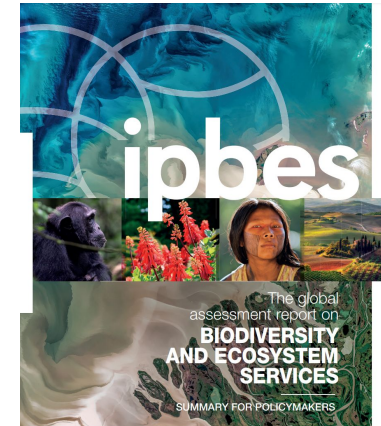


**UNIVERSITY OF
COPENHAGEN**



Importance of medicinal biodiversity

MATERIALS AND ASSISTANCE	Nature's contribution to people	50-year global trend		Directional trend across regions	Selected indicator
	 11 Energy				- Extent of agricultural land—potential land for bioenergy production - Extent of forested land
	 12 Food and feed				- Extent of agricultural land—potential land for food and feed production - Abundance of marine fish stocks
	 13 Materials and assistance				- Extent of agricultural land—potential land for material production - Extent of forested land
	 14 Medicinal, biochemical and genetic resources				- Fraction of species locally known and used medicinally - Phylogenetic diversity



- Medicinal plants and their bioactive molecules deliver vital ecosystem services by supporting the health of human societies through millennia (<https://doi.org/10.1002/evan.21763>)
- In the last four decades, and despite the disproportionally large investments in synthetic drug discovery, about half of the globally approved pharmaceutical drugs still have natural origin or are structurally inspired by natural products (<https://doi.org/10.1021/acs.jnatprod.9b01285>)v

Importance of medicinal biodiversity through time

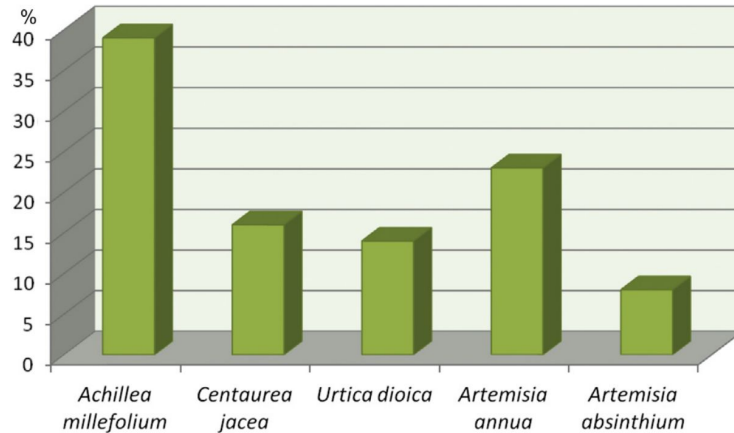


Fig. 8. Total relative abundances of pollen from the investigated medicinal plants summed up for all investigated caves.

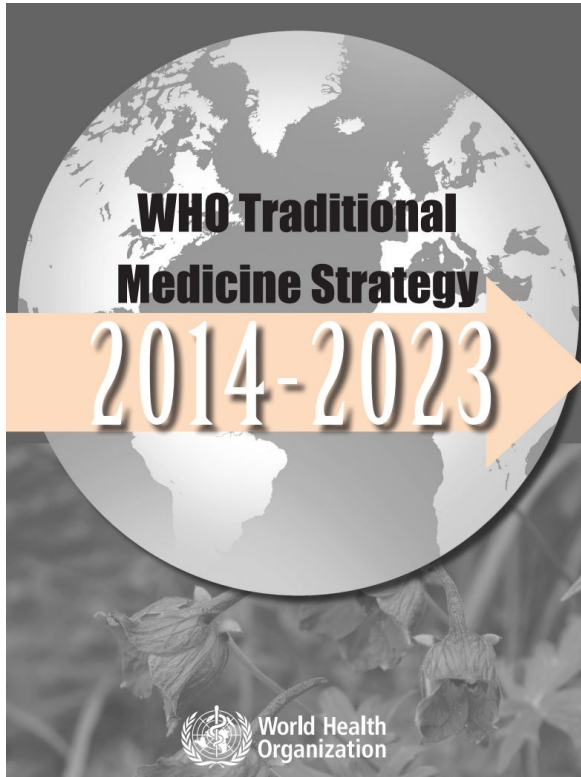
"ancient population living in the studied caves could have been prone to malaria, rheumatism and gastrointestinal diseases."

Nobel Prize in Physiology or Medicine 2015



ARTEMISININ
Novel therapy against malaria.

Importance of medicinal biodiversity



HISTORY & CULTURE | CORONAVIRUS COVERAGE

Cubans turn to natural remedies in midst of prescription drugs shortage

With prescription drugs in short supply in Cuba herbal remedies and other alternative treatments have become increasingly important.



FEATURES | SOCIETY | SOUTHEAST ASIA

To Fight COVID-19, Asia Increasingly Turns to Traditional Medicine

With vaccine access still uneven, many in Thailand, Vietnam, and beyond are looking for herbal treatments.



China relies on traditional medicine to fight COVID surge in Shanghai



Threats to medicinal biodiversity

- Global demand for medicinal plants and fungi has threatened certain species, contributing to biodiversity loss and depletion of natural resources.
 - Overcollection
- Some medicinal plants may respond to increased environmental stresses not only with declines in biomass production but with changes in chemical content, potentially affecting quality or even safety of medicinal products.
 - Rising temperatures
 - Droughts

Received: 24 April 2020 | Revised: 27 May 2020 | Accepted: 28 May 2020

DOI: 10.1002/ppp3.10138

REVIEW

Plants People Planet PPF
Open Access

Molecules from nature: Reconciling biodiversity conservation and global healthcare imperatives for sustainable use of medicinal plants and fungi

Reviews

Thieme

Scientists' Warning on Climate Change and Medicinal Plants

OPEN
ACCESS

Planta Medica

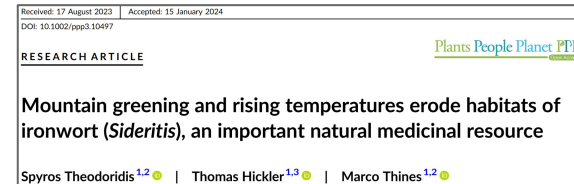
Journal of Medicinal Plant and Natural Product Research

Threats to medicinal biodiversity

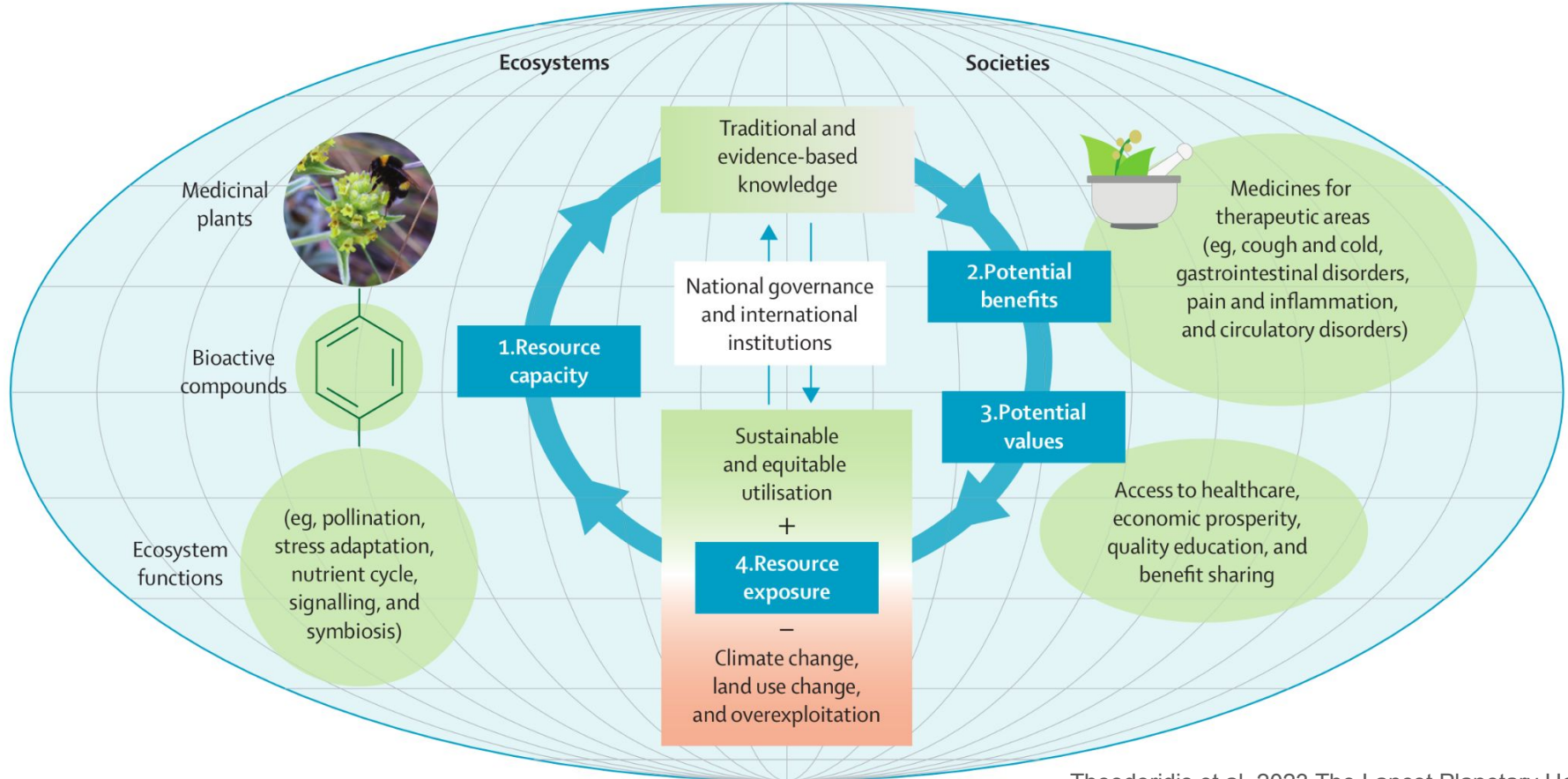
- Frankincense, the resin obtained from *Boswellia* trees, is used to treat arthritis, asthma, abdominal pain, cancer etc.
- Population collapse of *Boswellia papyrifera* caused by cattle grazing, frequent burns and reckless tapping



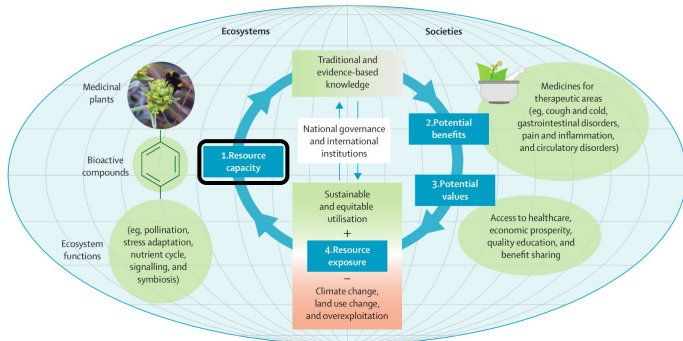
- Ironwort (*Sideritis*) is used to treat cough, cold, and gastrointestinal disorders
- Global warming and woody vegetation expansion erode its mountain habitats



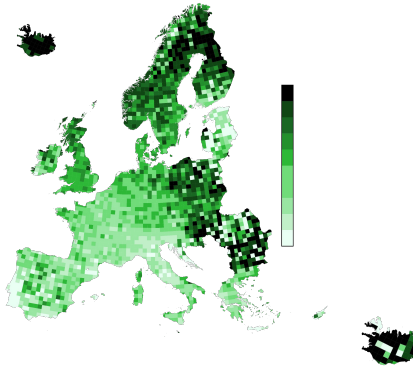
A framework to evaluate natural medicinal resources



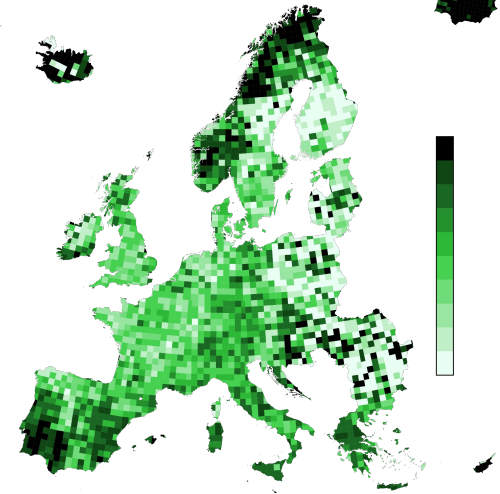
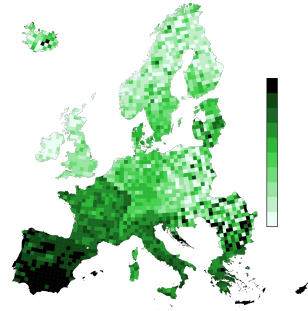
Indicator 1: The capacity of medicinal plant resources



Flavonoid richness

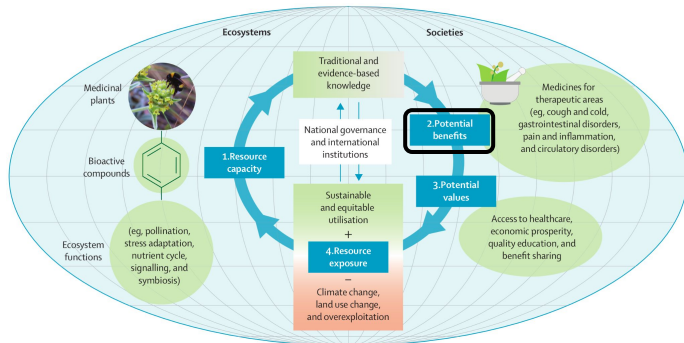


Plant volatile richness

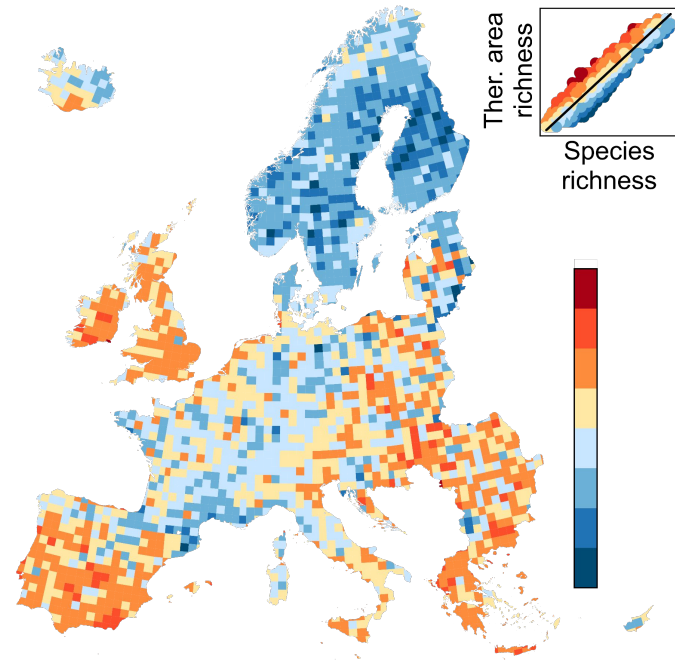


Bioactive compound diversity

Indicator 2: Potential societal benefits of medicinal plant resources



Therapeutic area relative richness
(e.g. cough and cold)



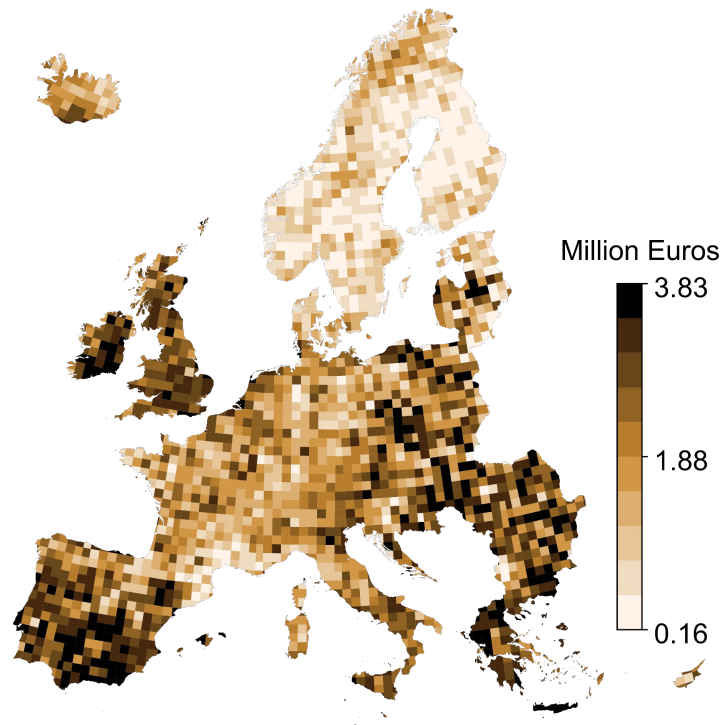
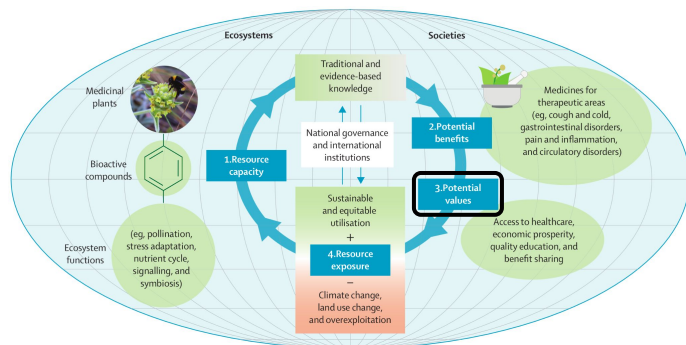
Indicator 3: Potential economic values of medicinal plant resources

Association of the European Self-Care Industry

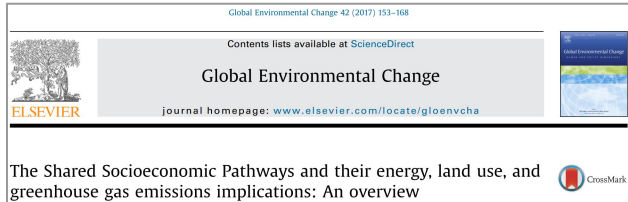


- The indicator approximates the cost that could be avoided by the consumer

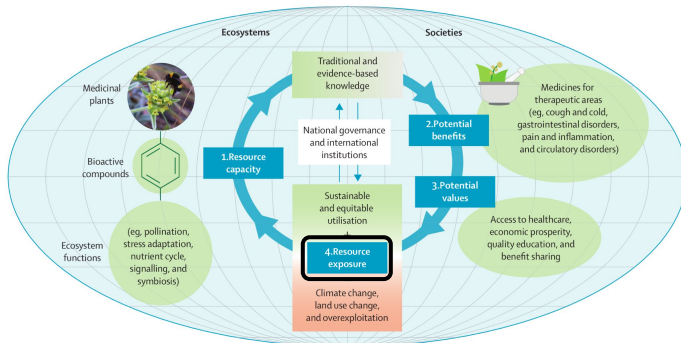
Potential avoided cost through resource use
(e.g. cough and cold)



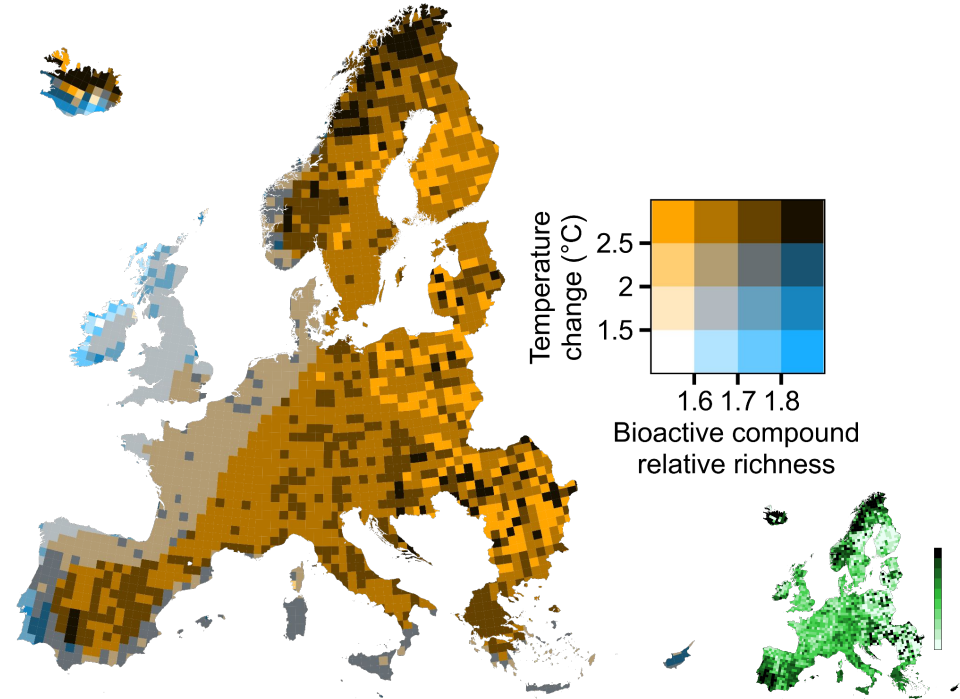
Indicator 4: The exposure of medicinal plant resources to global change



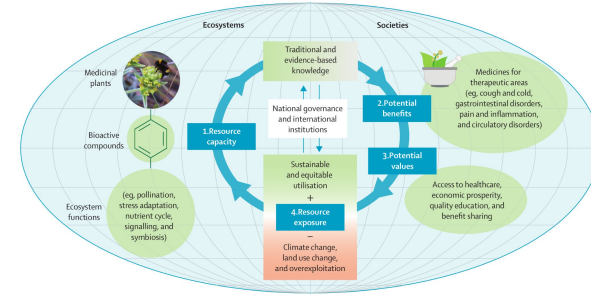
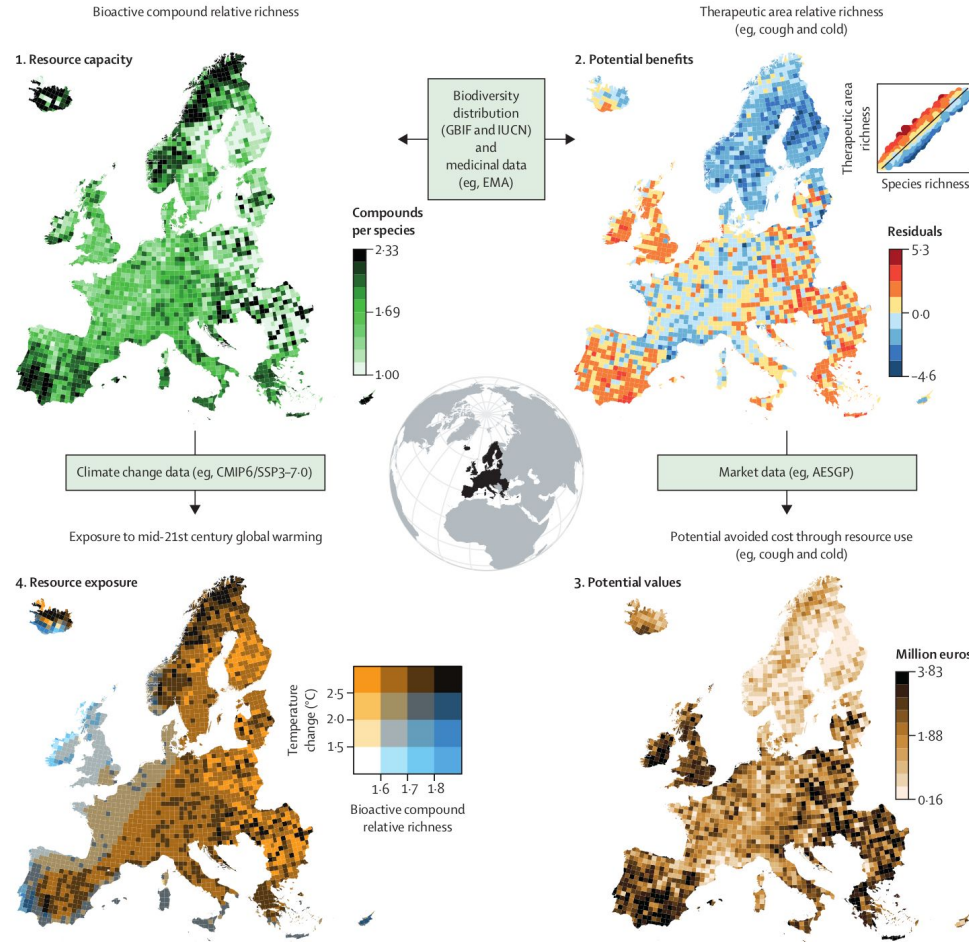
- The indicator shows reservoirs of bioactive compounds (ie, high resource capacity) that are exposed to high warming



Exposure to mid-21st century global warming



Indicators for evaluating natural medicinal resources



THE LANCET
Planetary Health

Personal View

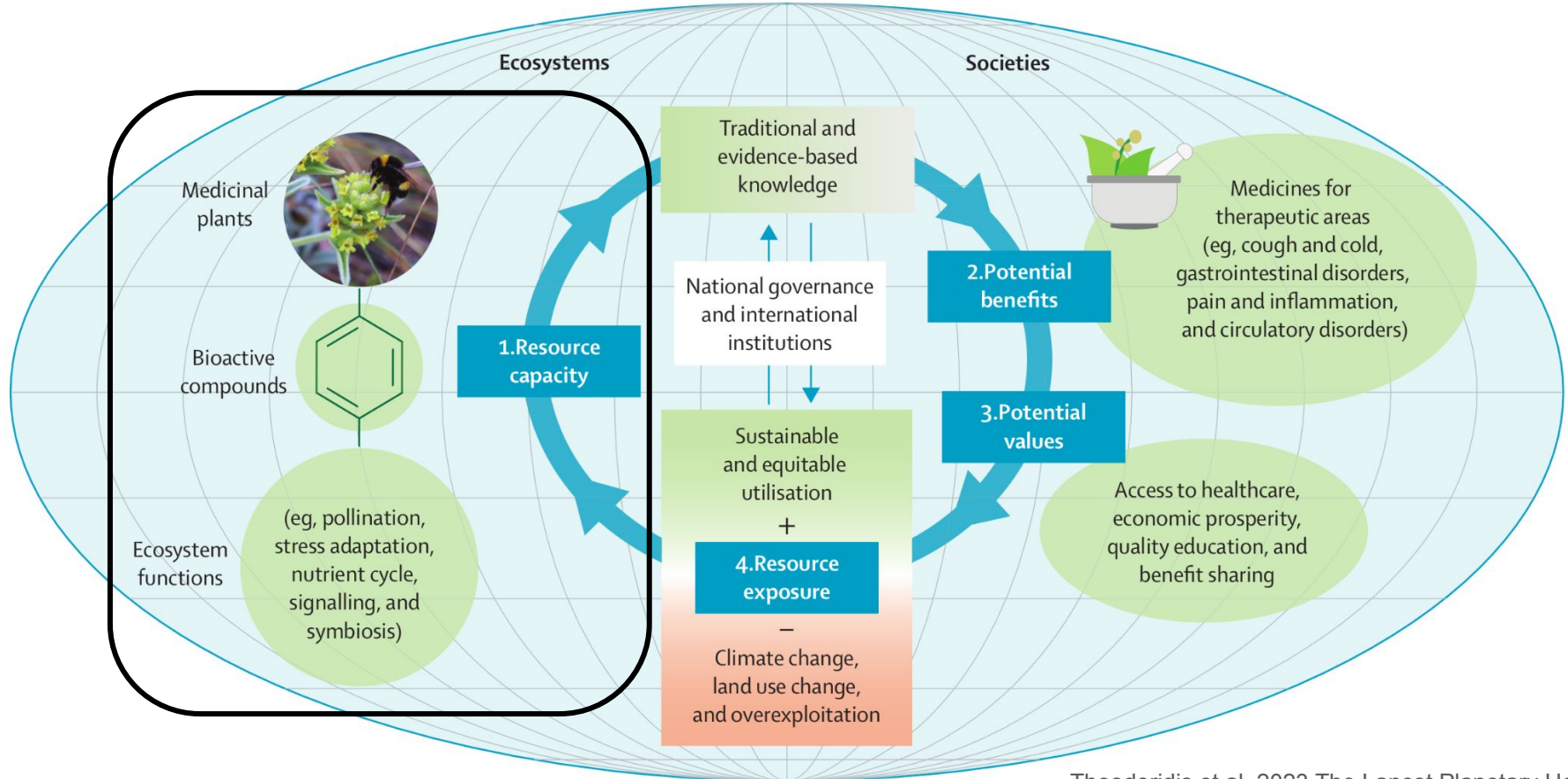
Evaluating natural medicinal resources and their exposure to global change

Spyros Theodoridis, Evangelia G Drakou, Thomas Hickler, Marco Thüne, David Nogueira-Bravo



oa

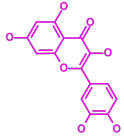
Resource capacity (Indicator 1): Addressing the knowledge gaps



Resource capacity (Indicator 1): Prior knowledge

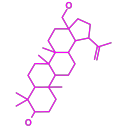
What are the ecological/ecosystem functions of plant bioactive compounds?

- Bioactive compounds are linked to abiotic stressors like light-induced oxidative damage, extreme climatic conditions, and soil properties



➤ Flavonoids, such as quercetin, luteolin, and apigenin, are suggested act as photoprotective agents, and influence the plant tolerance to climate stress

- The more diverse plant habitats are in terms of competitors and herbivory pressure, the more diverse and abundant the bioactive compounds will be

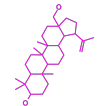


➤ Di- and triterpenoids, such as betulin, lupeol, and betulinic acid, are suggested to act as allelopathic agents inhibiting the growth of antagonistic plants and as defense metabolites demonstrating toxicity to herbivore but not to beneficial insects

- Bioactive compound production is shaped by plant-microbe interactions, with certain microbe communities co-occurring with higher diversity and abundance of bioactive compounds

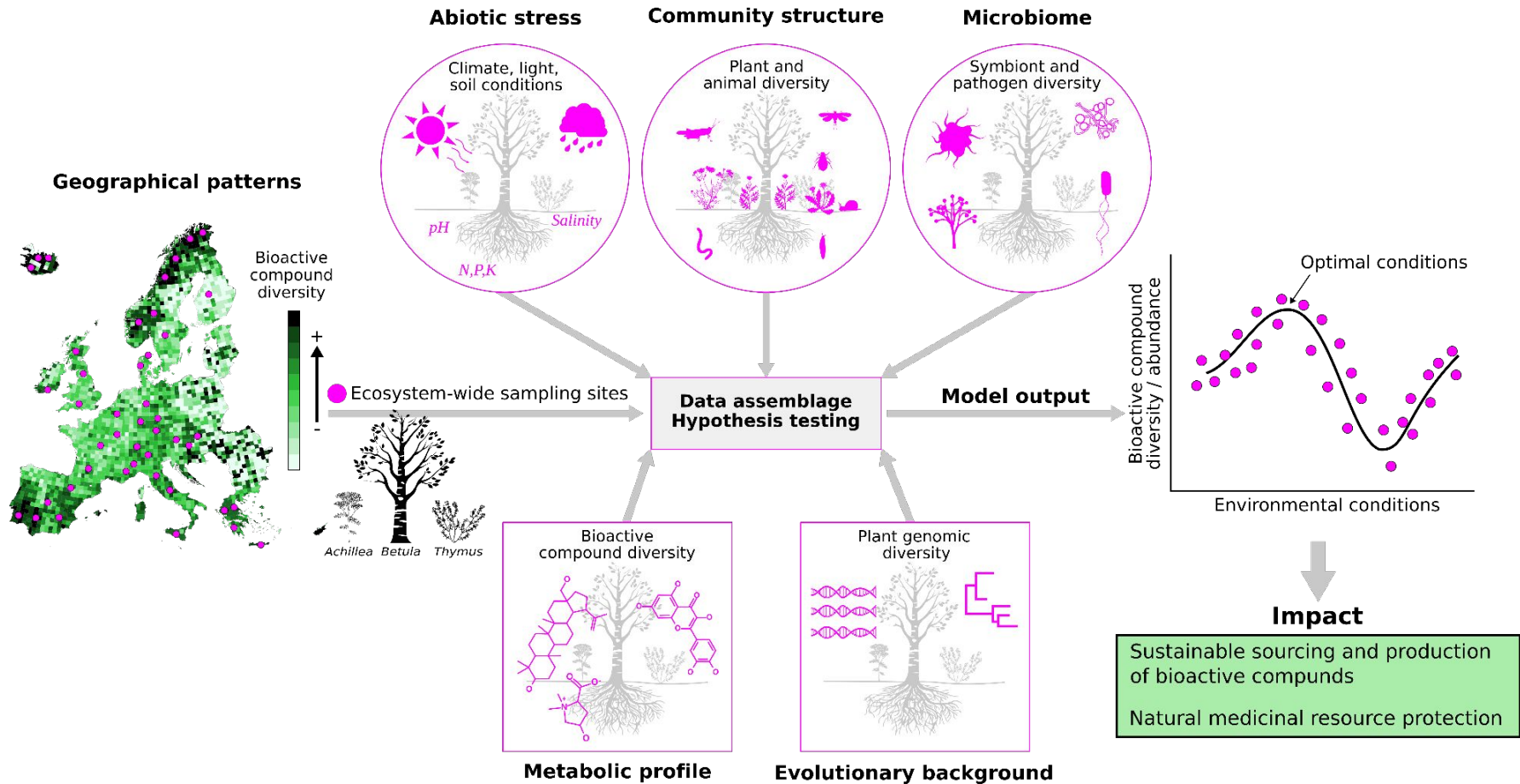


➤ Flavonoids are suggested to attract beneficial symbionts into the plant rhizosphere, e.g. Arbuscular Mycorrhizal Fungi, promoting nutrient uptake and plant growth.

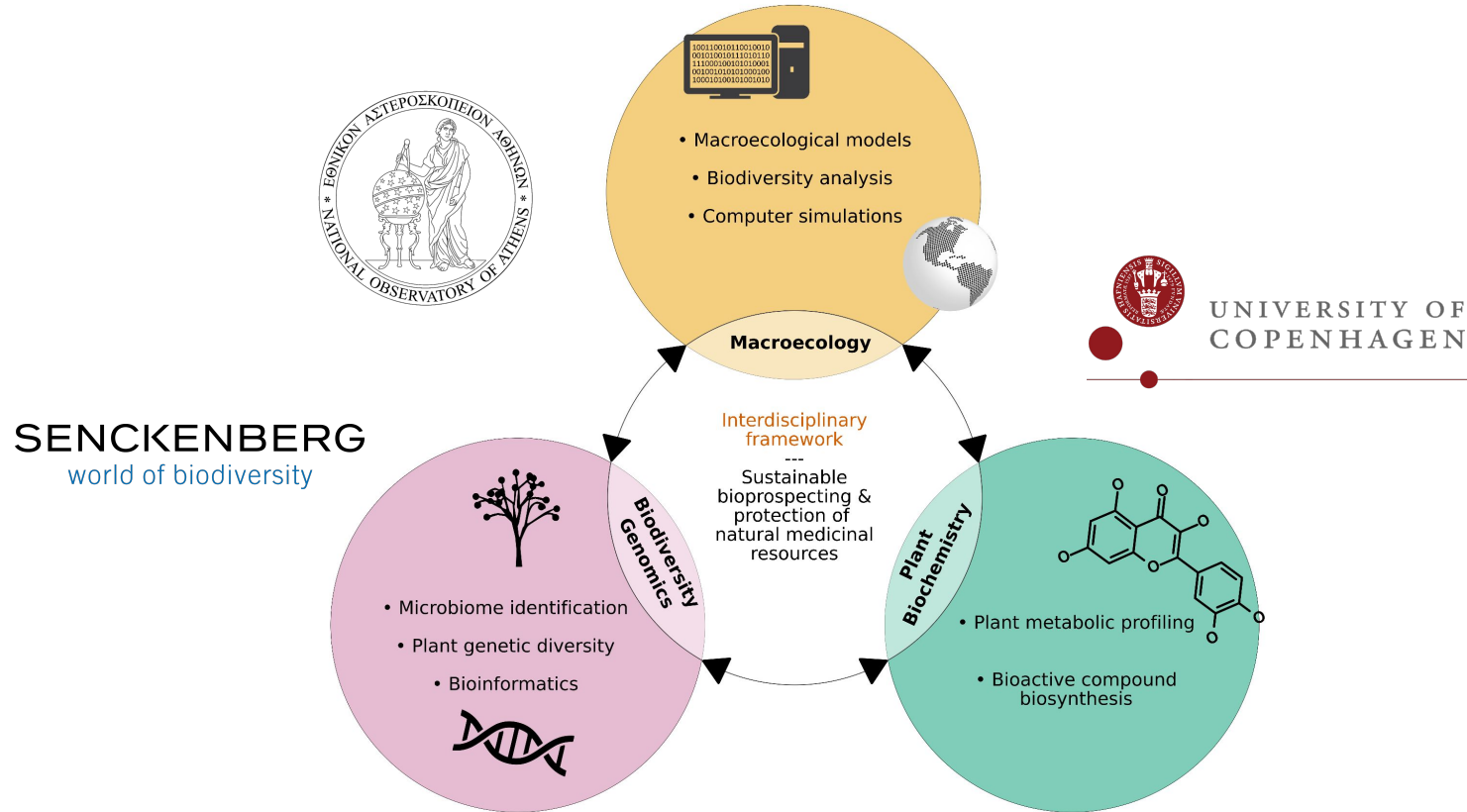


➤ Di- and triterpenoids are hypothesized to act as effective phytoalexins that provide defense against pathogens via direct antimicrobial activity, particularly below ground.

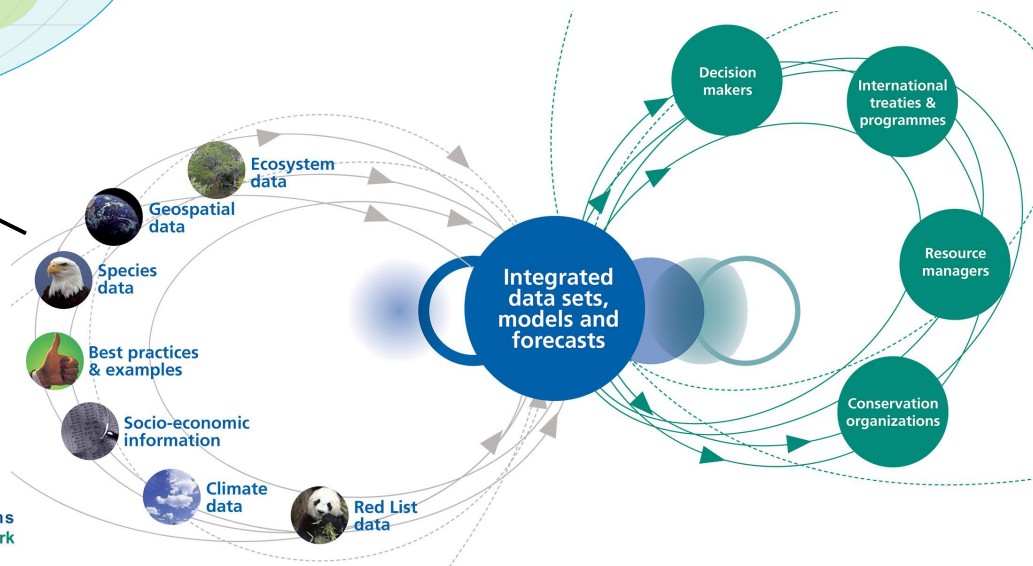
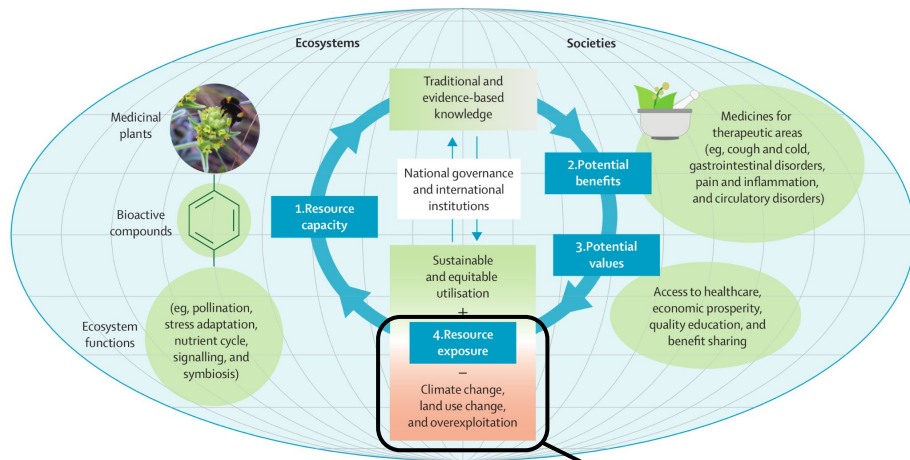
Resource capacity (Indicator 1): Addressing the knowledge gaps



Resource capacity (Indicator 1): Addressing the knowledge gaps



Resource exposure (Indicator 4): Addressing the knowledge gaps



Resource exposure (Indicator 4): Addressing the knowledge gaps

Sideritis raeseri



Sideritis scardica



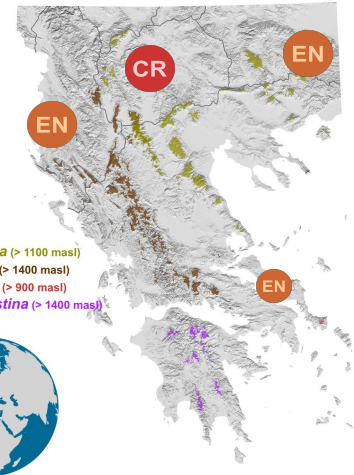
Sideritis euboea



Sideritis clandestina

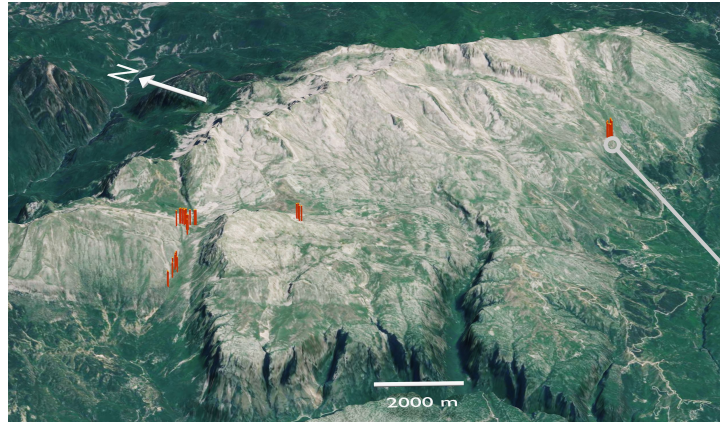


- "sideritis" (Gr: σίδηρος, En: iron)
- Known to ancient Greeks (reported from Dioscorides and Theophrastus)
- **Approved therapeutic areas:** Cough and cold, gastrointestinal disorders
- Reported properties:
 - Antioxidant, Antimicrobial, Antiviral , Anti-inflammatory, Spasmolytic, ADHD – Attention-Deficit, Alzheimer's disease...

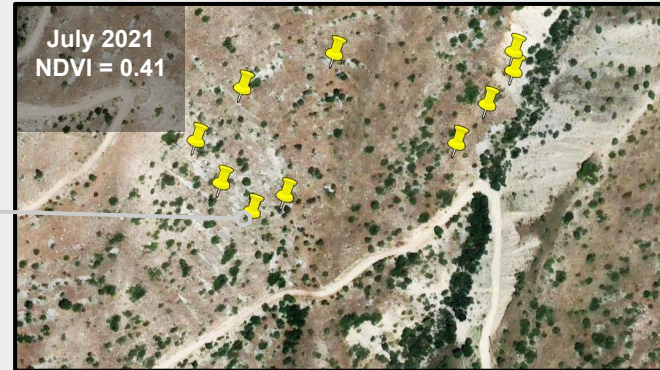


Resource exposure (Indicator 4): Addressing the knowledge gaps

Land abandonment and global warming drive "mountain greening"



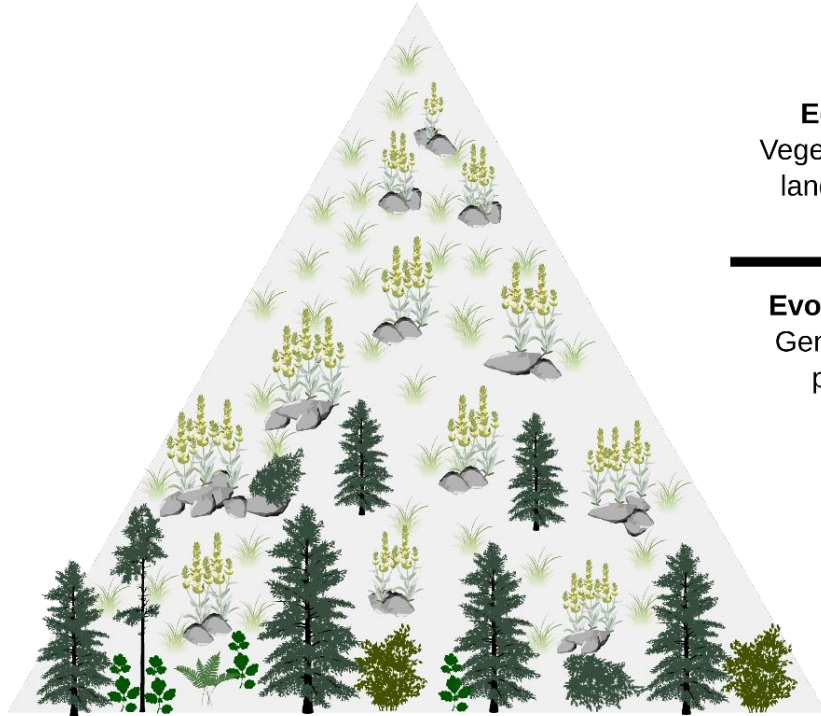
Google earth historical archive



Resource exposure (Indicator 4): Addressing the knowledge gaps

"Mountain greening" drives genomic erosion

Past



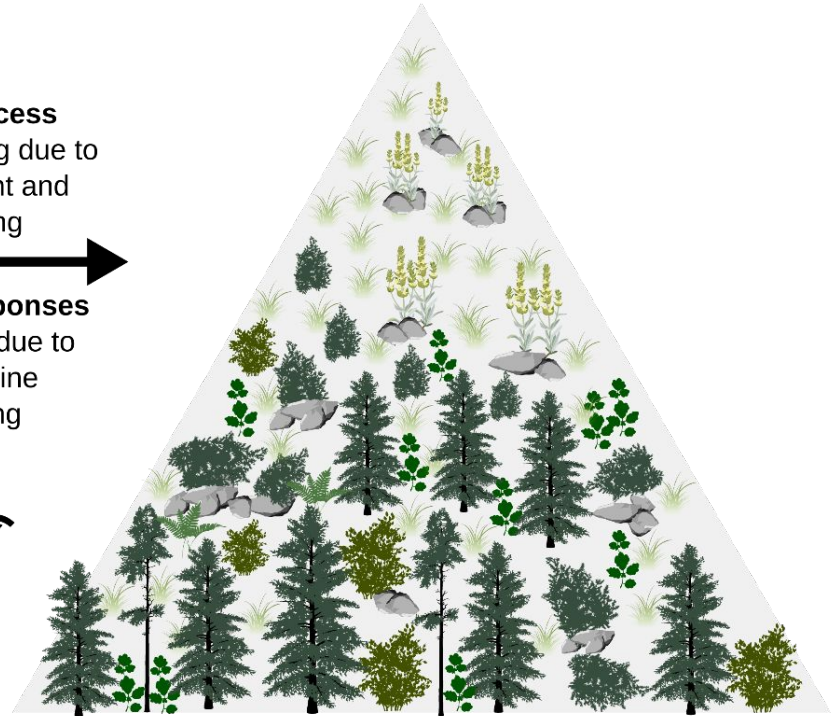
Ecological process
Vegetation greening due to
land abandonment and
global warming



Evolutionary responses
Genomic erosion due to
population decline
and inbreeding

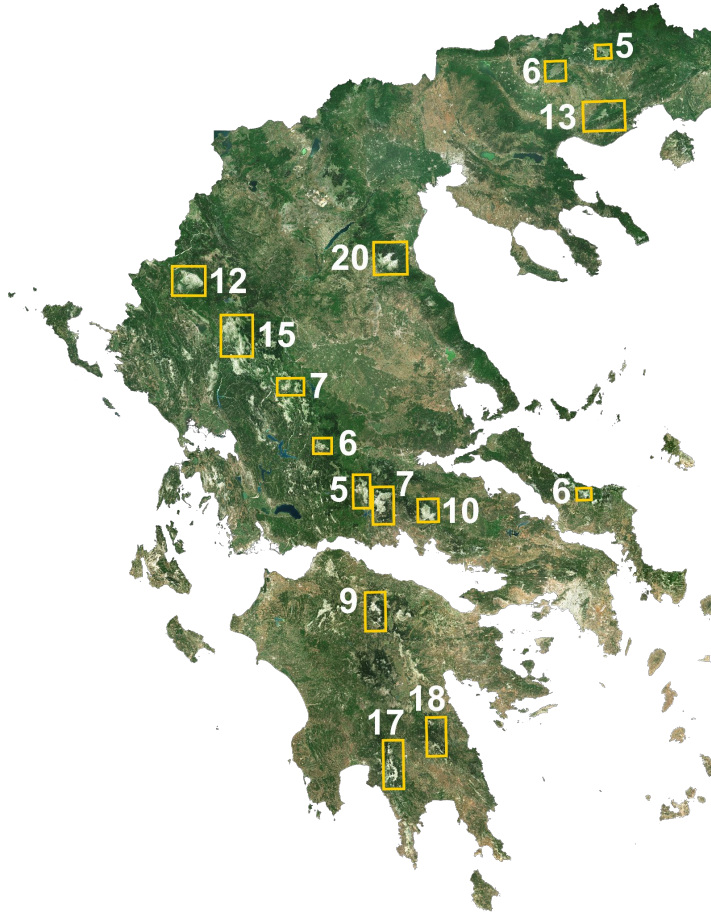


Present



Resource exposure (Indicator 4): Addressing the knowledge gaps

The importance of biological collections

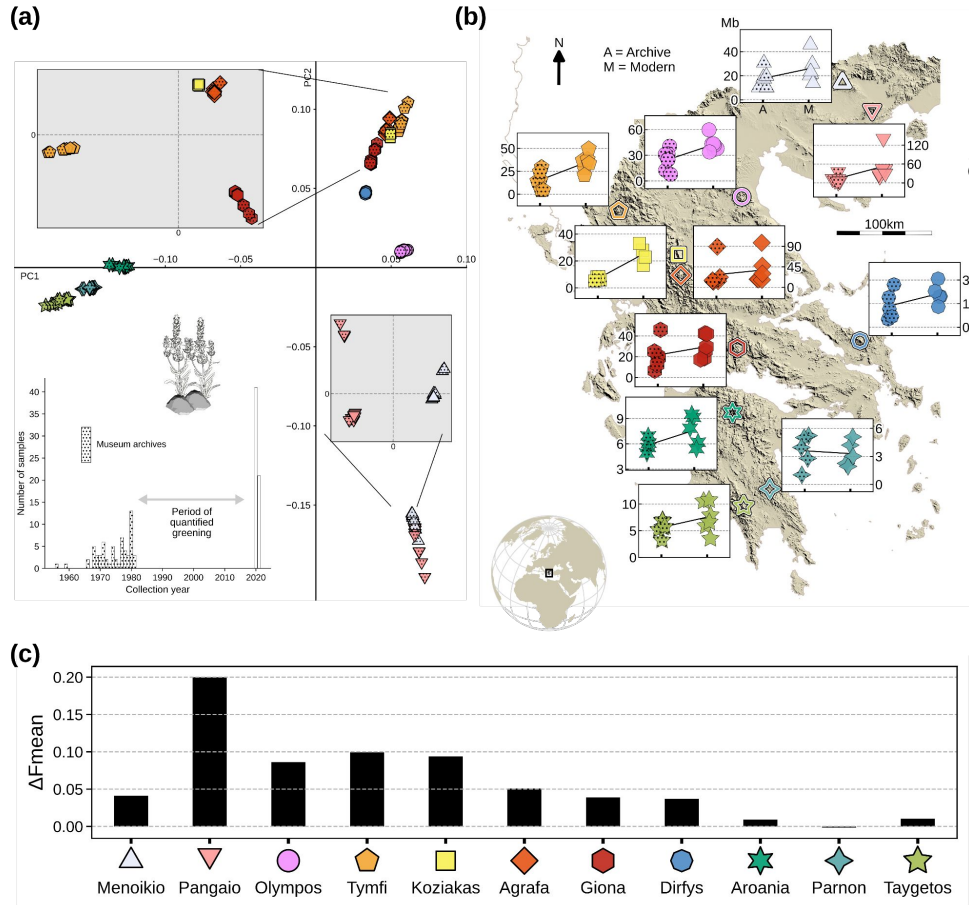


Historical records

> 200 herbarium specimens **sampled before 1985** and kept in the following collections:

- LD (Lund)
- CP (Copenhagen)
- ATH (Athens)
- B (Berlin)
- Arne Strid's private collection

Resource exposure (Indicator 4): Addressing the knowledge gaps



Demographic declines
assessed using genomic data

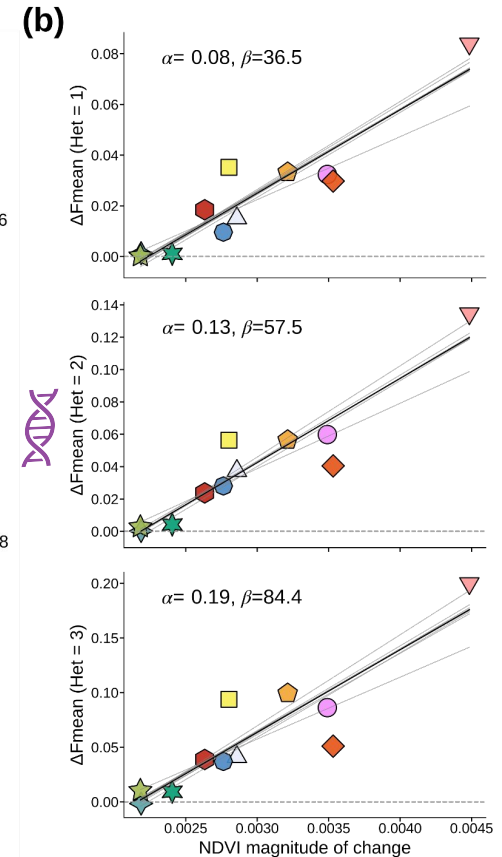
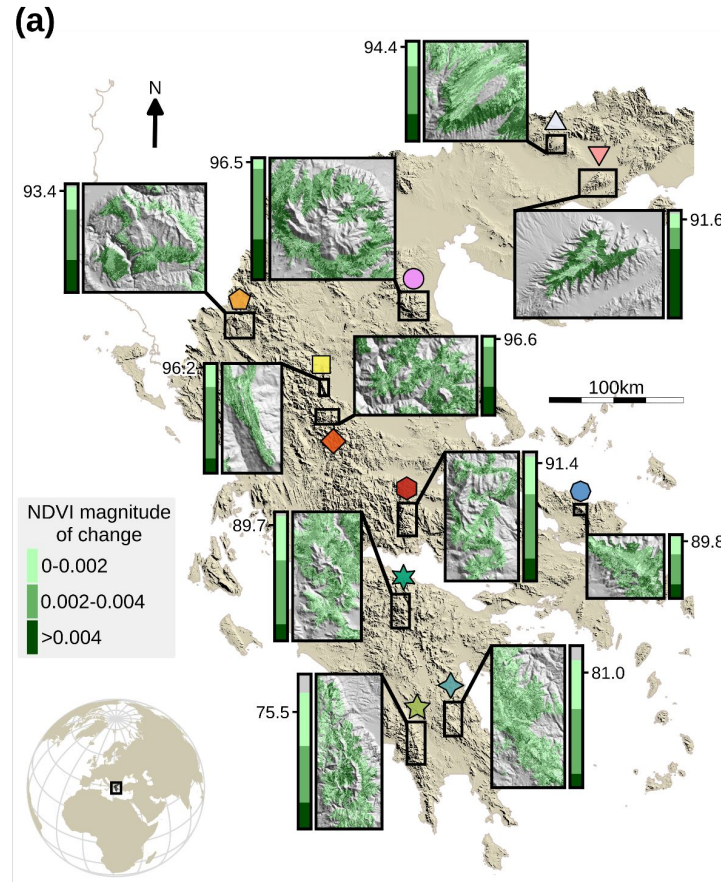


The development of Ironwort's
genome and whole genome
resequencing of 124 museum
archives and modern samples
reveal widespread genomic
erosion across populations

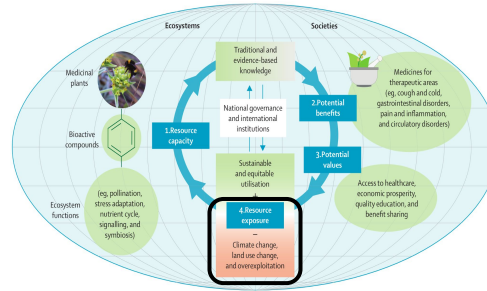
Resource exposure (Indicator 4): Addressing the knowledge gaps



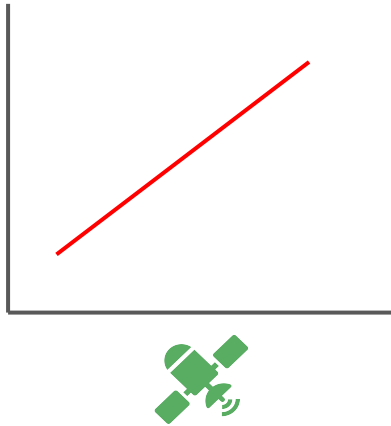
Satellite-captured vegetation greening of the last four decades predicts genomic erosion



Resource exposure (Indicator 4): Addressing the knowledge gaps

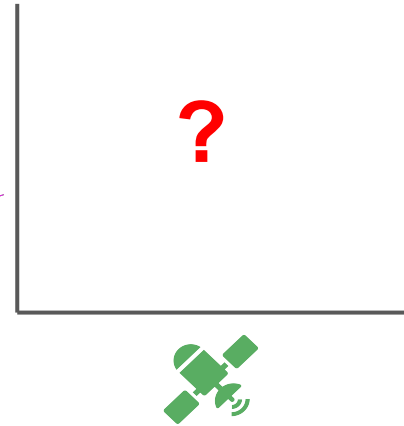


Genomic
composition change



Satellite-captured
ecosystem change

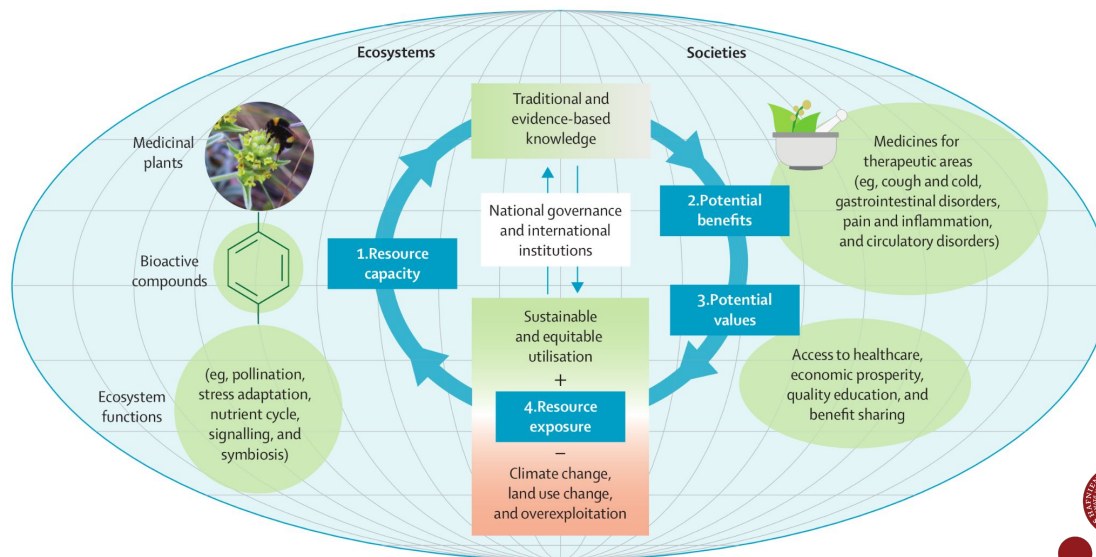
Bioactive compound
composition change



Satellite-captured
ecosystem change



Thank you!



SENCKENBERG
world of biodiversity

GOETHE

UNIVERSITÄT
FRANKFURT AM MAIN



**UNIVERSITY OF
COPENHAGEN**