# Perennial Vegetables:

## *Biodiversity, Carbon Sequestration and Nutrition*

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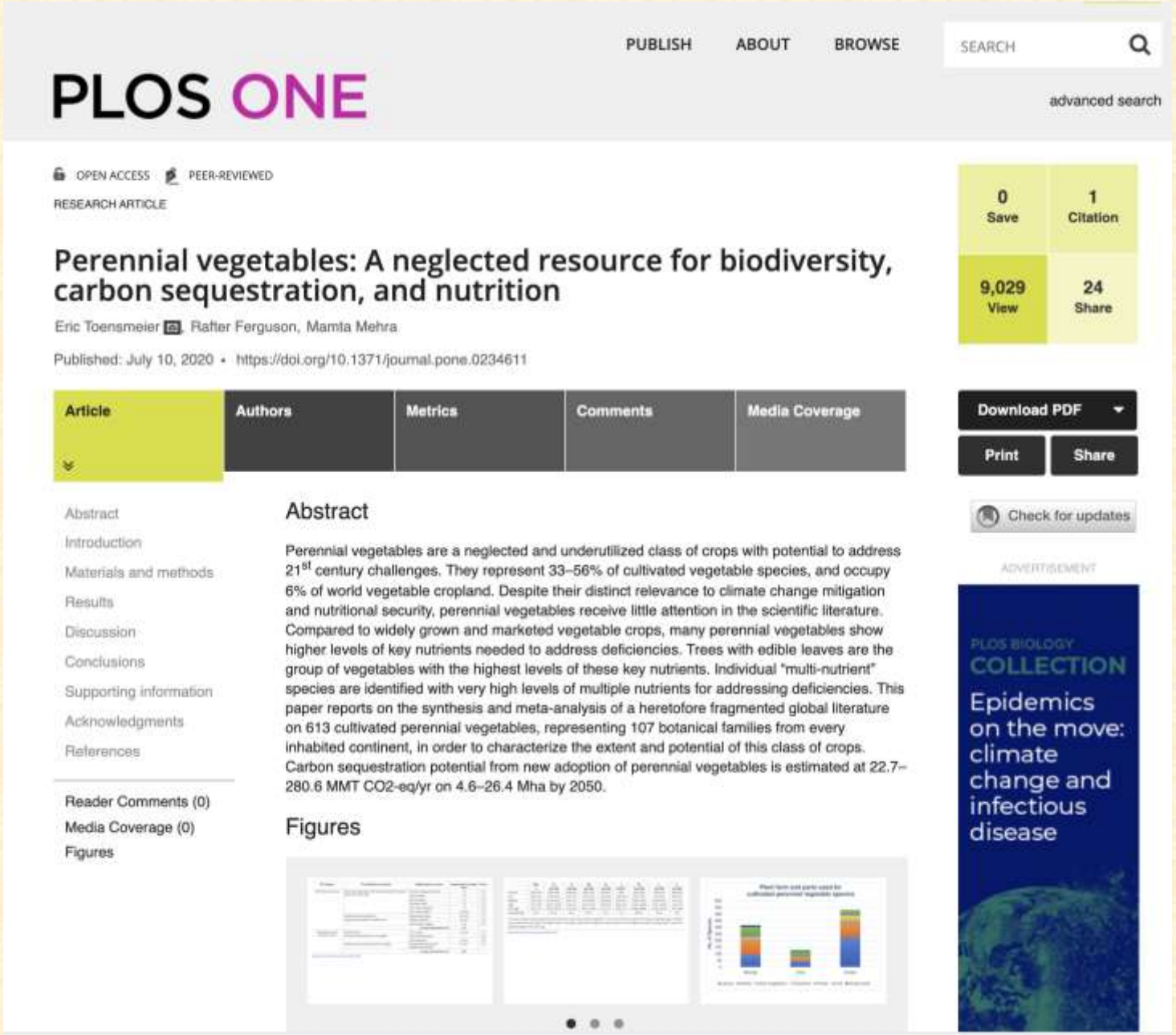
# A Neglected and Underutilized *Class of Crops*

- How many are there?
- What's their potential climate impact?
- How nutritious are they?



# Definition

- Perennial
  - 3-3,000 years
  - Including woody species and vines
- Primary use is cooking or using raw in salads
  - VEGETATIVE: leaves, shoots, stems
  - REPRODUCTIVE: flowerbuds, flowers, ripe or unripe fruit, unripe seeds
- NOT
  - Primarily used as a culinary herb
  - Staple crops like bananas and root crops
  - Dessert fruits like strawberries and melons

*Crambe maritima*

# Benefits & Tradeoffs

| Benefits | Tradeoffs |
| --- | --- |
| • Species for niches where annual vegetables won't grow<br>• Season extension<br>• Many resist pests and diseases<br>• No-till after establishment<br>• Climate change adaptation<br>• Many well-suited to agroforestry systems | • Some hard to acquire<br>• Some more expensive<br>• Viruses and other diseases<br>• Some unfamiliar flavors and textures<br>• Some potential weeds |

*Cercis canadensis*

# Season of Harvest – Paradise Lot

| | November to March | April | May | June | July to September | October |
|---|---|---|---|---|---|---|
| **Perennial shoots** | | Asparagus, milkweed, *Hablitzia,* hosta | asparagus, *Hablitzia,* bamboo | | | |
| **Herbaceous perennial leaves** | Korean celery | Scallions, garlic chives | Milkweed, scallions, garlic chives, sylvetta | *Hablitzia,* scallions, sylvetta | | Korean celery, sylvetta, scallions |
| **Aquatic perennial leaves** | | Water celery, cattail | Water celery, arrowhead | Arrowhead | Arrowhead | |
| **Coppiced woody leaf crops** | | | Goji, grape leaf | Goji, mulberry, Chinese toon, linden, grape leaf | Goji, mulberry, Chinese toon, linden, grape leaf | |
| **Perennial greenhouse leaves** | Perennial kales | Perennial kale, vegetable fern | Vegetable fern | Vegetable fern | Vegetable fern | Perennial kale, vegetable fern |
| **Flowers & broccolis** | | | redbud, sea kale, Turkish rocket | Milkweed | Garlic chives | |
| **Perennial fruit vegetables** | | | Siberian elm | | Milkweed | Ground cherry |
| **Annual crops** | | | Various leaf crops | Various leaf crops | Various fruits and leaves | |
| **Winter greenhouse annuals** | Various leaf crops | Various leaf crops | | | | Various leaf crops |

# Biodiversity

*Broadening the base of food security*

# Agricultural Biodiversity Crisis

- 80% of crop production is from 17 families
  - 12 families of vegetables
- 107 families of cultivated PVs
  - 63 among those suited to Europe

# Findings

- 35-56% of cultivated vegetable species are PVs
- 7.7% of all cultivated crops are PVs
- 613 cultivated species globally
  - 251 cult spp. for warm temp, cold temp, boreal, arctic
  - 101 cultivated native PV species from Europe

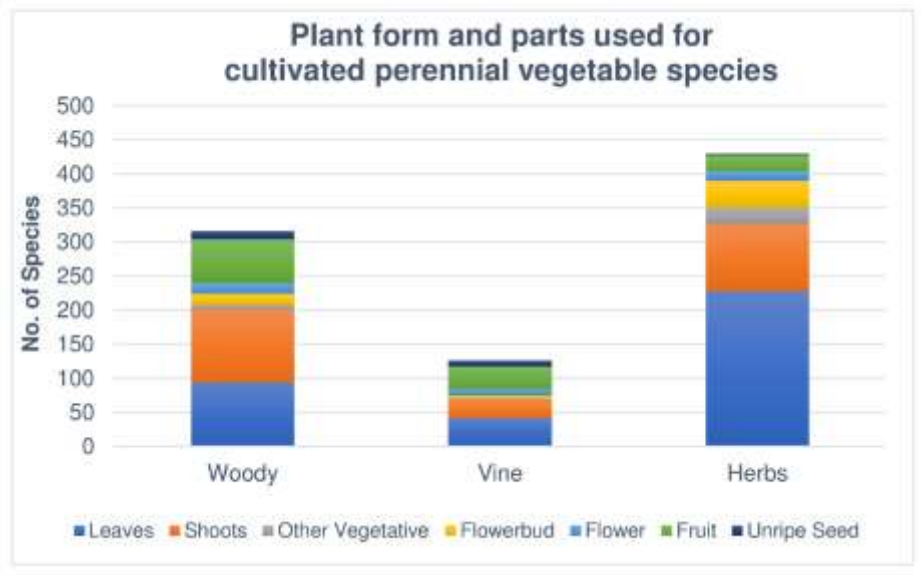
# Findings from Mexico

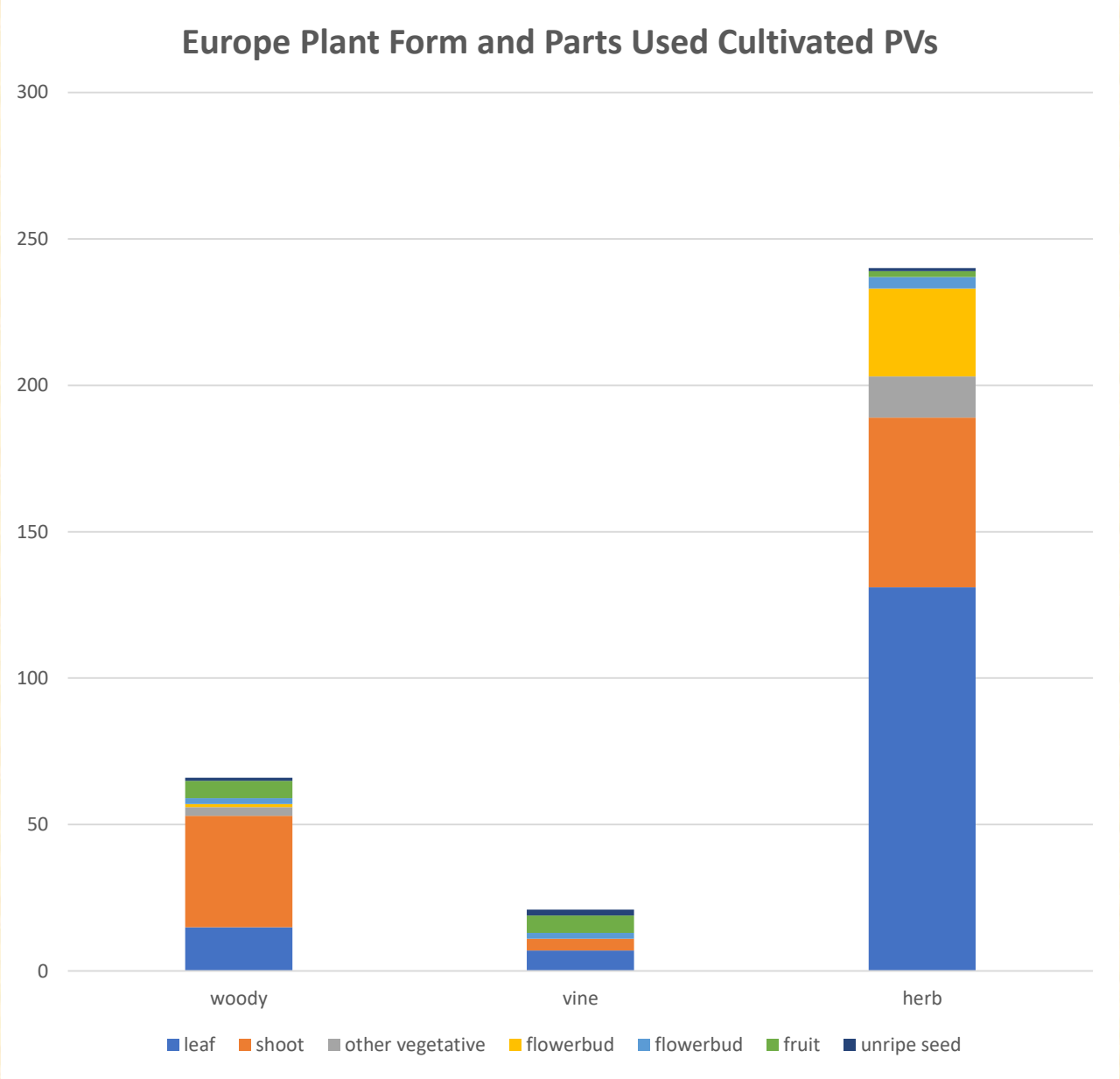
- Analyzing native PVs of Mexico
  - Cultivated and wild
- 2.25% of all Mexican plant species are PVs
- If applied to globe, 7,882 species of PVs including cult and wild
- Found 23 additional cultivated species
  - If same % missed globally, 287 additional spp
  - 901 global cult PV spp estimated

Toensmeier, Salinas, Mehra, Ferguson, Smith, Boehnel, Ruiz (in progress) “Native Perennial Vegetables of Mexico”

# Form and Habit

Global



# Carbon Sequestration

*Contributing to the Perennialization of Agriculture*

# Sequestration Rates by Type

**Table 1. Carbon sequestration rates of PVs.**

| PV Category | PV production system type | Sample species or system | Sequestration rate MgC/ha/yr | Source |
|---|---|---|---|---|
| Woody perennial crops | Orchard and plantation; full-sized woody plants for flowers, fruits, and unripe seeds | Convert cropland to orchard | 3.5 | [54] |
| | | *Olea europaea* | 2.6 | [55] |
| | | *Bactris gasipaes* | 5.1 | [56] |
| | | *Dacryodes edulis* | 7.8 | [57] |
| | | Tree crops–temperate | 2.1 | [58] |
| | | Tree crops–tropical | 1.8–10.0 | [58] |
| | Bamboo for shoot production | Bamboo plantations | 6.0–13.0 | [59] |
| | Coppiced woody plants for edible leaves | Fodder tree blocks | 0.1–0.5 | [54] |
| | | Short rotation coppice | 1.18 | [60] |
| | | ***Average sequestration rate*** | **3.71** | |
| Perennial vines and herbaceous crops | Perennial vines | *Vitis vinifera* | 0.3–0.8 | [61] |
| | Robust perennial herbs (over 2m height) | Giant biomass grasses | 1 | [62] |
| | | Perennial grains | 0.3–0.5 | [63] |
| | Ordinary perennial herbs (under 2m height) | Residential landscape with herbaceous perennials | 0.0–0.1 | [64] |
| | | ***Average sequestration rate*** | **0.43** | |

# Global Sequestration Potential

- 22.7-280.6 MMT CO2-eq/yr in 2050 globally
  - Between impacts of restoring coastal wetlands and hybrid cars
- Variables
  - Does vegetable expansion triple to meet the world's nutrition needs?
  - How much emphasis is placed on woody PVs?
- A higher impact than improved annual cropping systems alone

*Olea europaea* Image Petr Pakandl CC BY-SA 2.5

# Nutrition

*The World Must Triple Vegetable Production to Meet Nutrient Needs*

# Industrial Diet Deficiencies

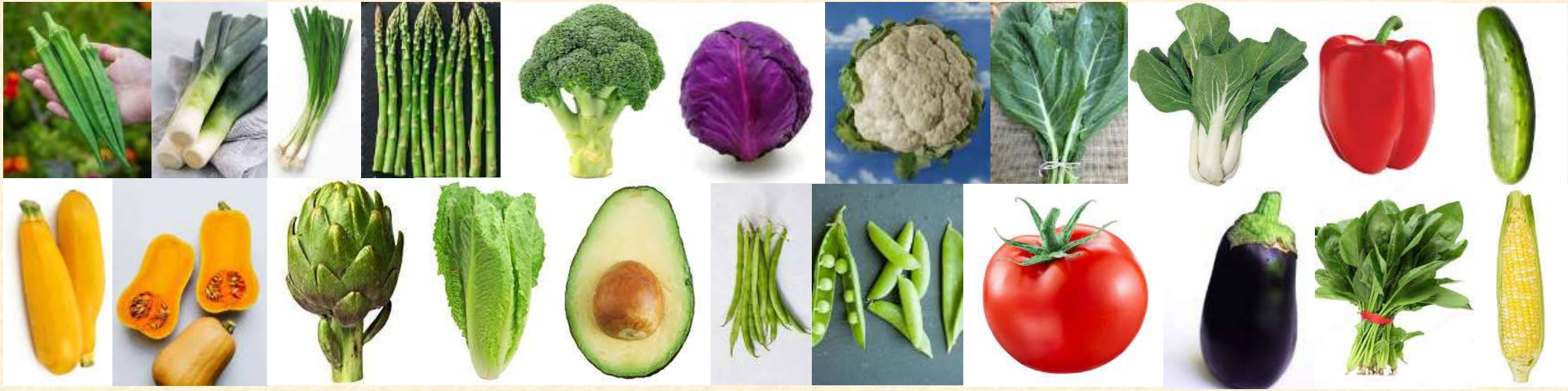
| Deficiency | Health Impacts |
|---|---|
| Fiber | • Heart disease<br>• Obesity |
| Magnesium | • Diabetes<br>• High blood pressure<br>• Heart disease |
| Calcium | • Osteoporosis |
| Antioxidants like Vitamins A, C and E | • Cardiovascular disease |

# Research

- Nutrient data on 350 perennial and annual vegetables
- From 53 sources
- Many gaps
  - Species missing
  - Nutrients missing
- Fundraising for further research
- All available open access data

*Hablitzia tamnoides*

# The Reference Crops



**Superabundant:** Higher than the highest levels reported in the reference vegetables
**Multinutrient:** Superabundant in more than one nutrient

# European "Top Ten" Superabundant

| Fiber | Calcium | Magnesium | Vitamin A | Vitamin C | Vitamin E |
|---|---|---|---|---|---|
|  |  |  |  |  |  |
| 1. Runner bean (*Phaseolus coccineus*) | 1. Saltbush (*Atriplex halimus*) | 1. Saltbush (*Atriplex halimus*) | 1. Goji fruit (*Lycium barbarum*) | 1. Milkweed (*Asclepias syriaca*) | 1. Chinese toon (*Toona sinensis*) |
| 2. Grape leaf (*Vitis vinifera*) | 2. Mulberry leaf (*Morus alba*) | 2. Arctic willow (*Salix reticulata*) | 2. Chinese toon (*Toona sinensis*) | 2. Arugula, rocket (*Eruca vesicaria*) | 2. Garland chrysanthemum (*Glebionis coronaria*) |
| 3. Fava bean (*Vicia faba*) | 3. Amaranth leaf (*Amaranthus retroflexus*) | 3. Mulberry leaf (*Morus alba*) | 3. Sow thistle (*Sonchus oleraceus*) | 3. Winter cress (*Barbarea vulgaris*) | 3. Hops shoots (*Humulus lupulus*) |
| 4. Akkoub (*Gundelia tournefortii*) | 4. African eggplant leaf (*Solanum aethiopicum*) | 4. Grape leaf (*Vitis vinifera*) | 4. Black nightshade (*Solanum americanum*) | 4. Mulberry leaf (*Morus alba*) | 4. Stinging nettle (*Urtica dioica*) |
| 5. Korean celery (*Dystaenia takesimiana*) | 5. Stinging nettle (*Urtica dioica*) | 5. Ragged jack kale (*Brassica napus*) | 5. Arctic willow (*Salix pulchra*) | 5. Stinging nettle (*Urtica dioica*) | 5. Bladder campion (*Silene vulgaris*) |

| Woody | Vine | Herb | Annual |
|---|---|---|---|

# Trees With Edible Leaves

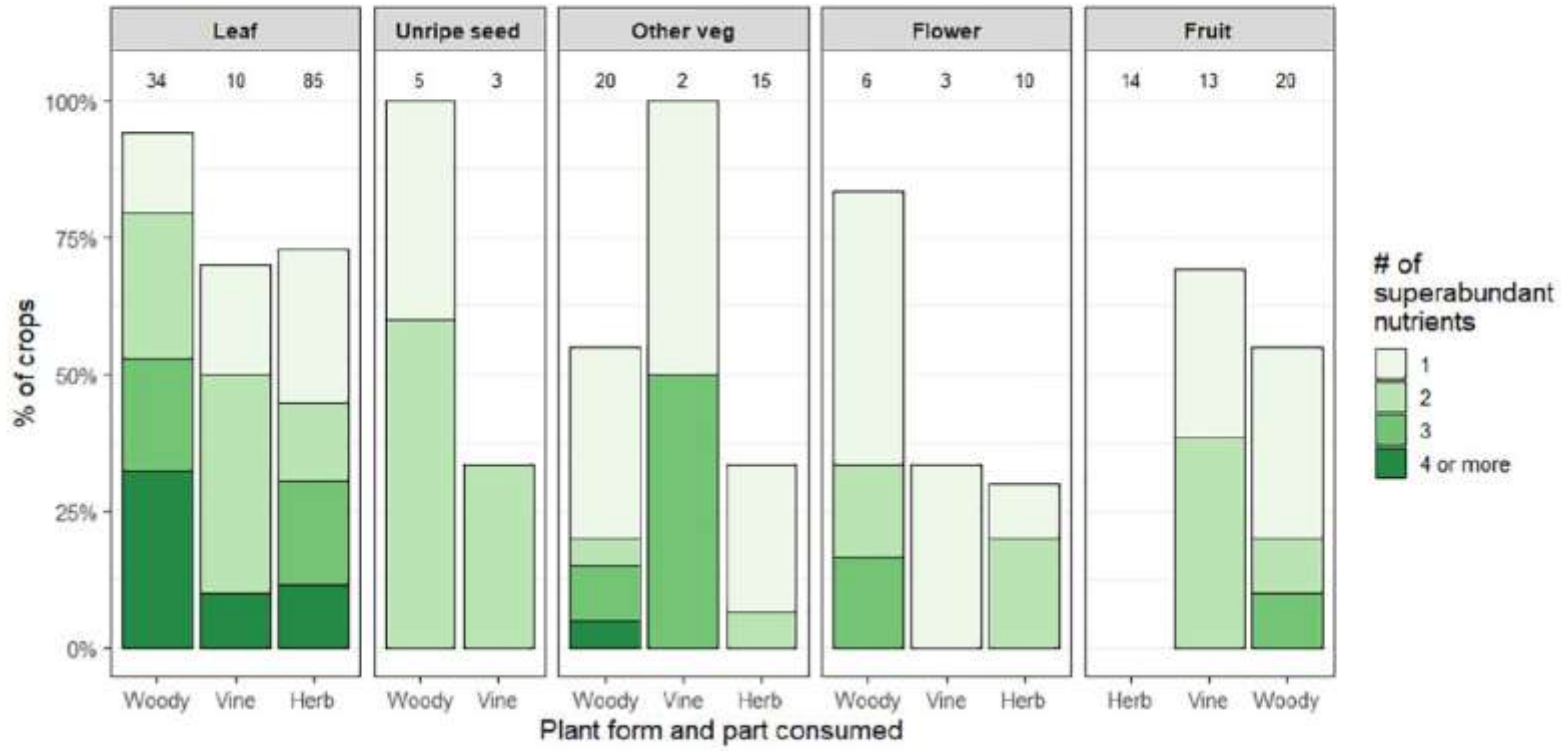



**Fig 4. Proportions of perennial vegetables with one or more superabundant nutrients by plant form and part consumed.** Nutrient levels are classified as superabundant when they are higher than the highest level of that nutrient among the reference vegetables. Here the percentage of crops with one or more superabundant nutrients is displayed for 240 perennial vegetables broken down by plant form and part used. The numbers of crops within each category are displayed along the top of the plot.

# Multi-nutrient Species to Address Industrial Diet Deficiencies for Europe

| Latin Name | Common Name | Part | Fiber | Calcium | Magnesium | Vitamin A | Vitamin C | Vitamin E |
|---|---|---|---|---|---|---|---|---|
| *Asclepias syriaca* | Milkweed | Leaf | | VH | | VH | XH | |
| *Atriplex halimus* | Saltbush | Leaf | VH | XH | XH | | | |
| *Chamerion angustifolium* | Fireweed | Shoot | H | H | VH | | VH | |
| *Morus alba* | Mulberry | Leaf | VH | VH | VH | VH | VH | |
| *Silene vulgaris* | Bladder campion | Leaf | VH | | | VH | | XH |
| *Toona sinensis* | Chinese toon | Leaf | | VH | | XH | VH | XH |
| *Urtica dioica* | Stinging nettle | Leaf | H | VH | H | | VH | XH |
| *Vitis vinifera* | Grape | Leaf | XH | VH | VH | VH | | H |

# Standout Species

*Nutritional superstars for Europe*

# Chinese Toon

*Toona sinensis*

- Leaves
- Extremely high: Vitamins A and E
- Very high: calcium, Vitamin C
- Coppice management

# Saltbush, Tree Purslane

*Atriplex halimus*

- Leaves
- Extremely high: calcium, magnesium
- Very high: fiber
- High in salt as well
- Hedgerow management

# Edible-Leaf Mulberry

*Morus alba*

- Leaves
- Very high: fiber, calcium, magnesium, Vitamins A and C
- Coppice management

# Goji, Edible-Leaf Goji

*Lycium barbatum, L. chinense*

- Fruit extremely high in Vitamin A
- Leaves extremely high in Vitamin E
- Coppice management for leaves

# Grape Leaf

*Vitis vinifera*

- Leaves
- Extremely high in fiber
- Very high in calcium, magnesium, and vitamin A
- Coppice management or prunings of fruiting grapes

# Stinging Nettle

*Urtica dioica*

- Shoots and leaves
- Extremely high in Vitamin E
- Very high in calcium and Vitamin C
- Herbaceous management, somewhat shade tolerant

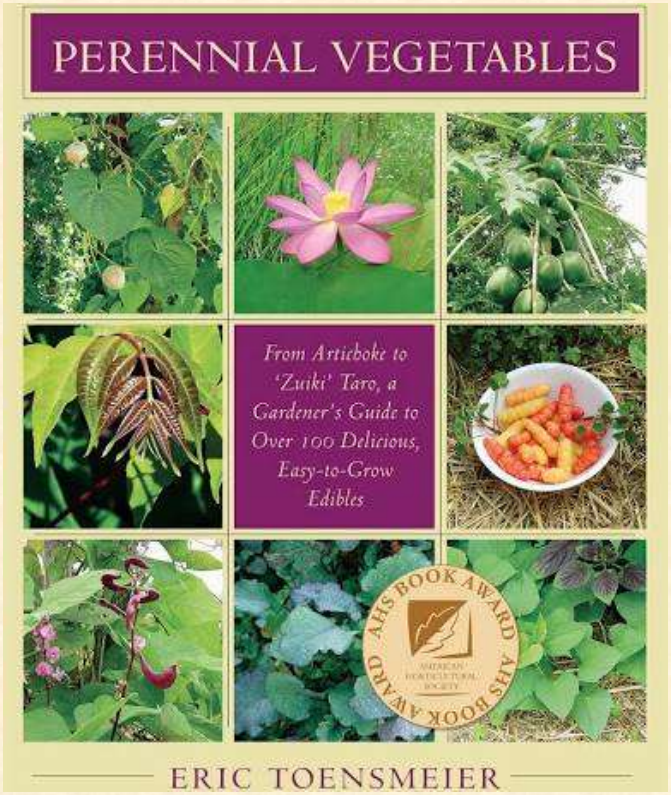
# Conclusions

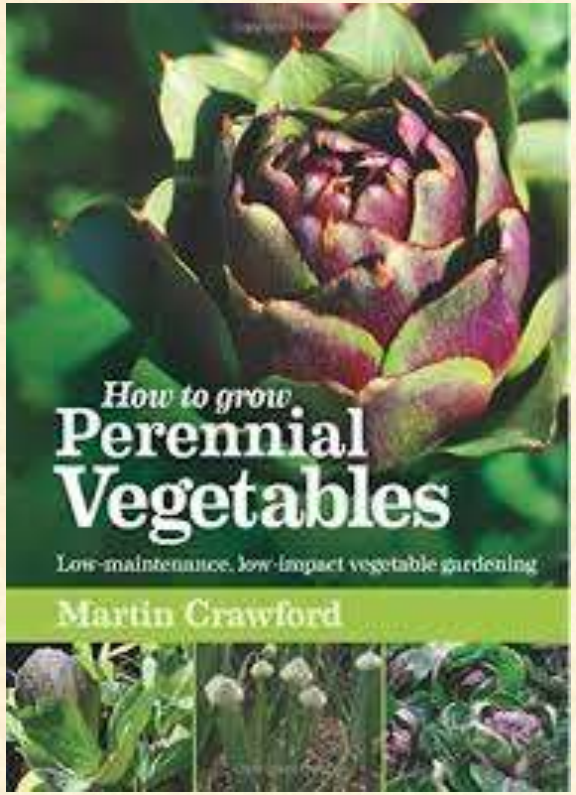
# Facing Challenges with Perennial Vegetables

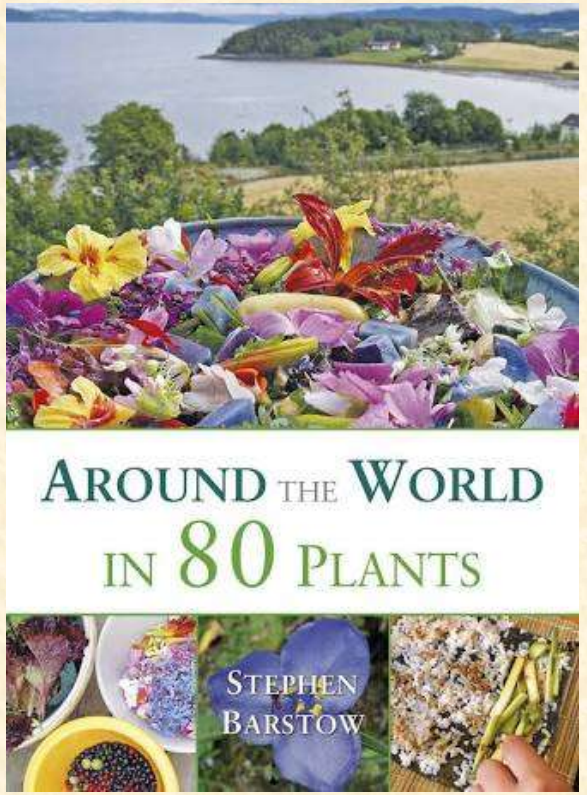
- Can increase agricultural biodiversity
- Can help perennialize agriculture and sequester carbon
- Can address nutrient deficiencies impacting millions of people in Europe
  - The species most widely grown and marketed are not the best to address these deficiencies
  - Many trees with edible leaves are outstanding

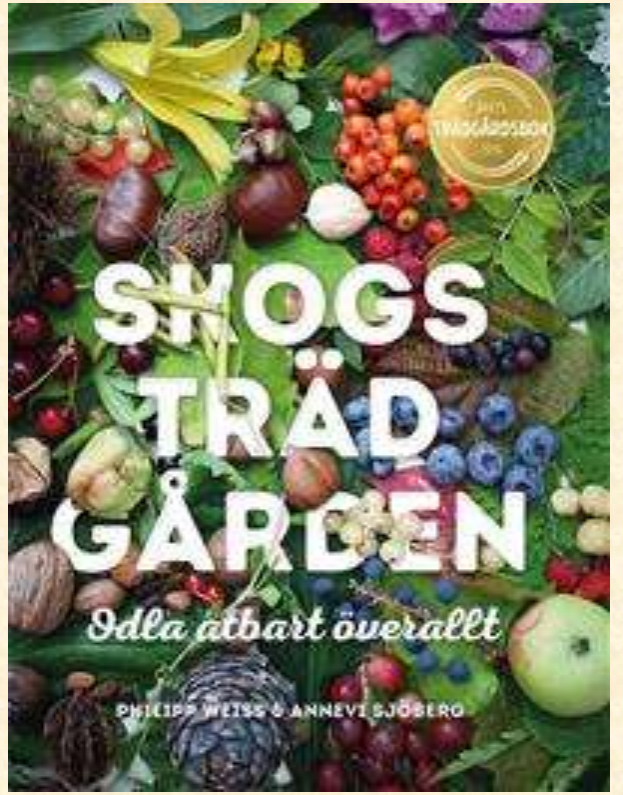
*Morus alba*

# Further Reading



# www.perennialagriculture.institute