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region

From the wild of the Brazilian Atlantic forest to the bench: the multi-approaches of *Acca sellowiana* domestication

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CNR-IVALSA
TREES AND TIMBER INSTITUTE

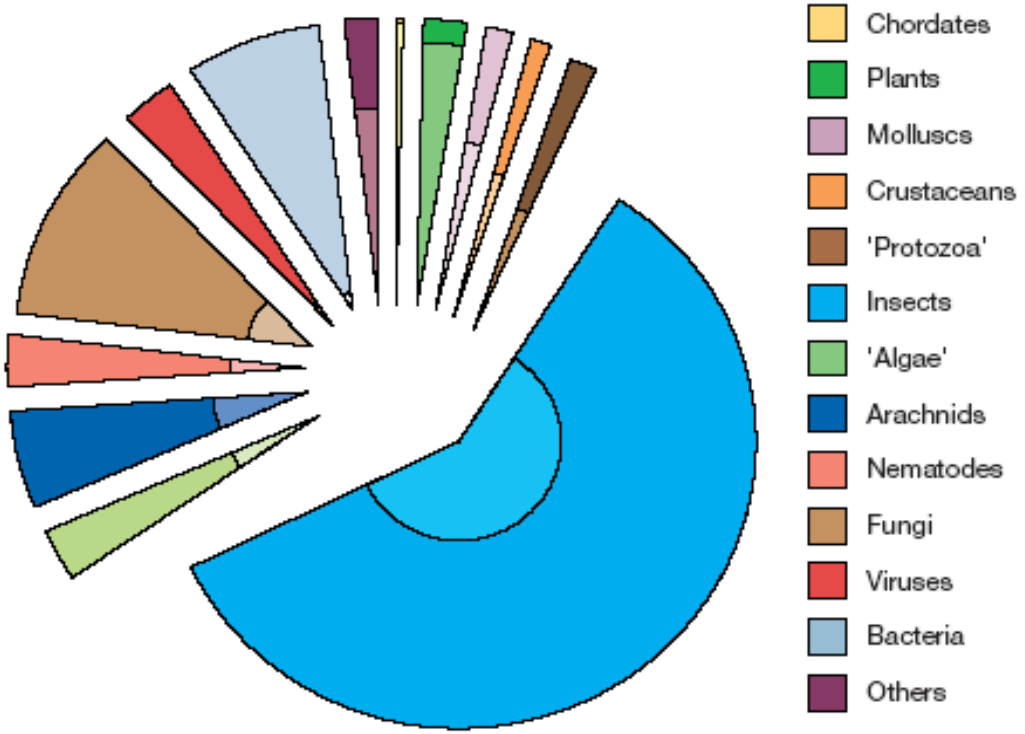
Where are we?

Florianópolis, Santa Catarina Island, Santa Catarina State, South Brazil

Getting the measure of biodiversity

NATURE | VOL 405 | 11 MAY 2000 | www.nature.com

Andy Purvis* & Andy Hector†



15 million species

Figure 4 Species richness in major groups of organisms. The main 'pie' shows the species estimated to exist in each group; the hatched area within each slice shows the proportion that have been formally described. Data from ref. 7.

Megadiversity countries

- **America**: Brazil, Colombia, Ecuador, Peru, Venezuela, USA, México
- **Ásia**: China, Filipinas, Índia, Indonésia, Malásia
- **África**: Madagascar, Congo, África do Sul
- **Oceania**: Austrália, Papua-Nova Guiné

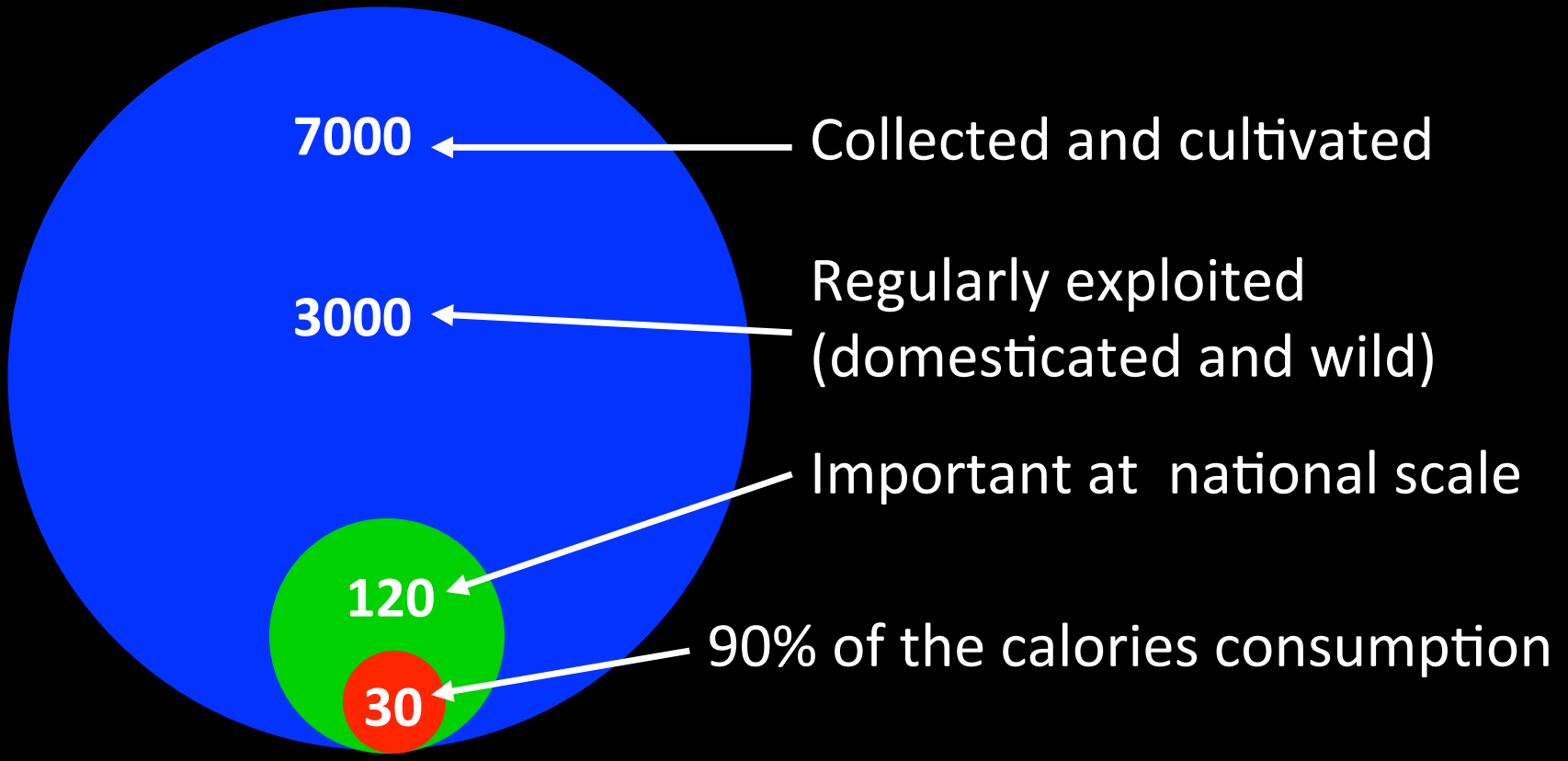
Brazil: ≅20 % planet species

15 % mammals and amphibians 17 % birds

5 a 10 million insects 25 % plants

Number of edible plant species

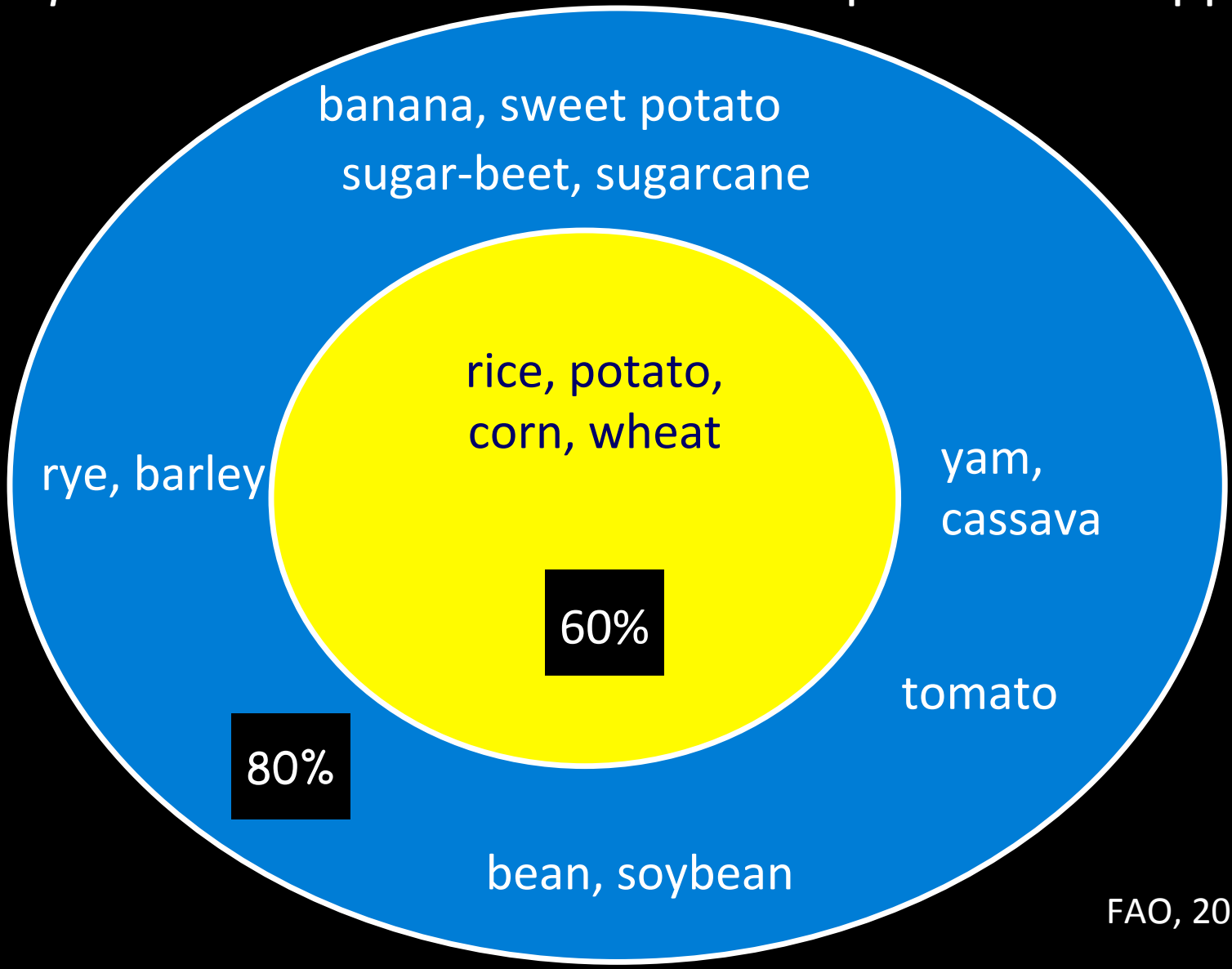
Of the 250,000-350,000 species of plants known to exist on the planet at least **30,000 are edible**



FAO, 2010

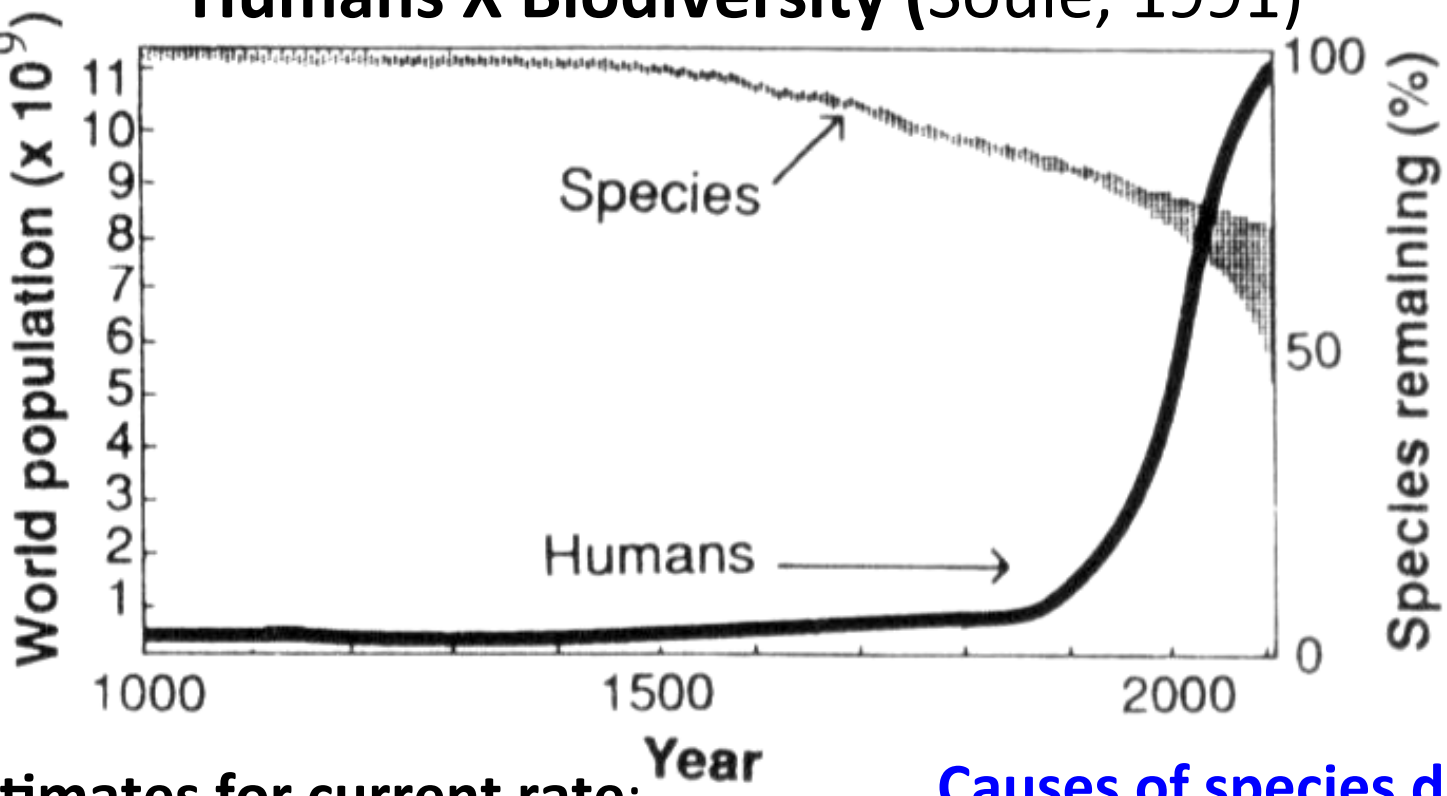
Origin of calories

103 *sp* contribute 90% of the world's plant food supply



FAO, 2010

Humans X Biodiversity (Soulé, 1991)

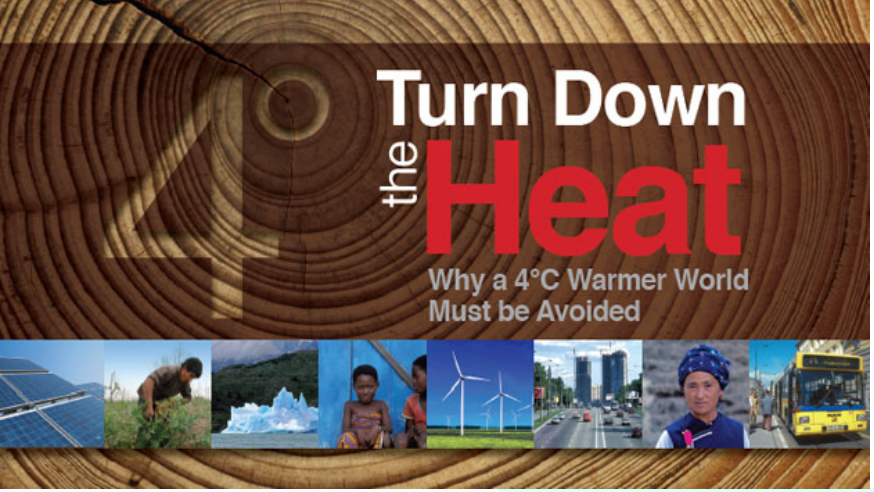


Some estimates for current rate:

- 1 species per hour
- 1 million species total, so far
- 10% of all species so far
- 8.8% of all species
- 27,000 species per year
- 20% of neotropical plant species
- 100 to 10,000 times the background rate

Causes of species declines

- Habitat destruction and fragmentation
- Introduced species
- Exploitation and overharvesting
- Pollution
- Climate change

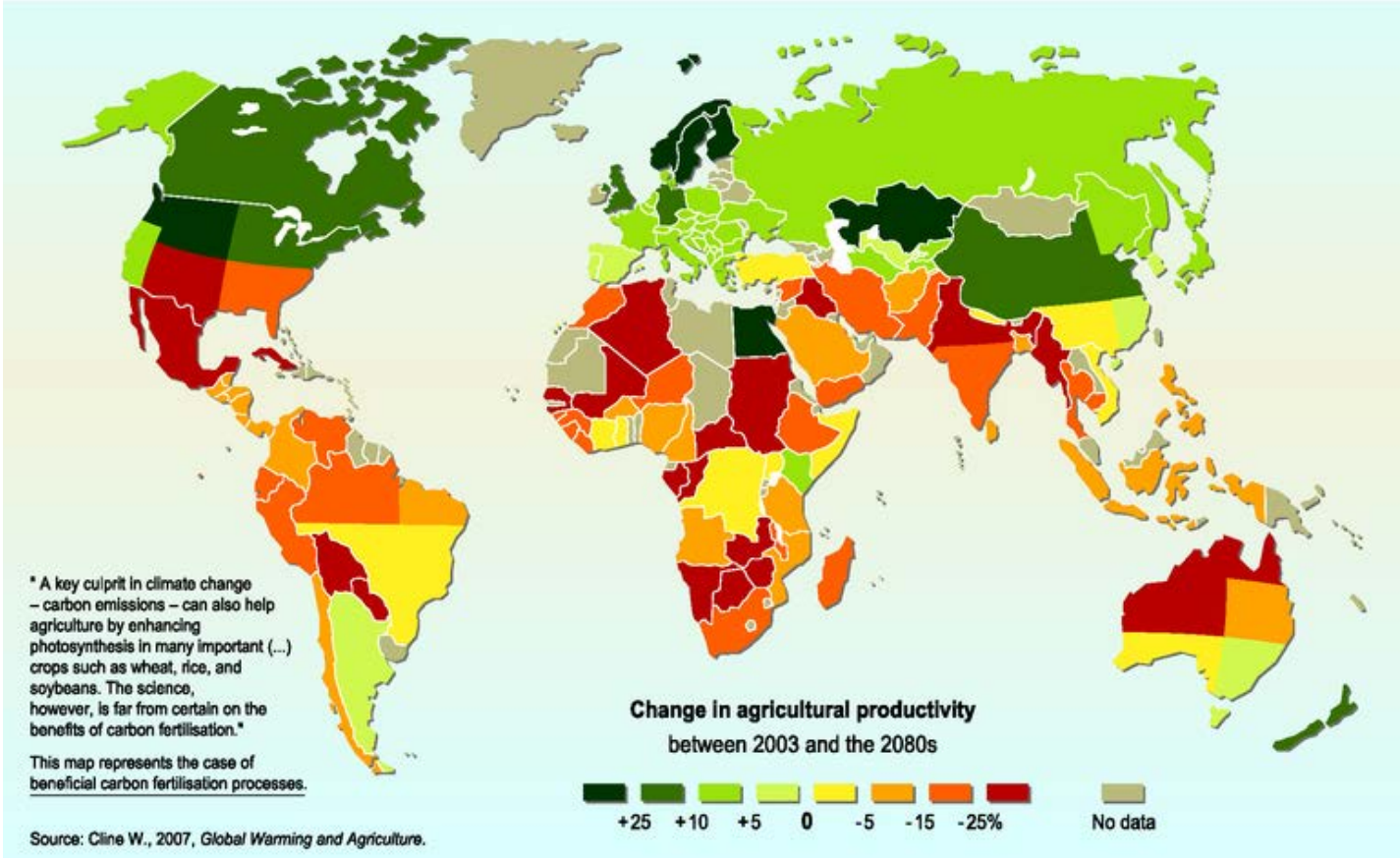


The mains threats

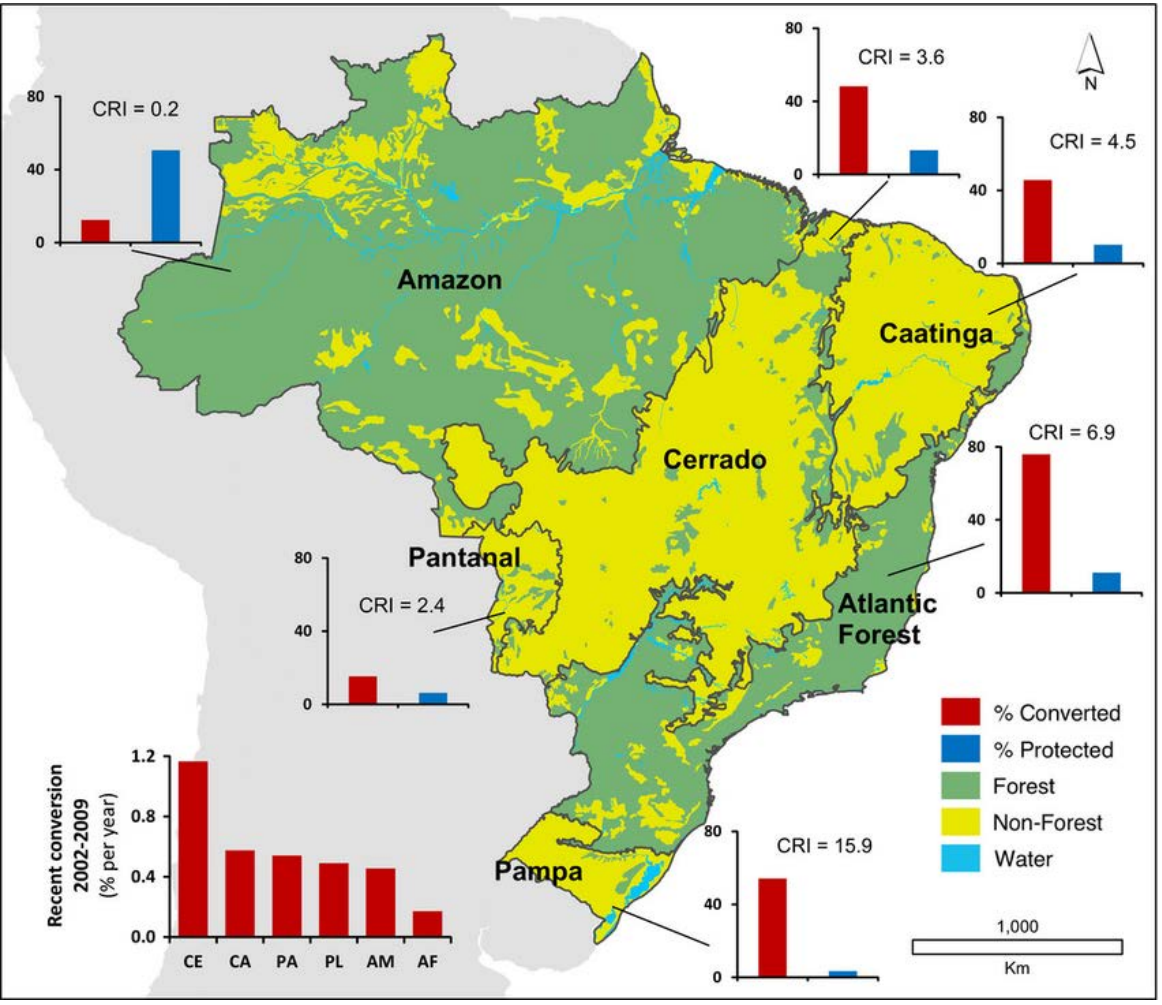
Global Climatic Changes

November 2012 - A Report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics

Projected impact of climate change on agricultural yields



Original vegetation in the Brazilian biomes



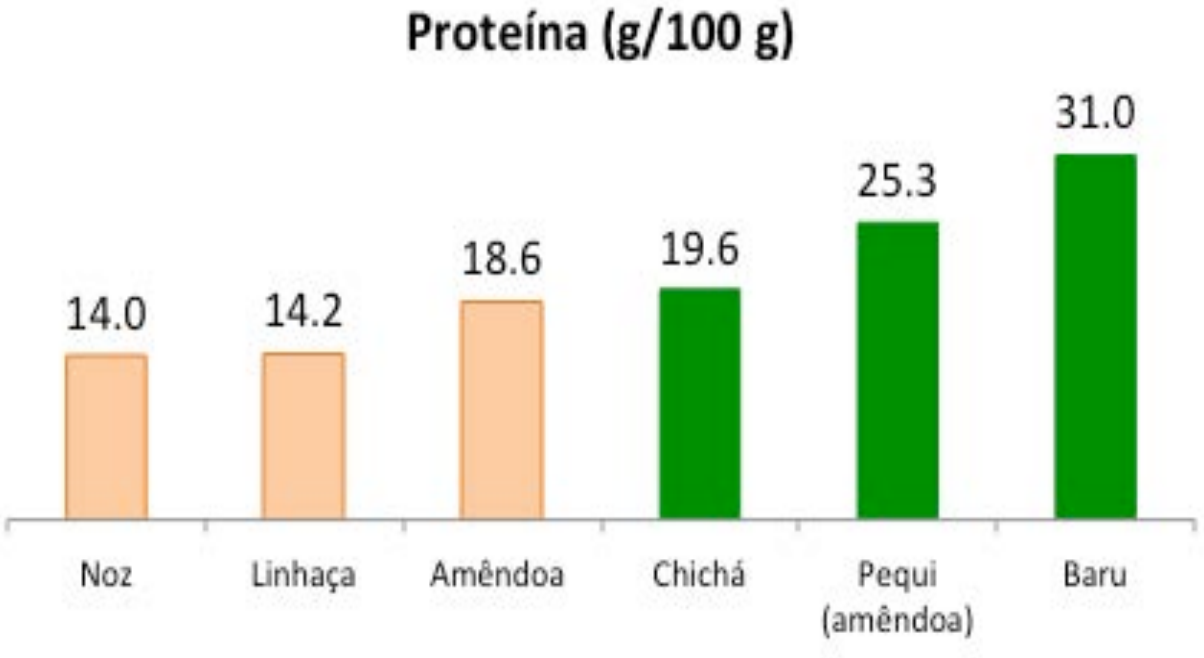
Small graphs show the proportion of converted (red) and protected (blue) areas in 2009. PA include IUCN categories I–VI and Indigenous Reserves. The Conservation Risk Index (CRI) given for each biome is the ratio of converted to protected percentages. Overbeck *et al*. *Diversity and Distributions 21*, 1455–1460, 2015.

http://floradobrasil.jbrj.gov.br

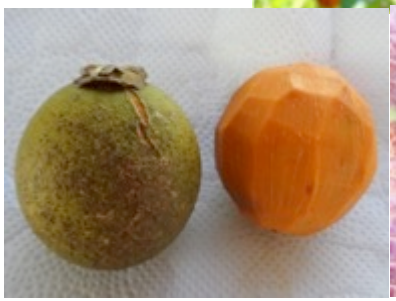
- **Brazilian biodiversity ≅ 20 % world; 46.403 sp;**
- Three of the richest world biomes in plant species:
  - Amazon, **Atlantic forest**, Cerrado

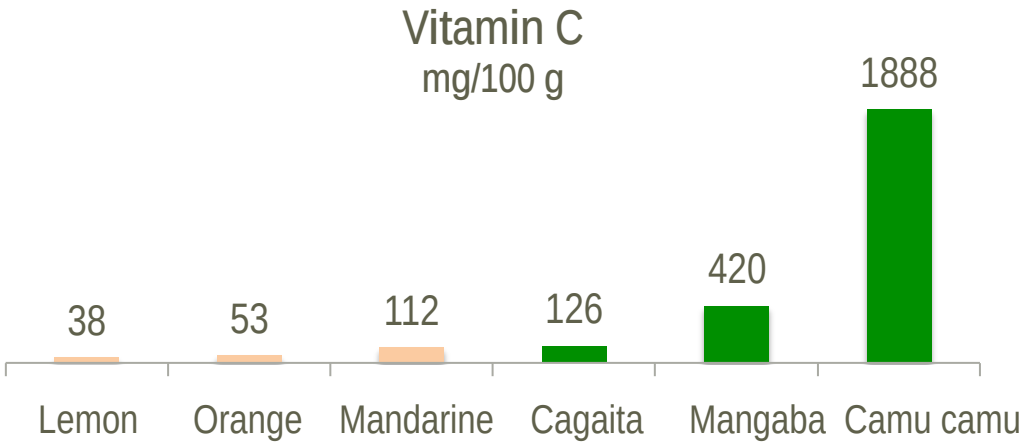
Atlantic Forest 20,000 plant species, 40 % of which are endemic

Nutritional potential of Brazilian native species



Nutritional potential of Brazilian native species

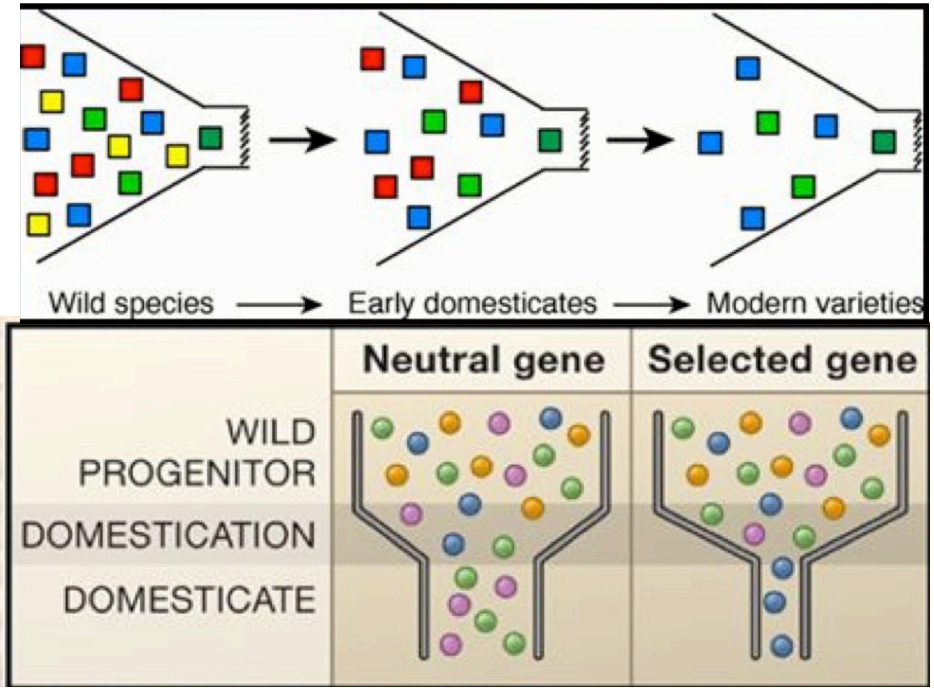




What plant domestication is?

The process by which humans actively interfere with and direct crop evolution

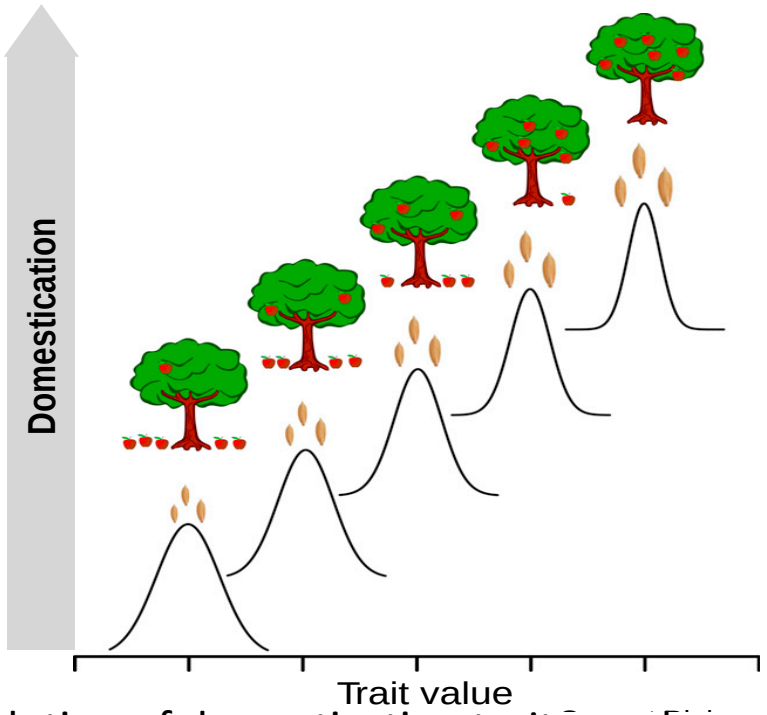
- It involves a genetic bottleneck



Often only few genes are selected and account for large shifts in phenotype

- Crops exhibit various levels of domestication

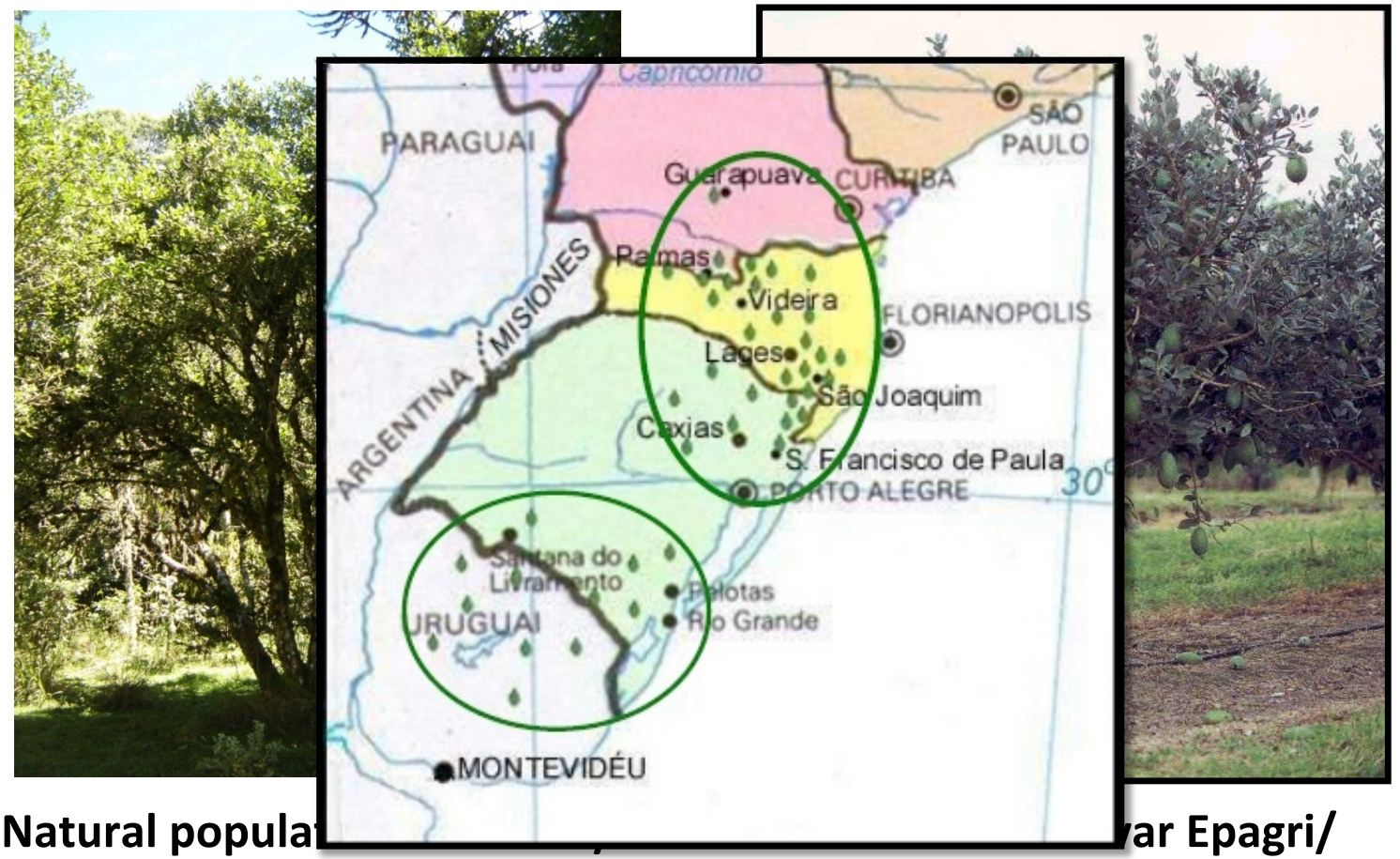
Evolution of domestication traits



Evolution of domestication traits, such as fruit abscission in apples or seed size in rice. Most traits are quantitative, showing variation in both wild and domesticated taxa. Adaptation from this standing genetic variation often results in gradual change over time, reflected in steadily decreasing variation for the trait.

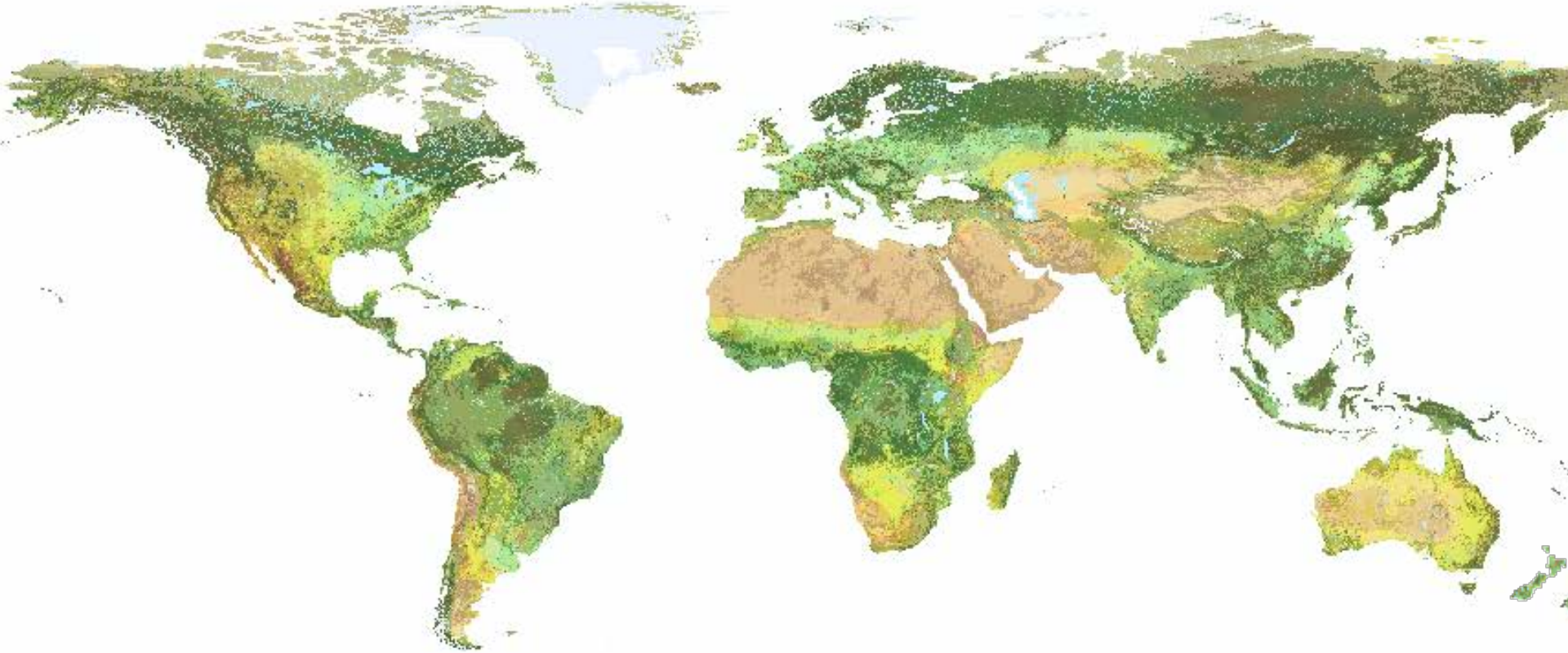
Acca sellowiana: Myrtaceae

- **Native of southern Brazil and northern Uruguay.**



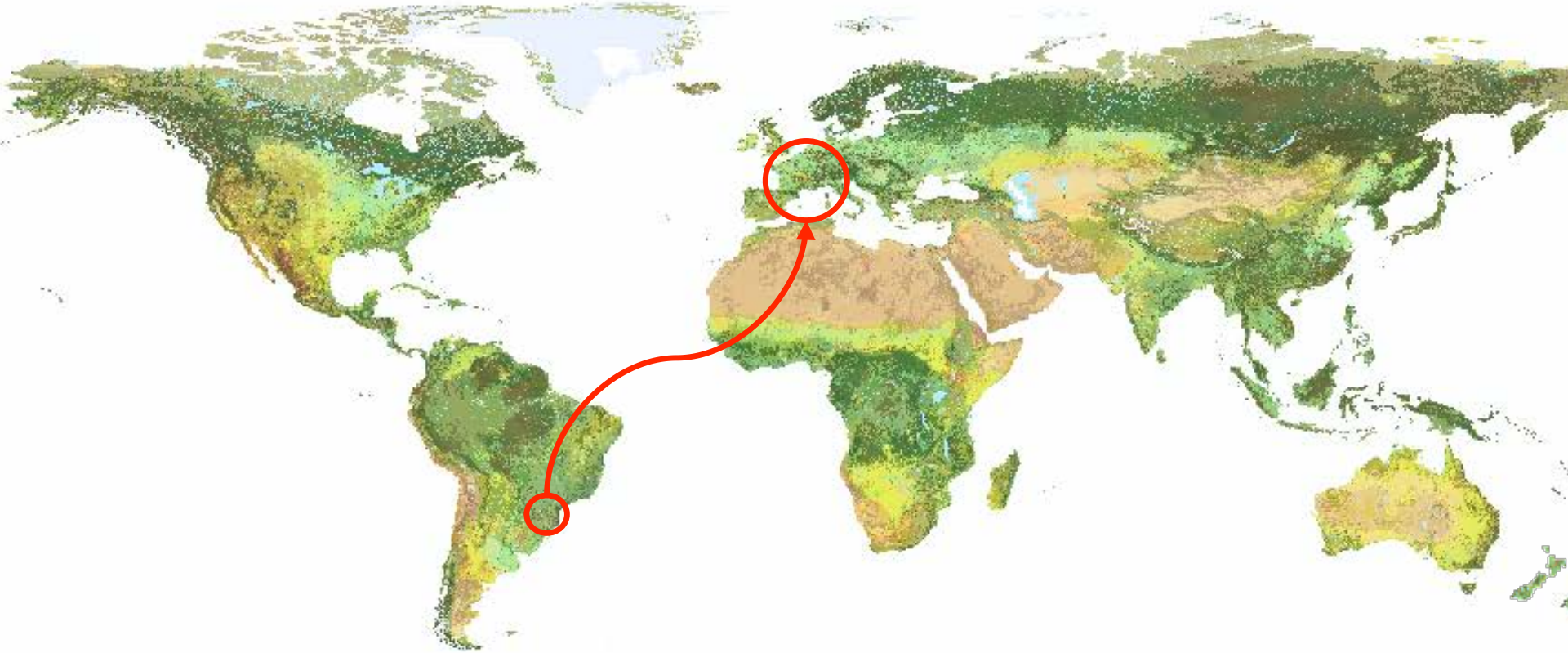
Natural popula **var Epagri/ USFC - 03/04/07**

Wild to the bench



Wild to the bench

1890



Brazil → France

Wild to the bench

1899

- France → USA

Wild to the bench

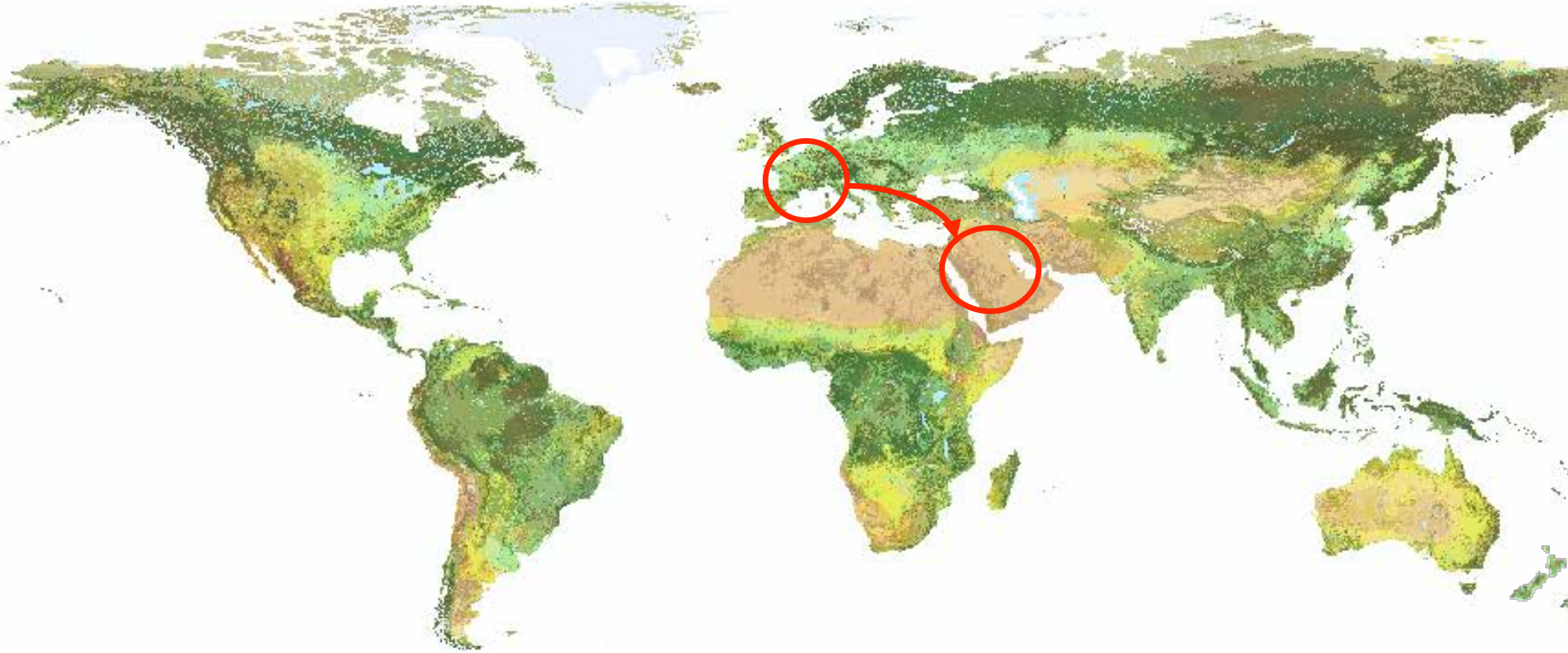
1910

- France → USA

var. Collidge

Wild to the bench

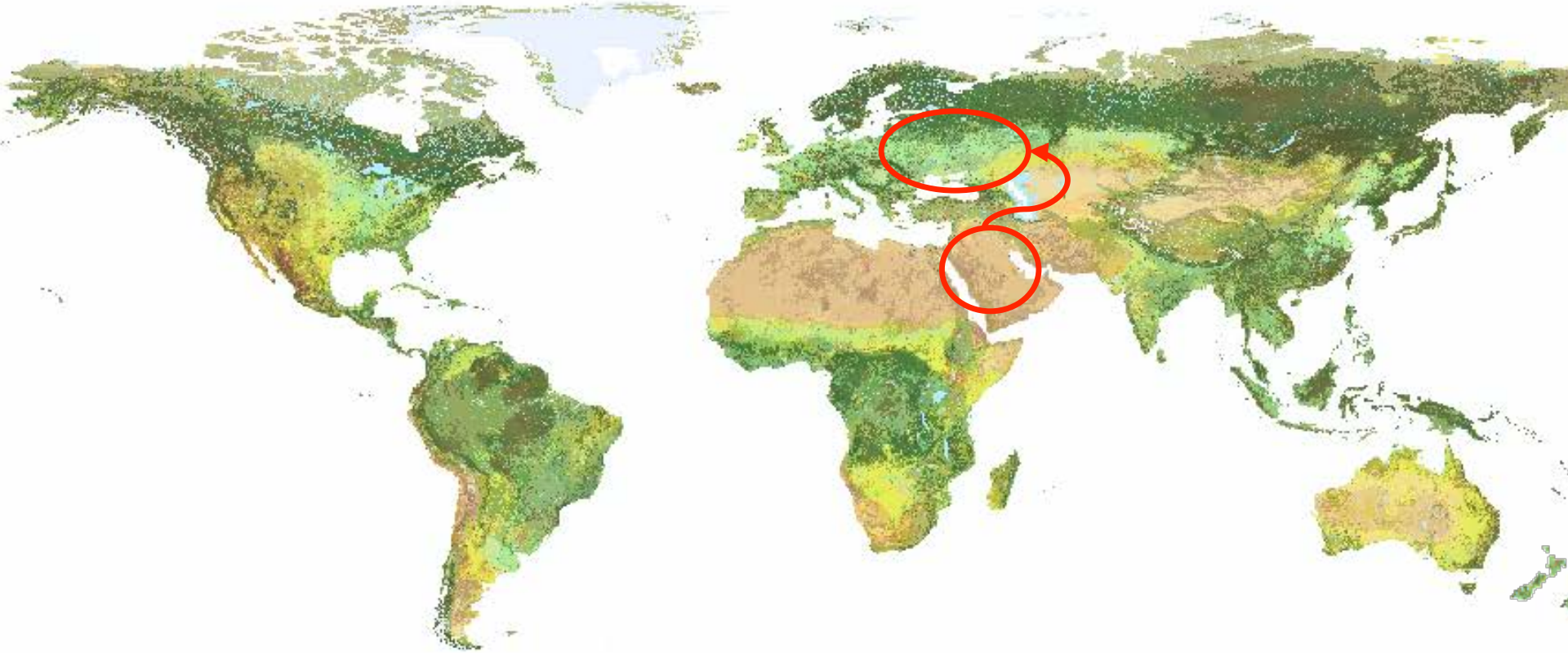
1910



- France → Israel
  → New Zealand

Wild to the bench

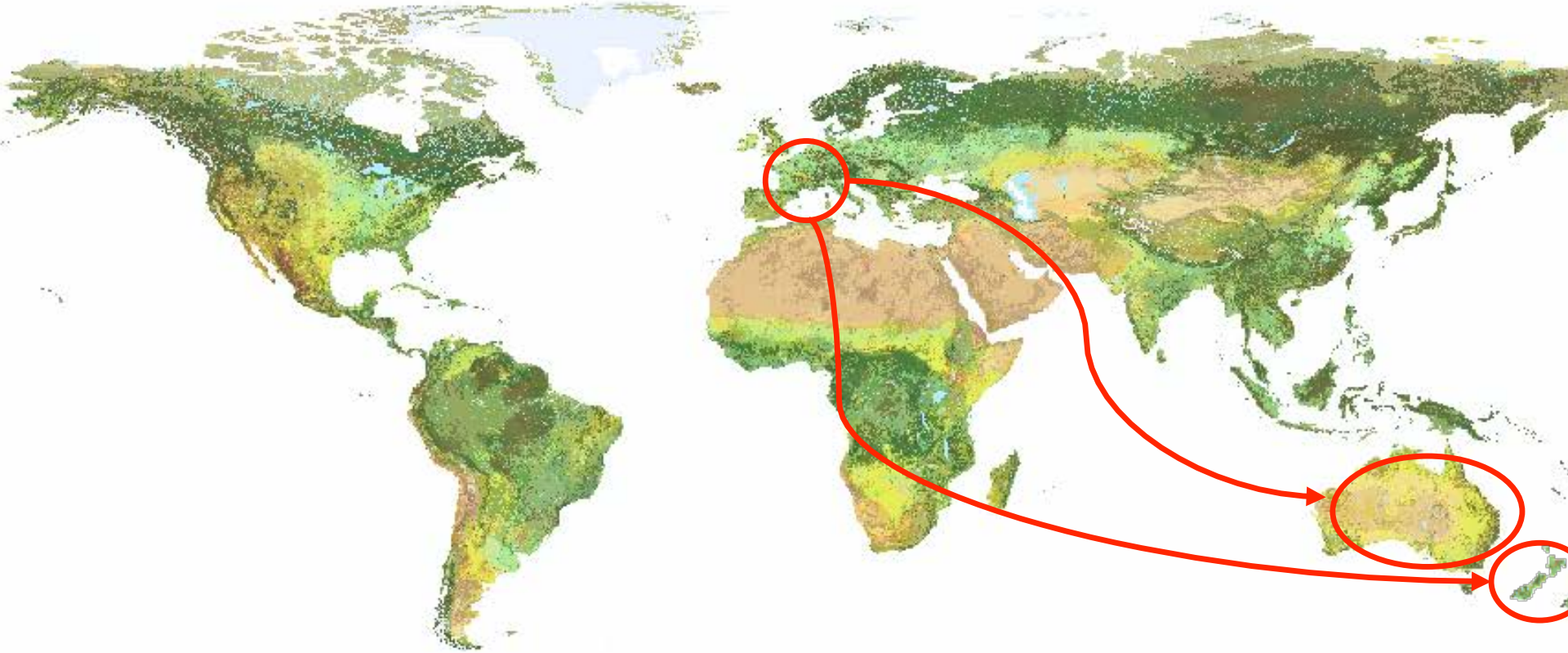
1910



Brazil → France → Israel → Georgia, Ukraine

Wild to the bench

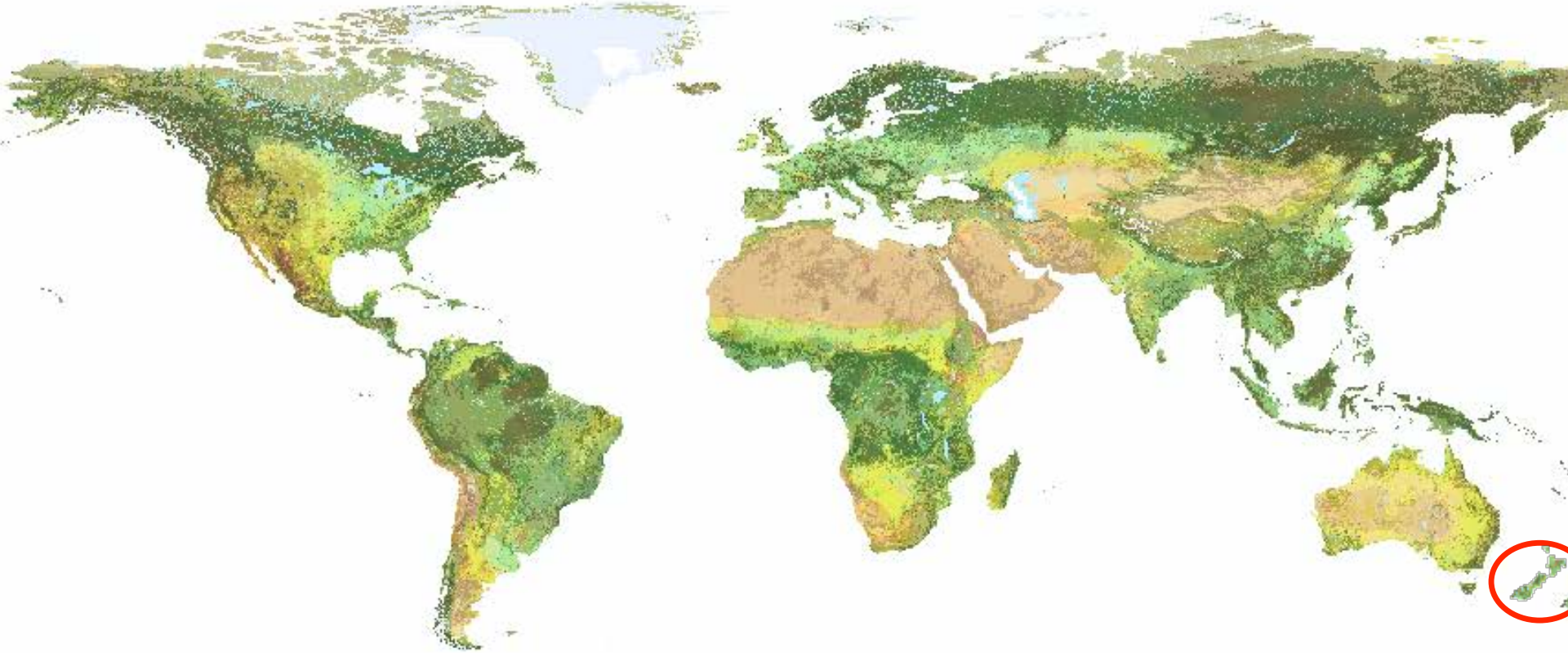
1910



France → Israel

→ New Zealand

Wild to the bench

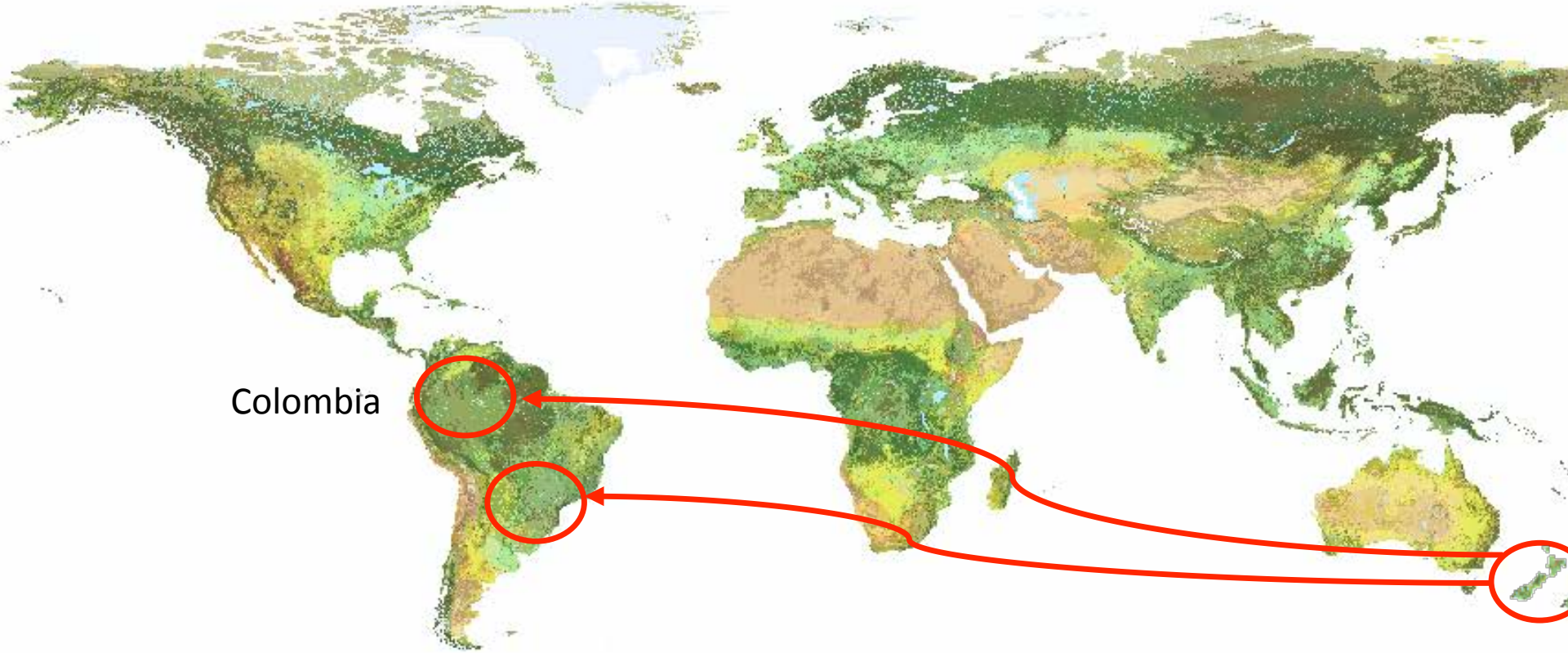


New Zealand

var. Mamoth, Apollo, Triumph, Unique and Gemini

Wild to the bench

2007



Helena cultivar from crossing between 101 access [collected in Urubici (SC)] x Unique

Mass selection

Products


HINTERLAND
feijoas
Feijoa Jam
Made from organic feijoas grown on our farm in the Sunshine Coast
280g net


Yoplait
Apricot & Feijoa
97% fat free
Source of calcium
Probiotic culture
No artificial colours or flavours
1Kg


LOTHLORIEN


NEW ZEALAND
PREMIUM
FRUITY
FEIJOA
CHOCOLATE
35% COCOA | MILK CHOCOLATE
MADE IN NEW ZEALAND 100g NET


PINTO
TOTALLY ORGANIC
Feijoa & Appl
PHOENIX
Muse


Las Margaritas
AREQUIPE CON PULPA DE FEIJOA
Las Margaritas
MERMELADA DE FEIJOA
Las Margaritas
FEIJOA EN ALMIBAR


Puhoi
VALLEY
Fabulous
Feijoa

1. Germoplasm collection in EPAGRI, São Joaquim (SC) 1995 - Present

BAG *Acca sellowiana* – Epagri/S. Joaquim.
Photo: JPHJ Ducroquet

345 accessions in the BAG

1. Mass selection 1995

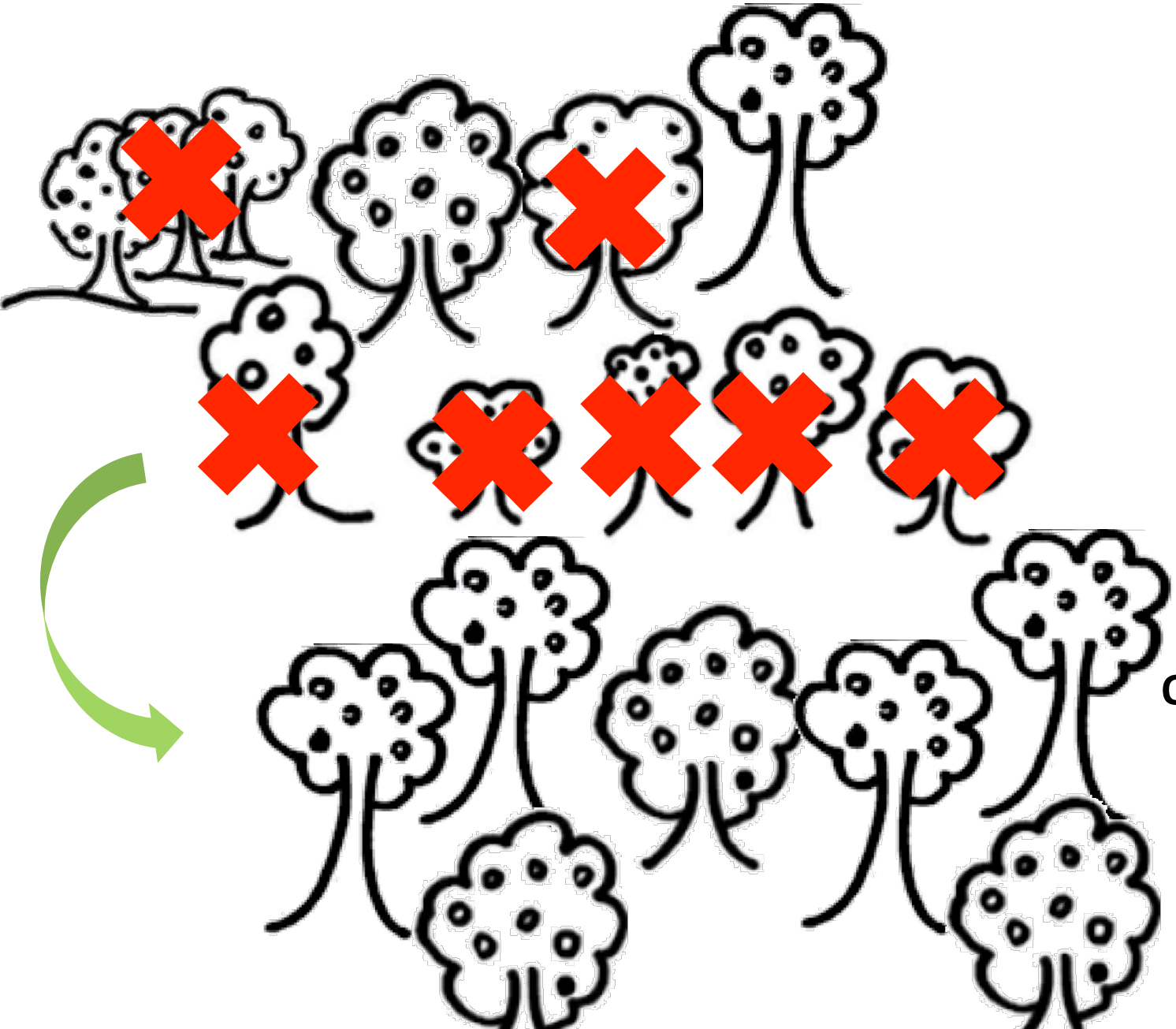
BAG *Acca sellowiana* – Epagri/S. Joaquim. Photo: JPHJ Ducroquet

210 plants

BAG

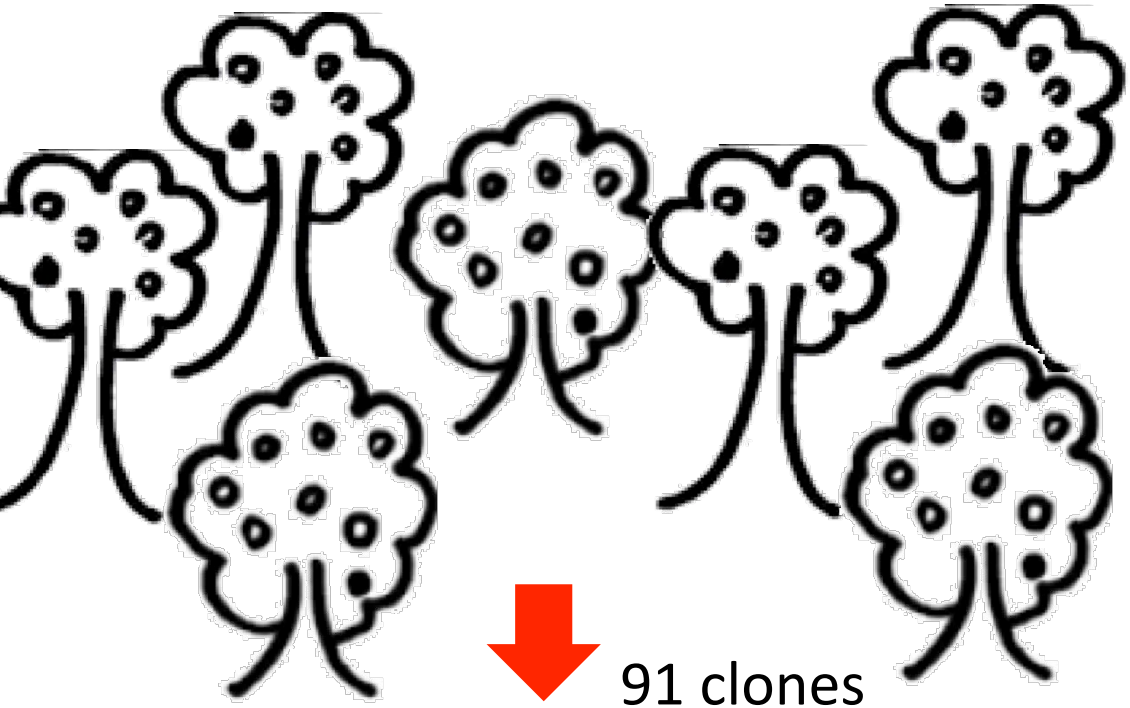
80 pre-selected clones from segregating populations

Approach 1. Mass selection: 290 plants, dialelic breeding

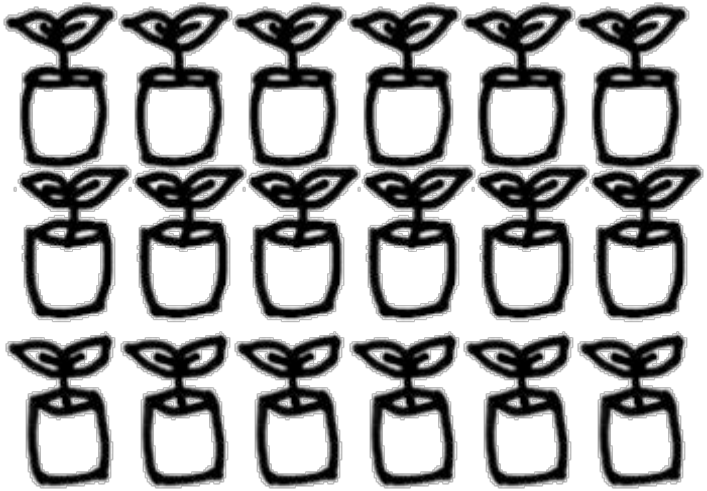


21 families
Open pollination

Approach 1. Mass selection - 840 segregating plants



91 clones



Vol. 20, nº 2, jul. 2007 - R$ 10,00
ISSN 0103-0779

Epagri

Agropecuária catarinense

Goiabeira serrana

Lançadas as primeiras cultivares brasileiras

- SCS 115 CL: nova cultivar de arroz irrigado
- Sistema Clearfield de produção de arroz irrigado
- Agroecoplano para Santa Catarina
- Microdestilaria de álcool: gera renda e proteção ambiental

Agropecuária Catarinense - Vol. 20, nº 2, jul. 2007 - R$ 10,00

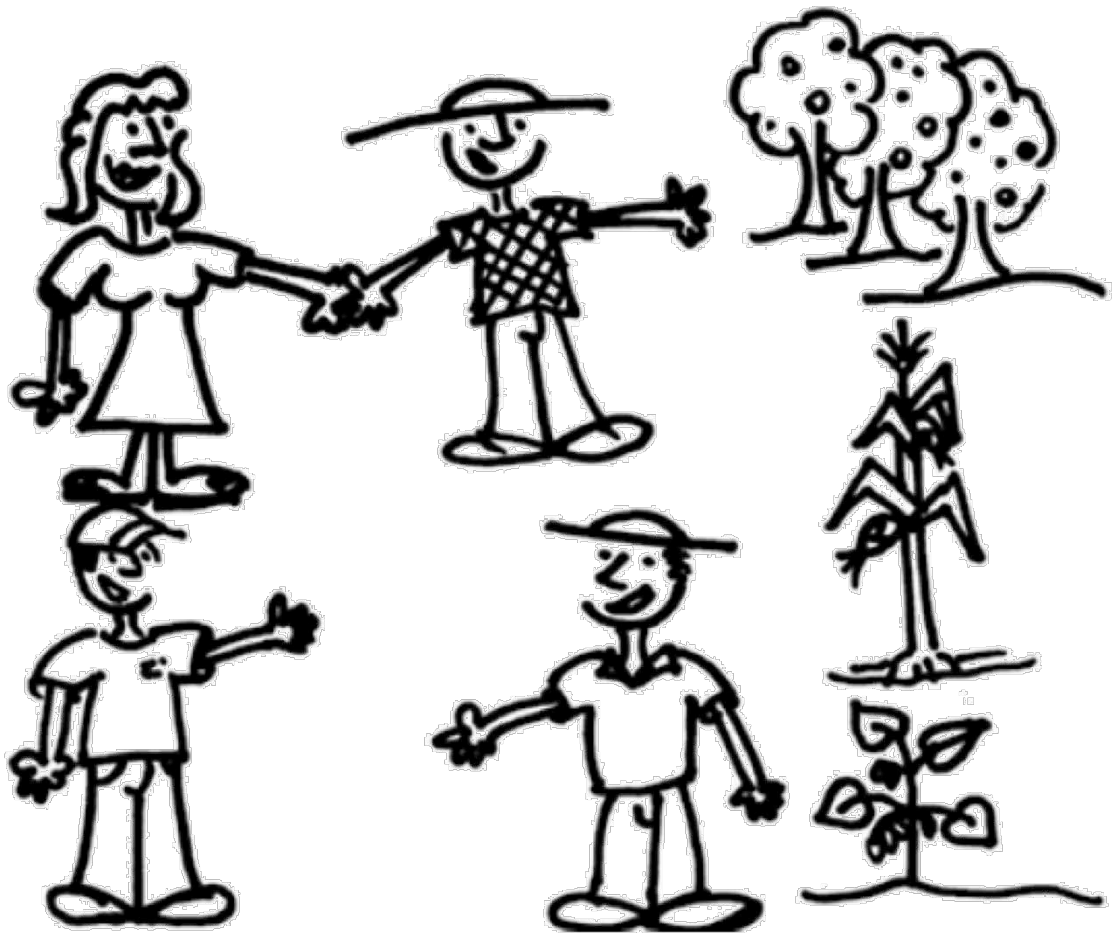
The new varieties

Selection criteria – evaluated traits

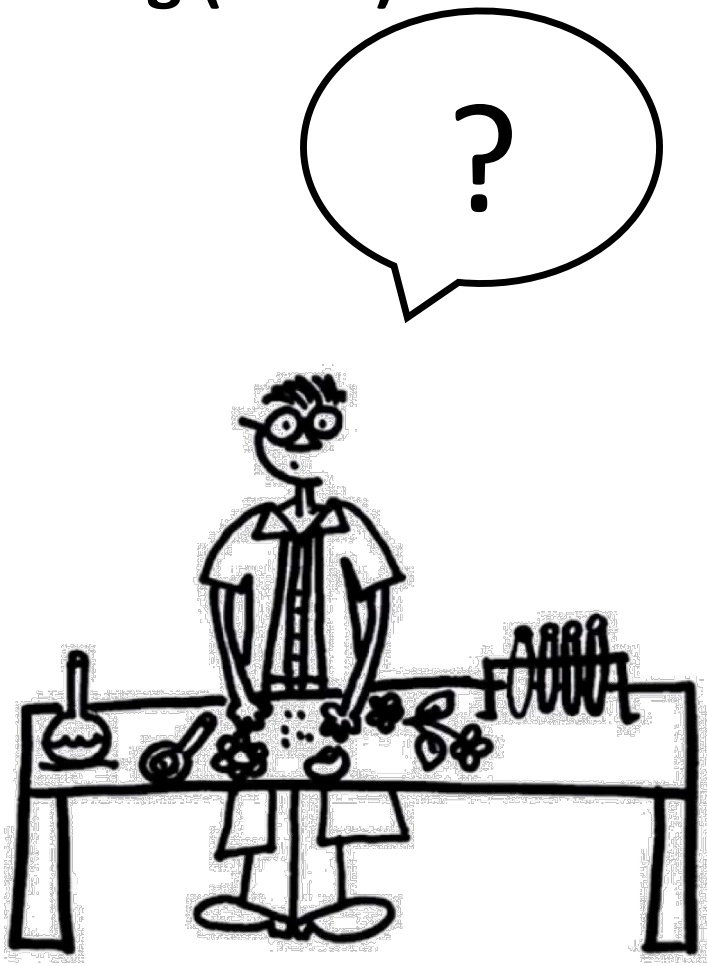
- Canopy architecture
- Stem and canopy shape
- Beginning of sprouting
- Beginning/end of flowering
- Beginning/end of ripening
- Fruit color, shape and size
- Ratio pulp/peel
- Ratio acidity/Brix
- Yield alternation
- Diseases susceptibility
  - Anthracnose
  - Flower rot

- Establishment of 36 descriptors which were published by the Service of Cultivars Protection of the Brazilian Ministry of Agriculture (November 12, 2008).
- Emphasis on floral pieces as descriptors.

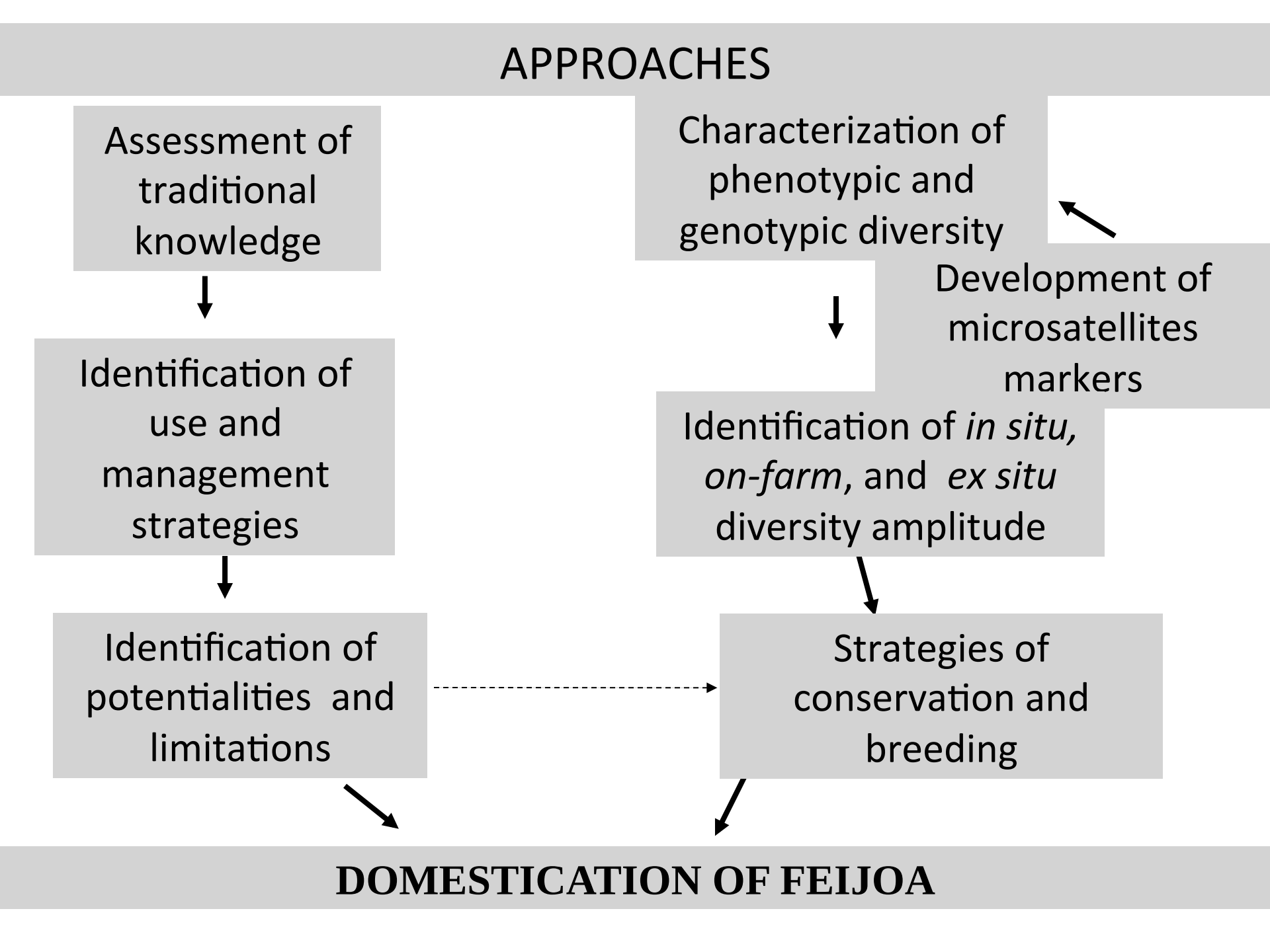
Approach 2. Participatory breeding (2009)



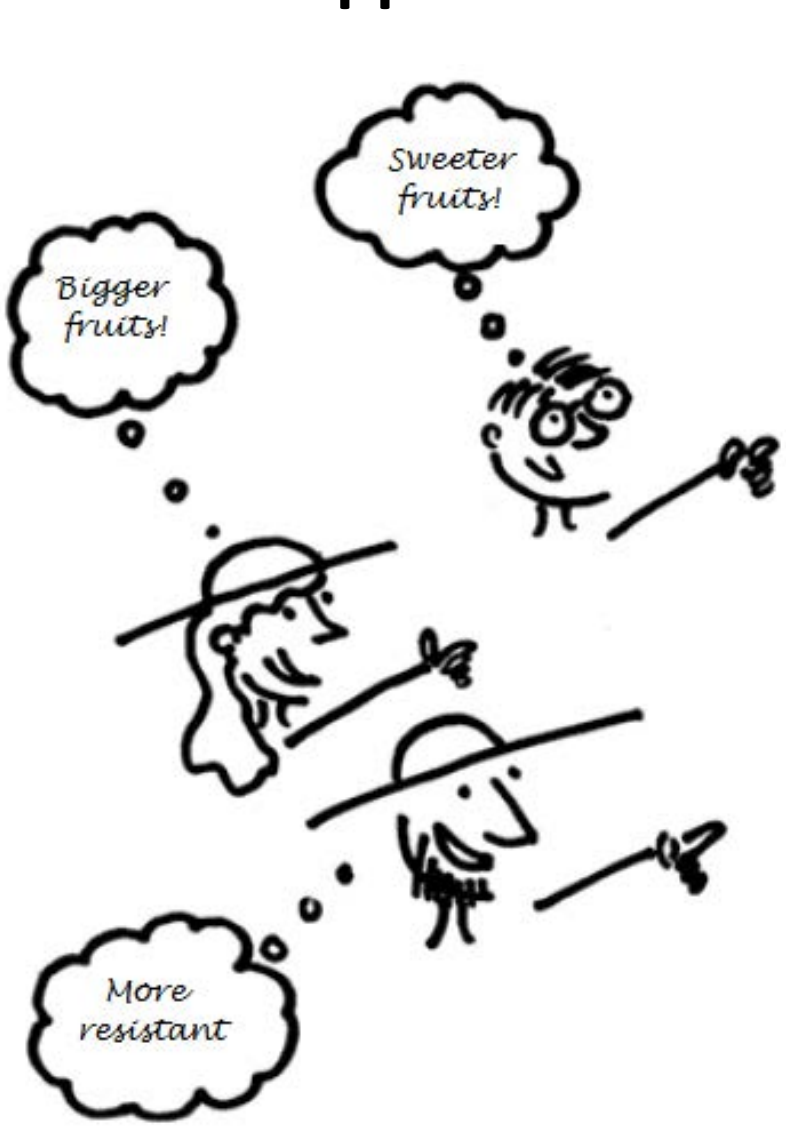
Small farmers

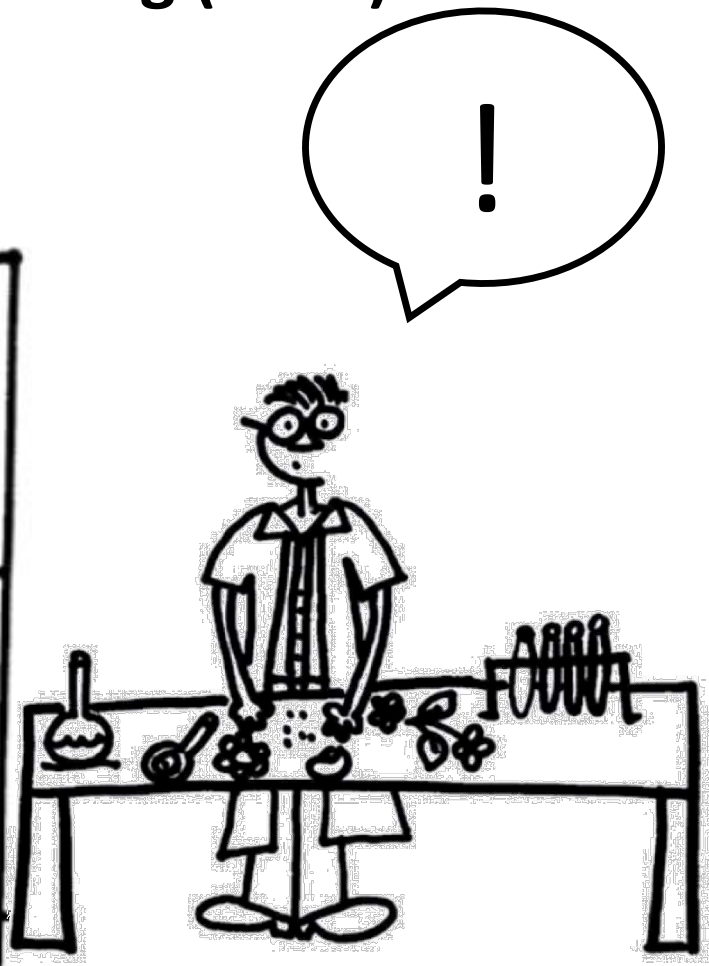


Plant breeder


APPROACHES
Assessment of traditional knowledge
Identification of use and management strategies
Identification of potentialities and limitations
Characterization of phenotypic and genotypic diversity
Development of microsatellites markers
Identification of *in situ, on-farm*, and *ex situ* diversity amplitude
Strategies of conservation and breeding
DOMESTICATION OF FEIJOA

Approach2. Participatory breeding (2009)

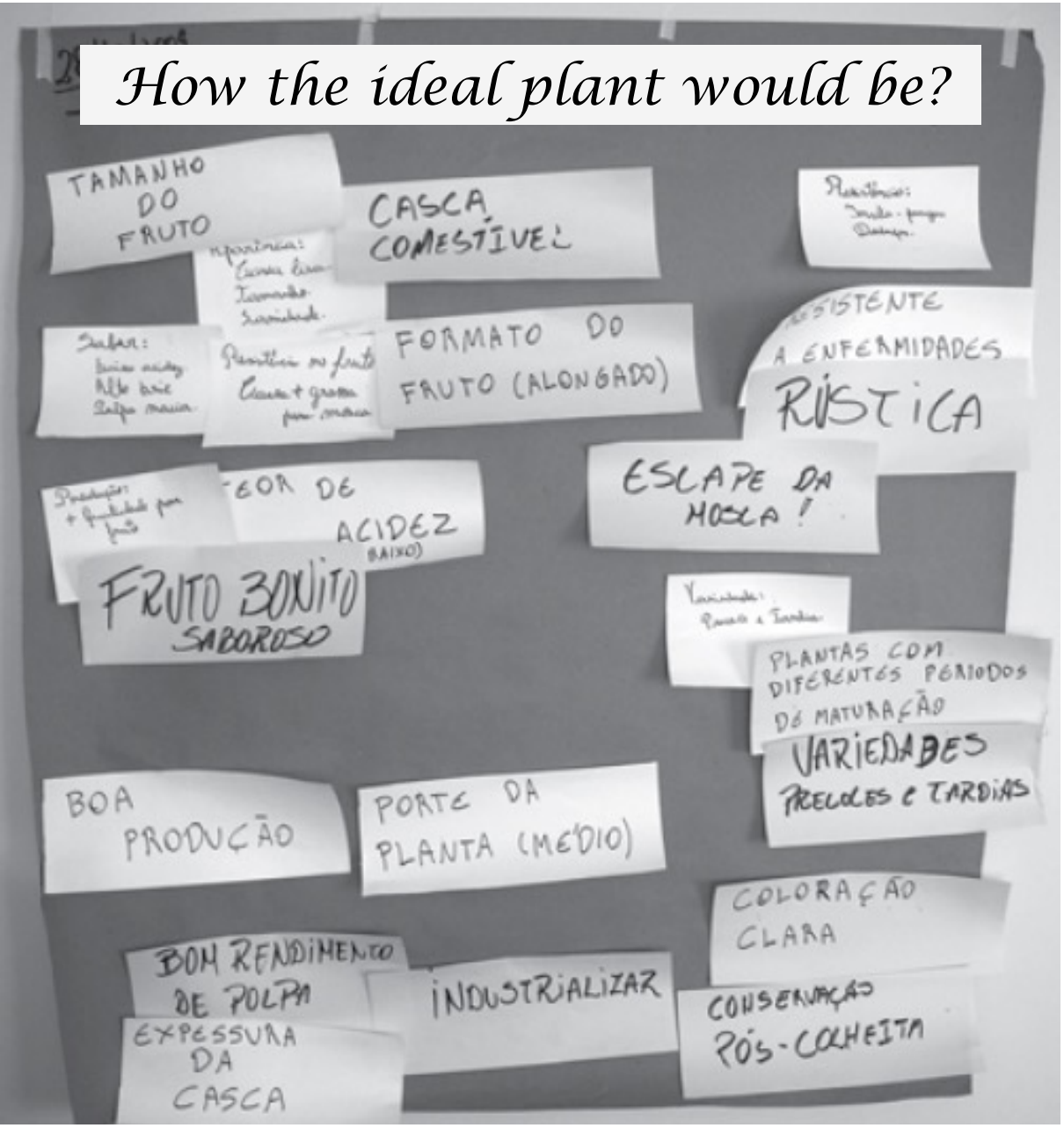


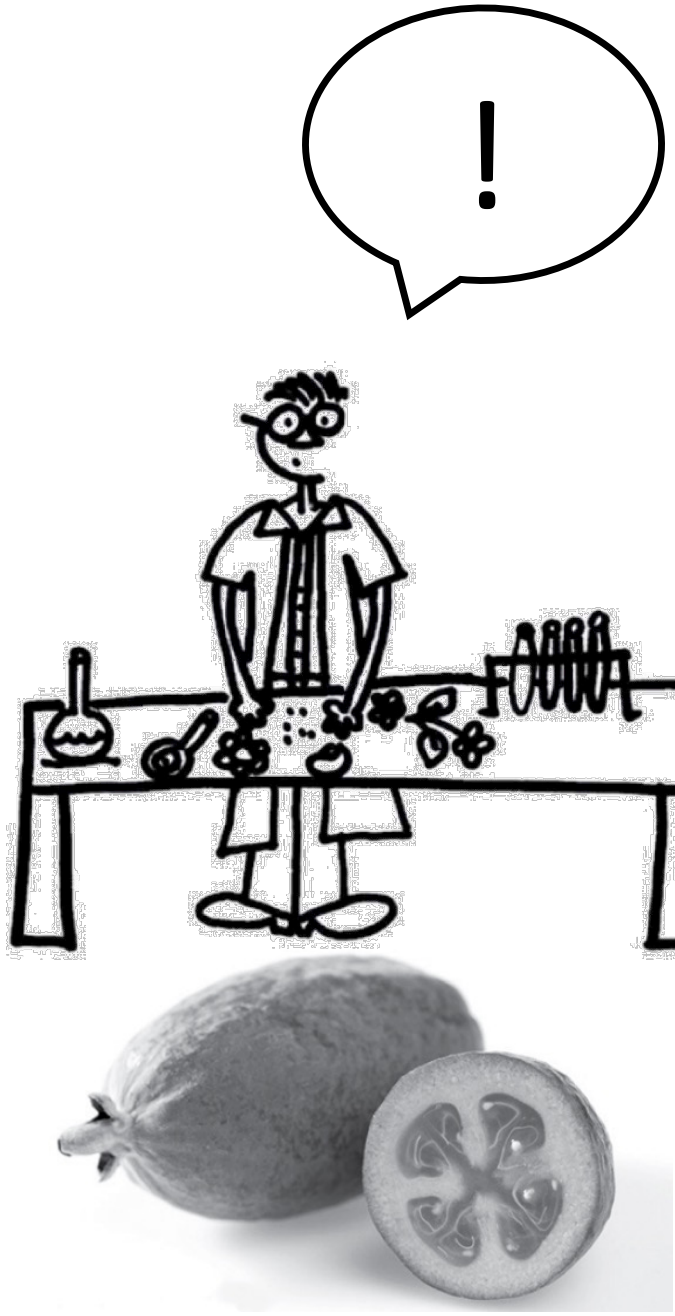


Small farmers

Plant breeder

Approach 2. Participatory breeding (2009)





The ideal Feijoa

Period of maturation
- Early and late varieties
- Distinct periods of maturation

Flavor
- Lower acidity
- Higher Brix
- Tasty

Yield
- Elevated fruit production

Fruit
- Edible peel
- Size
- Pleasant esthetic
- Thin and smooth peel
- Quality
- Bright color
- Elongated shape

Fruit pulp
- Soft
- Good yield

Post harvest
- Conservation
- Industrial processing

Rusticity
- Sanity
- Gross peel against fruit flies
- Resistance against pathogens and plagues
- Maturation out of the usual period

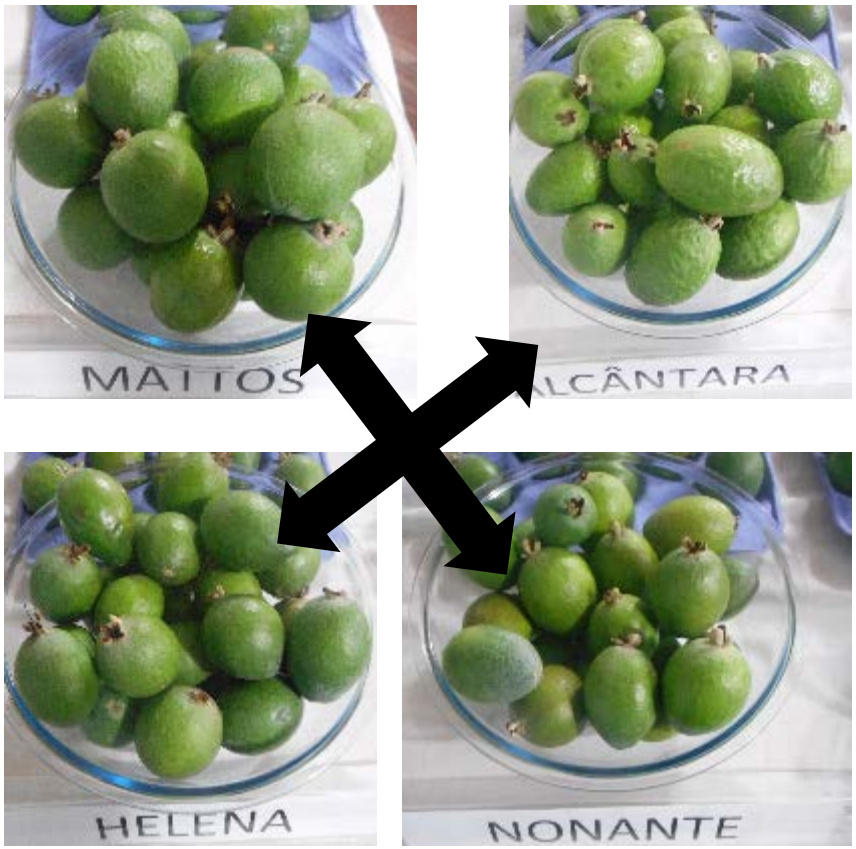
Plant architecture
- Medium size

Adapted from Donazzolo, 2012.

Summary of the shifts of morphophysiological traits from natural 713 populations to human-managed or selected feijoa populations

Location	Trait	Naturally occurring types			Domesticates		
		n	Mean	Sd	n	Mean	Sd
São Joaquim, Urubici, and Urupema (Fig. 1, Brown), state of Santa Catarina.	Fruit diameter (cm)	68	4.0	0.65	97	4.5	0.62
	Fruit length (cm)	68	4.7	0.82	97	5.3	0.99
	Fruit weight (g)	68	47,4	21,5	97	67.6	28.2
	Pulp yield (g)	27	28.6	4.49	68	25.6	5.58
	Solid Soluble content (^{o}Brix)	68	11.1	1.05	97	11.2	1.49
Ipê, Antonio Prado and Monte Alegre dos Campos (Fig. 1, Gold), state of Rio Grande do Sul	Fruit diameter (cm)	41	3.5	0.42	202	4.2	0.61
	Fruit length (cm)	41	4.1	0.67	202	5.2	0.81
	Fruit weight (g)	41	30.7	11.31	202	55.2	23.5
	Pulp yield (g)	41	35.2	4.70	202	34.4	6.91
	Solid Soluble content (^{o}Brix)	41	12.0	1.04	202	11.6	1.27
	Peel thickness (cm)	41	0.4	0.11	202	0.5	0.2
All studied locations indicated in Fig. 1	Peel roughness	Smooth, rough and intermediate			High frequency of smooth		
	Auto-incompatibility	Near 50%			Highly frequent		

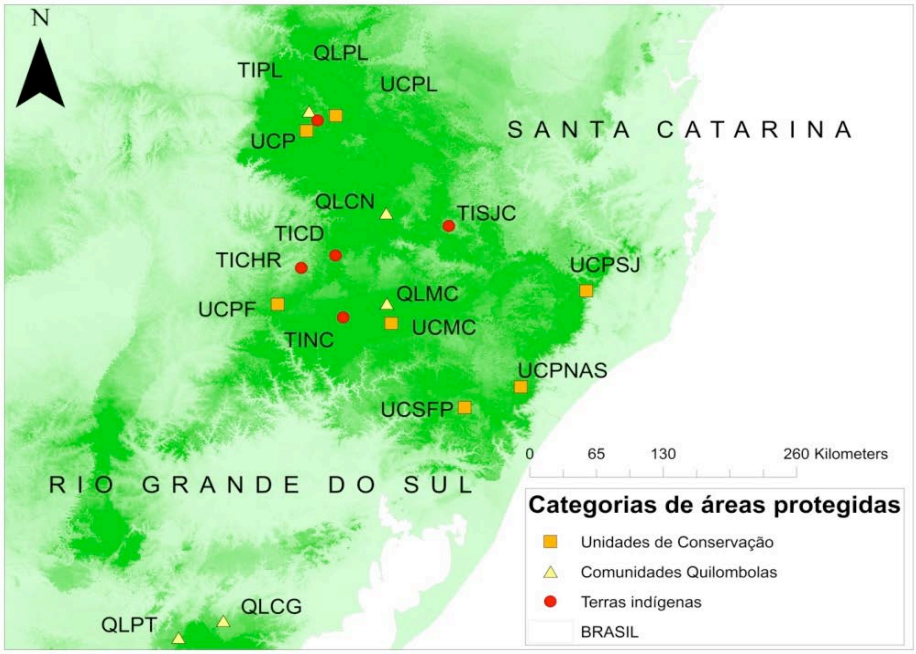
Approach 2. Participatory breeding (2009) – Step 2



Seedlings to the community

Approach 3. Home gardens – Vacaria County, RS

Approach 4. UCs, quilombolas and indigenous communities



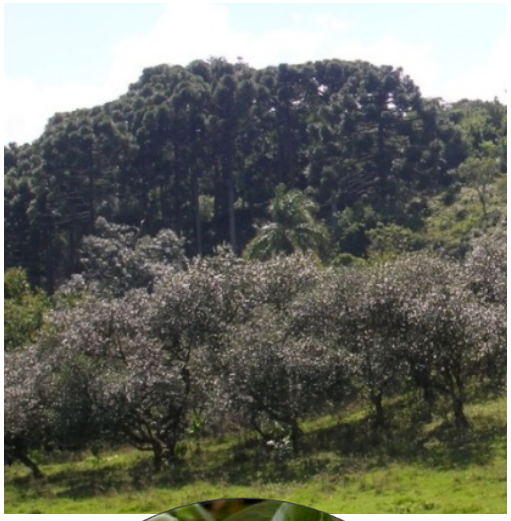
Phenotypic variability in feijoa fruits on indigenous lands, quilombolas communities and UCs in the South Brazil (Right). Left: map of the States of South Brazil with those communities and UC showing the distribution of feijoa (Borsuk, 2015).

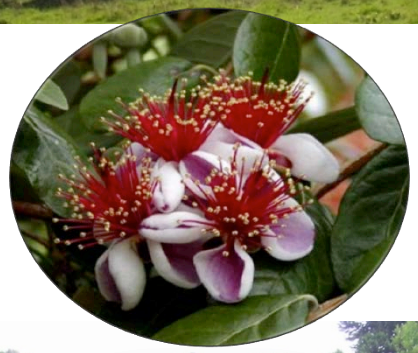
A. sellowiana in the Quilombola Communities Invernada dos Negros. Borsuk, 2015.

A. sellowiana associated with *Araucaria angustifolia* in indigenous lands of Cacique Double, and Palmas. Borsuk, 2015.

4. Wildlife Resources

Forest borders





Grassland

Home gardens

"Potreiros"

Average number of SSR per locus (A) and Wright's fixation index (*f*) of naturally occurring and managed or selected feijoa populations in southern Brazil

Location	Population type	n	Number of loci	A	*f*
São Joaquim, Urubici, and Urupema (Fig. 1, Brown), state of Santa Catarina.	Naturally occurring	66	12	9.7	0.066
	Domesticates	98	12	11.2	0.055*
Ipê, Antonio Prado and Monte Alegre dos Campos (Fig. 1, Gold), state of Rio Grande do Sul	Naturally occurring	101	9	16.4	0.032
	Domesticates	85	9	15.0	0.147*
Five locations, Figure 1, Green	Naturally occurring in Conservation Units	57	7	13.6	0.170*
Five Indigenous People lands (Fig. 1, Red), and five Quilombolas Communities (Fig. 1, Aquanarine)	Managed or selected population by Traditional People	56	7	12.0	0.241*

Source: Unpublished data from Donazzolo (2012); Borsuk (2015); Santos (2009).
n= sample size per population, * - Statistically different of zero.

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CHEMICAL COMPOSITION OF FRUITS OF A FEIJOA (F. SELLOWIANA) IN THE CONDITIONS OF SUBTROPICS OF RUSSIA

Oksana Belous, Magomed Omarov, Zuchra Omarova

ABSTRACT

The feijoa is culture quite widespread on the Black Sea coast of Russia. Difficulties are connected with absence in Russia of grades. All gardens have only the mix of grades, which is grown up from seeds. At institute are going of work on creation of productive varieties, with good quality parameters. Data on chemical and biochemical composition of fruits of high-

Functional fruit
High content Vitamin C

subtropics the grades containing increased quantity of carotinoids are steadier (0.31 $mg.g^{-1}$). The contents in fruits of a feijoa of such substances, as vitamin P, P-active and pectin substances, ascorbic acid, macro and microelements are revealed. Fruits of a feijoa are differed the increased accumulation of sugars, at some forms the content of sucrose prevails over amount of monosaccharide. High accumulation of vitamin C (41.89 - 78.68 $mg.dL^{-1}$) is noted. But we don't confirm the high content of iodine in fruits. Fruits of a feijoa can be considered as potential raw materials for production of canned products with a functional purpose.

Keywords: feijoa; form; vitamin; sugar; catalase; pigment; sugar-acid coefficient

Document heading doi:10.12980/JCLM.2.2014J12

Phytochemical composition and gastroprotective effect of *Feijoa sellowiana* Berg fruits from Sicily

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- antibacterial, analgesic, anti-inflammatory, antioxidant and anticancer;
- protection of the gastrointestinal mucosa
- Nutraceutic fruit.

histopathological observations.
Details on Page 20

KEYWORDS
Feijoa sellowiana Berg var. *coolidge* and *gorgiona*, Polyphenols, Tocopherols, Gastroprotective effect, HPLC, Peel, Pulp

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Review

Bioactive products from fruit of the feijoa (*Feijoa sellowiana*, Myrtaceae): A review

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ABSTRACT

The feijoa plant (*Feijoa sellowiana*, family Myrtaceae, synonym, *Acca sellowiana*) produces fruit similar to that of the guava. It is native to Brazil but is grown in many countries as a food crop, especially New Zealand, where it is valued for its highly aromatic fruit. This review covers published work on the bioactive components of the fruit of the feijoa and their pharmacology. Potential value might be added to this fruit if extracts of the fruit were to be used for nutraceutical purposes.

- Antimicrobial
- Anticancer
- anti-inflammatory
- Stimulatory immune system
- Antioxidant activity
- Essential oils
- Source of lipids and micronutrients
- Modulation of enzymes responsible for sugars hydrolysis

Patent

- Extract used for elaboration of food supplement to relieve pain and inflammation;
- Anti-oxidant;
- Reduces cholesterol absorption;
- Prevention and treatment diabetes type 2;
- Prevention and treatment of rheumatoid arthritis;
- 268 references of Feijoa in patented products

Weston, 2010

Concluding remarks

- Relying on a limited number of plant food species threatens global food security;
- Biodiversity hotspots should be a priority target for germplasm prospection and conservation to increase global food security;
- Is urgent to compile and unify regional, country and continent-based catalogs and data base on genetic resources to expand food and agriculture at a global level;
- Introducing new plant species of into the global food chain is one of the most important and urgent actions to counteract the negative effects of GCC;
- At the global level it is necessary to redesign a new sustainable agriculture on a more environmentally friendly basis.

…**and last but not least**

- Based on my experience, my best hunch: in the tropics and subtropics, more perennials plants;
  - They are more stable, productive and resilient.

Muchas Gracias

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

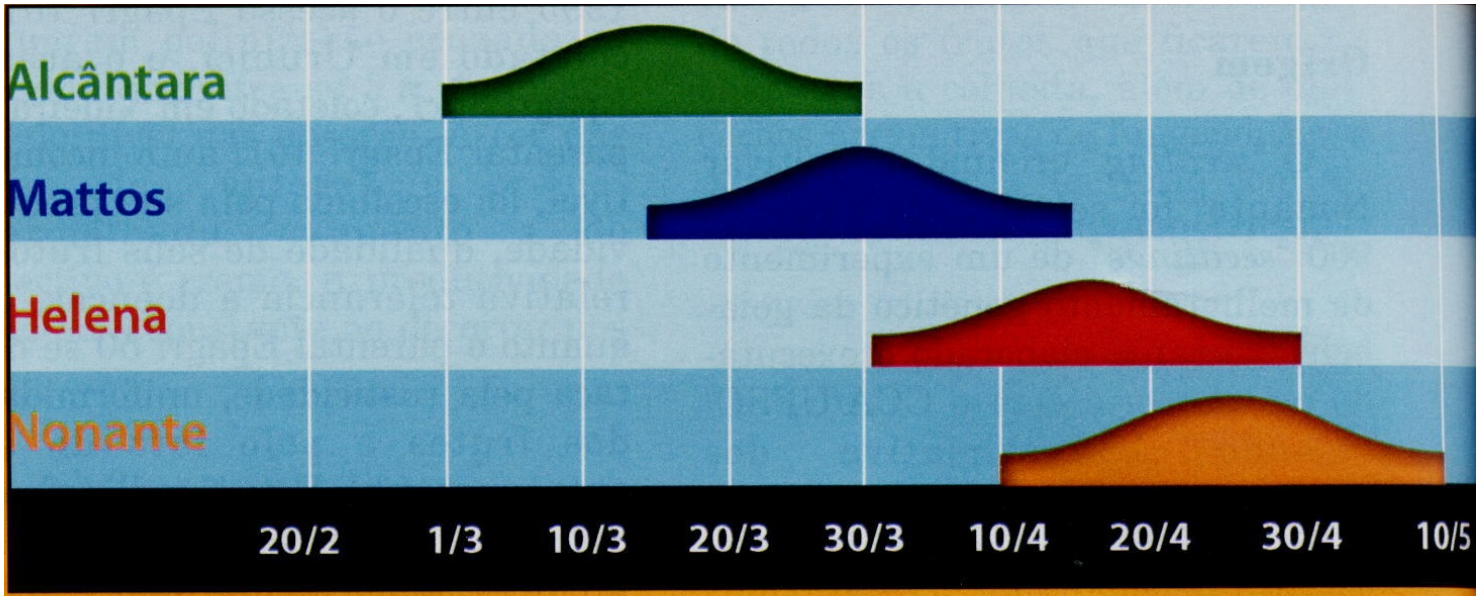
UFSC

UFSC RG

LFDGV

FAPESC
FUNDAÇÃO DE APOIO À PESQUISA CIENTÍFICA E TECNOLÓGICA DO ESTADO DE SANTA CATARINA

CAPES


Alcântara
Mattos
Helena
Nonante
20/2
1/3
10/3
20/3
30/3
10/4
20/4
30/4
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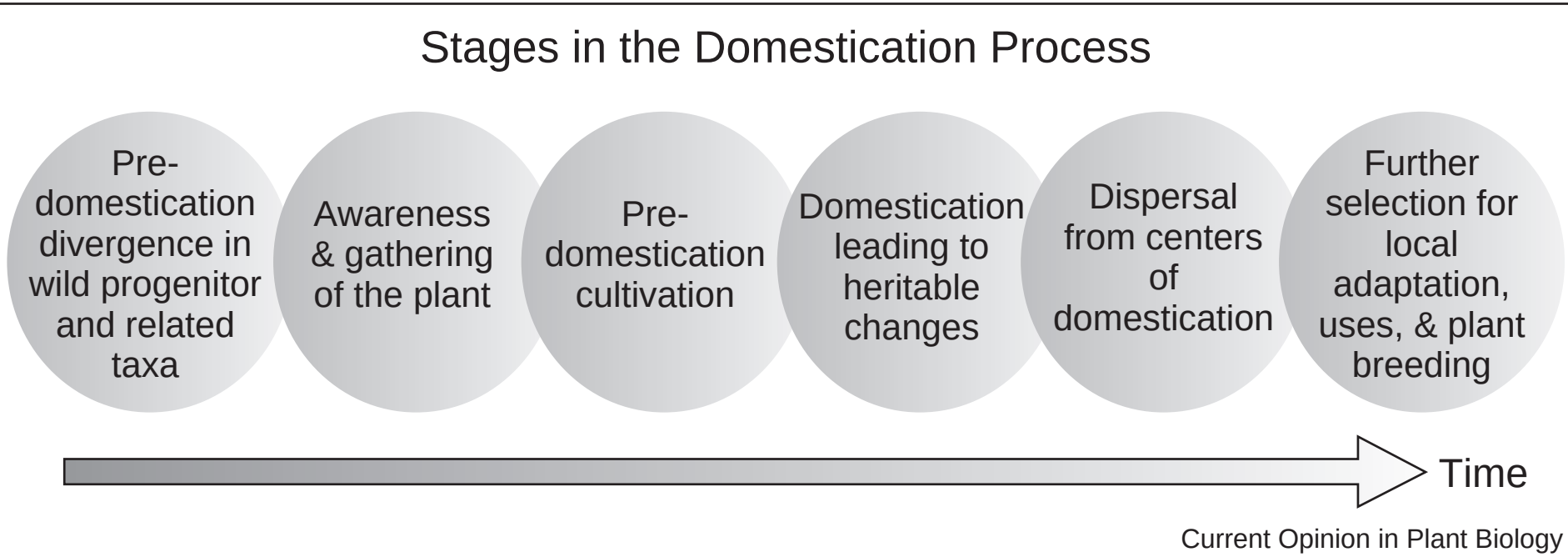


Successive stages in the transition from wild-gathered to domesticated plants. The actual duration of the transition may depend on the crop plant and center of domestication, but is thought to have lasted from several 100 to several 1000 years.

Variabilidade de formato e aspecto

Brazil - Passiflora

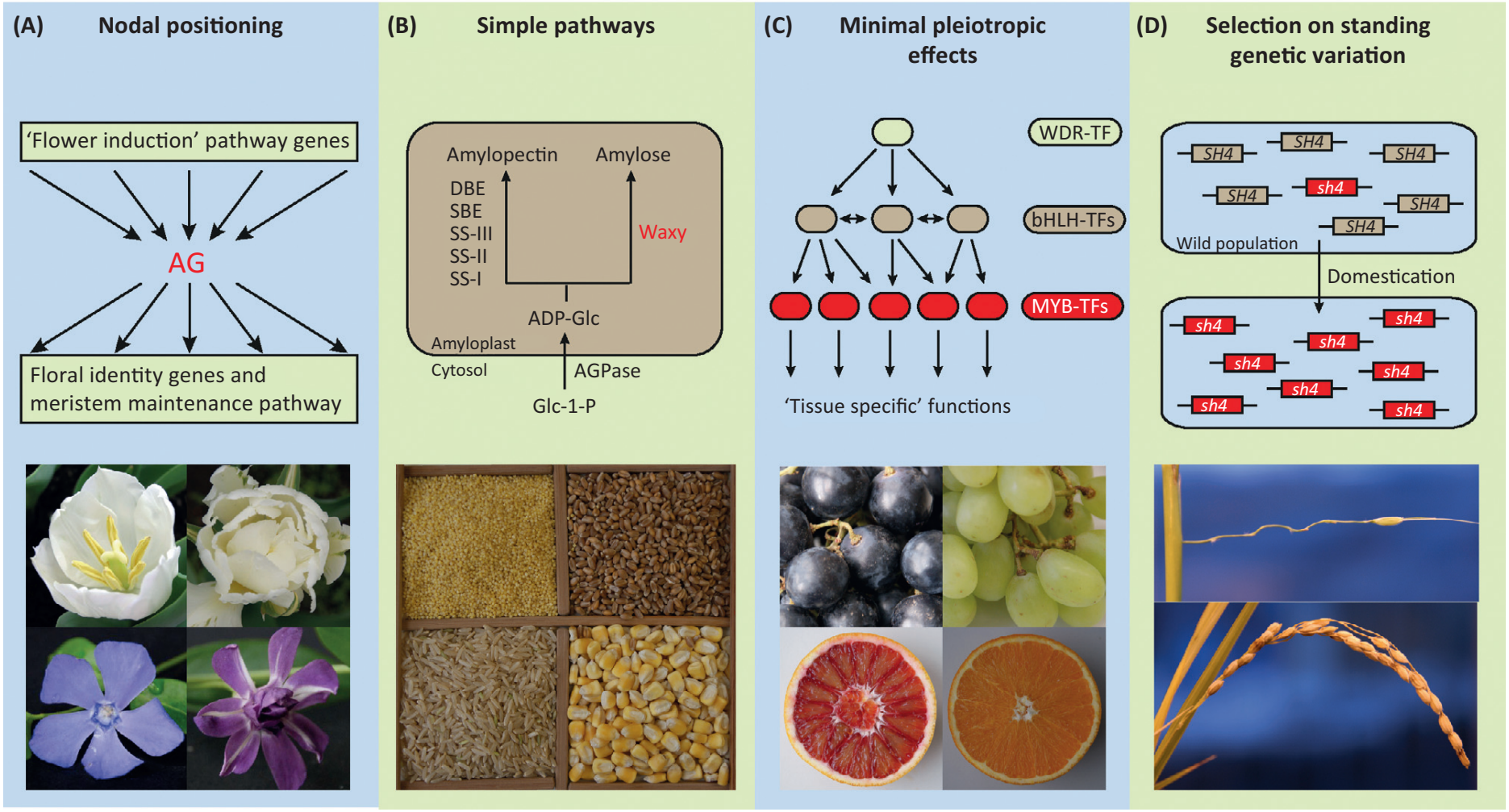
- Brazil - Paraguay center
  - In Brazil: more than 150 species
- Food, medicinal and ornamental value

http://www.cpac.embrapa.br/passitec/estudarpassifloras/

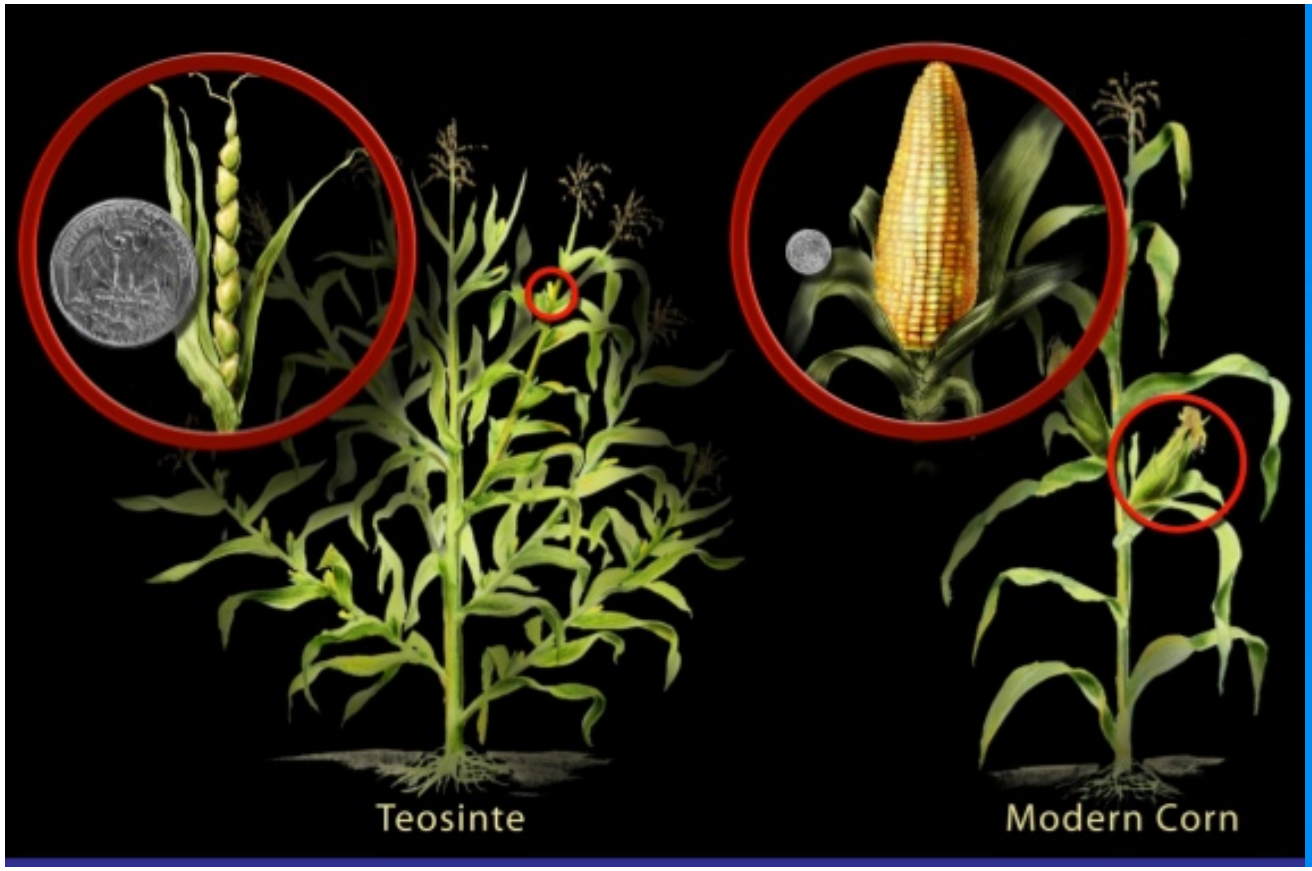
Unconventional food plants in Brazil

This **book describes more than 300 species native and exotics**, each with 3 recipe suggestions, with photos, scientific names and popular names.

Factors promoting convergent molecular domestication

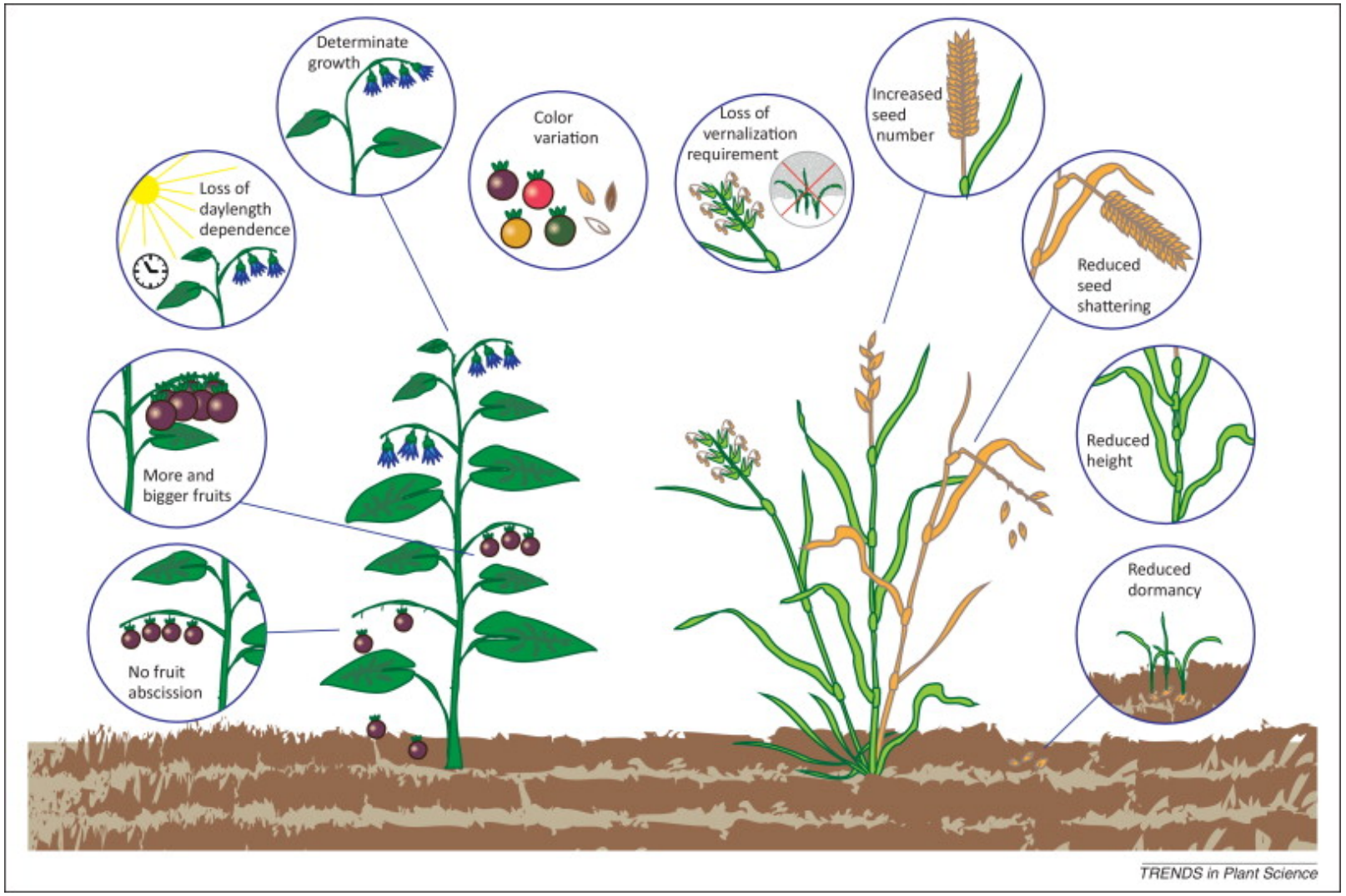


TRENDS in Plant Science


Teosinte
Modern Corn

Molecular mechanisms involved in convergent crop domestication

(Lenser &Theiben,2013)



DOI: http://dx.doi.org/10.1016/j.tplants.2013.08.007

1. Germoplasm collection in EPAGRI, Videira (SC) 1986 - 1995

Through competition in rural residents in the São Joaquim region (SC), it was possible to collect 148 accessions, of which the 49 best were introduced in the EEV collection.

Other 100 accessions were introduced from “maintainers,” “managers,” “cultivators", or collections from other countries.

Figura 1 - *Secamento da planta provocado por antracnose*

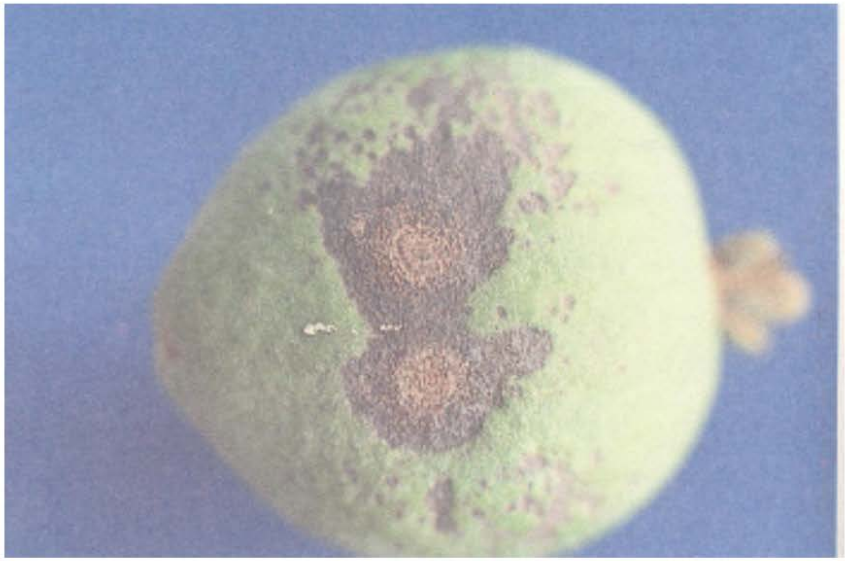


Figura 2 - *Dano no fruto causado por antracnose*

Colletotrichum gloeosporioides

Parker et al., 2010. **Domestication Syndrome** in Caimito (*Chrysophyllum cainito* L., Sapotaceae): Fruit and Seed Characteristics. Economic Botany, 64(2).

- Cultivated throughout the Caribbean, Central, South America, and Southeast Asia

Fig. 1. Locations of sampled wild and cultivated trees of *Chrysophyllum cainito* in central Panama. Rural communities and urban plantings are interspersed with protected forests harboring populations of wild *C. cainito*.

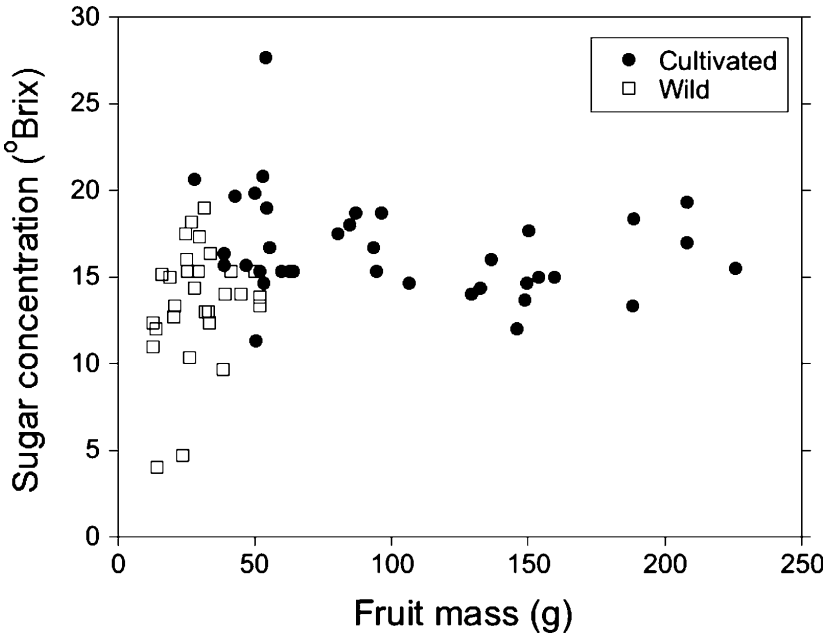


Fig. 4. Sugar concentration (°Brix) by fresh fruit mass (g) for means (over three fruits each) of individual *Chrysophyllum cainito* trees in central Panama. Filled circles are cultivated trees, open squares are wild trees. A Discriminant Function selected these two variables as most important in distinguishing cultivated from wild trees.

- Compared to their wild relatives, edible fruits of domesticated taxa tend to be larger and sweeter or higher in oil content.
- The ratio of edible product to waste, or "economic ratio" (Clement 1989), goes up.
- We also expect a reduction in toxic compounds that confer defense against natural enemies at the cost of palatability.

Food security & nutrition

1. Ng et al. 2014 2. FAO State of Food and agriculture, 2014 3. Global hunger index 2014

Dietary energy supply *can* be satisfied without diversity

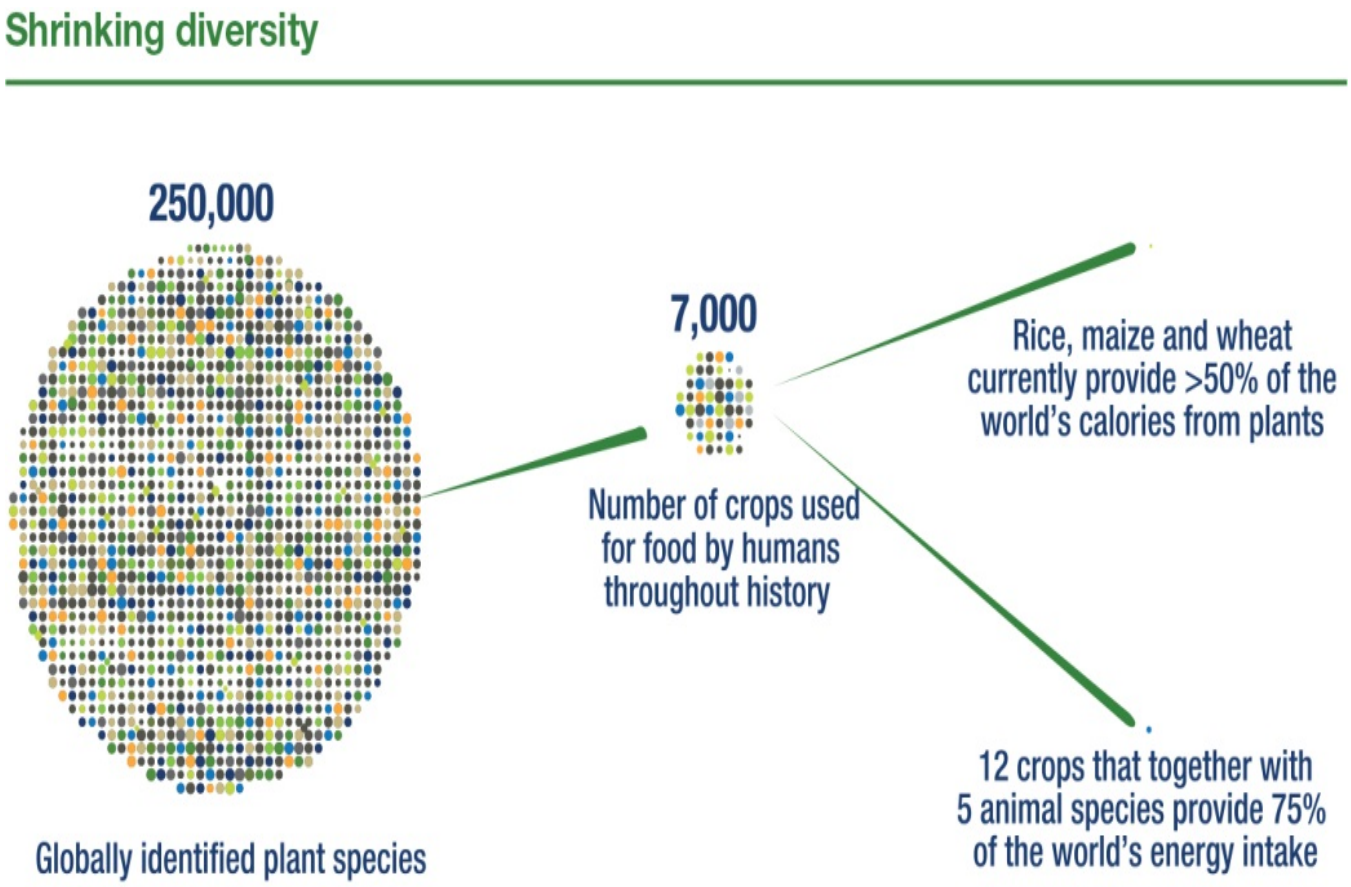
Micronutrient supply *cannot* be satisfied

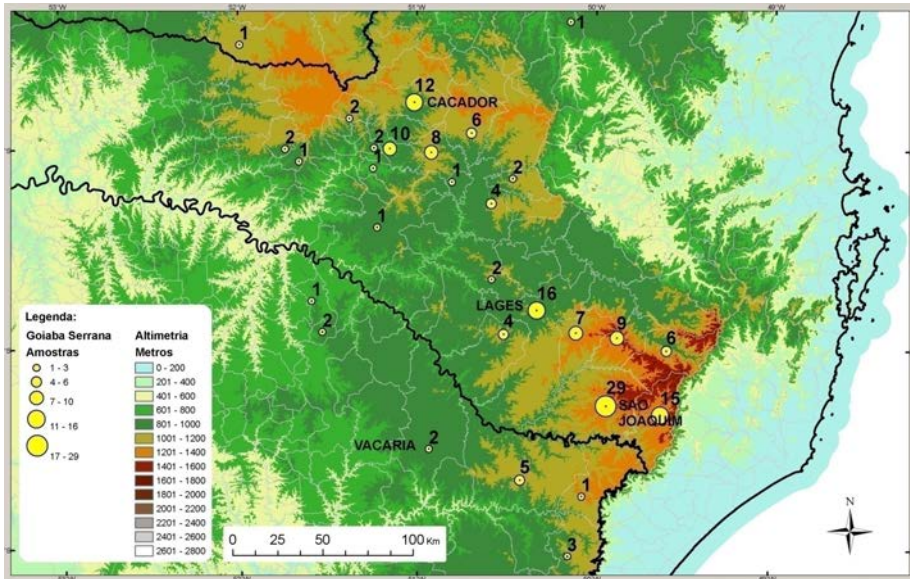
Future foods: What will we be eating in 20 years' time?

http://www.bbc.co.uk/news/magazine-18813075

Biodiversity & health linkages: Agricultural biodiversity

Agrobiodiversity underpins resilience yet…




CACADOR
LAGES
SAO JOAQUIM
VACARIA
Legenda:
Goiaba Serrana
Amostras
1 - 3
4 - 6
7 - 10
11 - 16
17 - 29
Altimetria
Metros
0 - 200
201 - 400
401 - 600
601 - 800
801 - 1000
1001 - 1200
1201 - 1400
1401 - 1600
1601 - 1800
1801 - 2000
2001 - 2200
2201 - 2400
2401 - 2600
2601 - 2800
0 25 50 100 Km
N

Revisiting Vavilov by N. Myers: The Hotspots of Biodiversity

Tumbes-Chocó-Magdalena
Endemic plant species 2.750

Tropical Andes
Endemic plant species - 15.000

Atlantic Forest
Endemic Plant Species - 8000

Cerrado
Endemic Plant Species - 4400

http://www.biodiversityhotspots.org/xp/Hotspots/resources/maps.xml

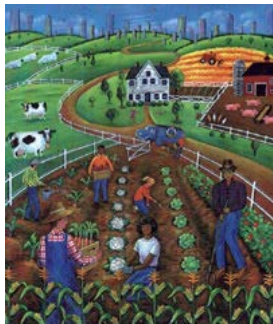
FOOD SECURITY

- Refers to the availability of food and one's access to it. A household is considered food-secure when its occupants do not live in hunger.

- Worldwide around 852 million people are chronically hungry due to extreme poverty, while up to 2 billion people lack food security intermittently due to varying degrees of poverty (FAO, 2003). Six million children die of hunger every year - 17,000 every day.

- Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

- Food security for a household means access by all members at all times to enough food for an active, healthy life. Food security includes at a minimum (1) the ready availability of nutritionally adequate and safe foods, and (2) an assured ability to acquire acceptable foods in socially acceptable ways (USDA).



Brazilian biodiversity ≅ 20 % world

- The most diverse flora (Heywood, 1995): 45,000 – 55,000

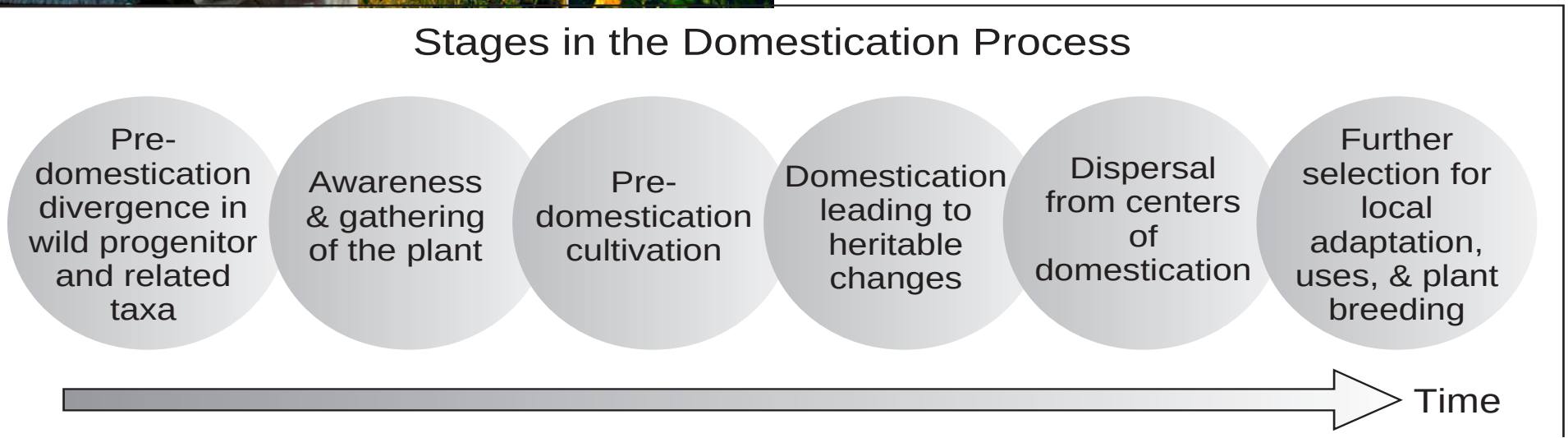
- Brazilian flora (2017): 46.403 sp
  - Angiosperms - 33.022 sp
  - Algae - 4.751 sp
  - Bryophytes - 1.552 sp
  - Ferns and Bryophytes - 1.322 sp
  - Gymnosperms – 30 sp
  - Fungi - 5.726 sp

- Three of the richest world biomes in plant species:
  - Amazon
  - Atlantic forest
  - Cerrado

http://floradobrasil.jbrj.gov.br

The domestication syndrome

(A) Conversion of teosinte to maize ear involved a change from a few small, loosely connected to a large maize cob with many naked seeds. (B) Loss of seed shattering during rice domestication. (C) Fruit size increase in tomato. (D) Loss of branching in sunflower leading to a single, large flower head per plant. Cell *127*, 1309–1321.



Stages in the transition from wild-gathered to domesticated plants. The duration of the transition depend on the crop plant and center of domestication, but is thought to have lasted from several 100 to several 1000 years. Gepts, P. 2014. Current Opinion in Plant Biology.

Plant Domestication (Clement, 1999)

For plant domestication to take place, there must be selection and management to cause differential reproduction and survival.

The degree of change in the targeted population can vary:

- **Wild** - A naturally evolved population whose genotypes and phenotypes have not been modified by human intervention.
- **Incipiently Domesticated** - A population modified by human selection and intervention but whose average phenotype is still within the range of variation found in the wild population for the trait(s) subject to selection.
- **Semi-Domesticated** – Population significantly modified by human selection and intervention so that the average phenotype may diverge from the variation range of the wild population for the trait(s) subject to selection.
- **Domesticated** - A plant population similar to (3) but whose ecological adaptability has been reduced to the point that it can only survive in human-created environments.
    - Landrace
    - Modern cultivar

BAG São Joaquim, SC

PHYTOTHERAPY RESEARCH
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(wileyonlinelibrary.com) DOI: 10.1002/ptr.5629

Acetonic Extract from the *Feijoa sellowiana* Berg. Fruit Exerts Antioxidant Properties and Modulates Disaccharidases Activities in Human Intestinal Epithelial Cells†

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Feijoa sellowiana **fruit has been shown to possess various biological activities, such as anti-bacterial and anti-cancer properties, in a variety of cellular models, but its activity on human intestinal epithelial cells has never**

- Antioxidant properties
- Modulation of enzymes responsible for sugars hydrolysis

Keywords: functional foods; disaccharidases deficiency; lactose malabsorption; sucrase-isomaltase deficiency; oxidative stress.

EPAGRI in collaboration with CCA/UFSC research

Dialelic breeding

1995 1st breeding	Brazilian type (accession 50, 85, 101 and 231); Uruguayan type (Unique (458)	21 families (960 segregating plants). 91 plants (clones) selected	SC: Boava, Fraiburgo, Agua Doce
2007 2nd breeding	Brazilian type (accession 85, 101, 223 and 509);); Uruguayan type (Unique - 458)	More segregating plants	RS: Antônio Prado, Sananduva, São Domingos, Paraí
2008 3rd breeding	Brazilian type (Accession 127, 373, 401, 522, 526, and Alcântara Cv)	28 segregating families, besides some reciprocals crossing	RS: Vacaria and Ipê SC: Campo Belo do Sul, Caçador, Rio do Sul e Urubici
2009/2010 4th breeding	CVs: Helena, Alcântara, Nonante and Mattos	15 segregating families, besides some reciprocals crossing	RS: Vacaria, Ipê, Monte Alegre SC: Campo Belo do Sul, Caçador, São Joaquim, Rio do Sul, Urubici PR: Pato Branco e Dois Vizinhos