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Biological Collections

Collecting principles, practices and proper use of biological collections

“A case study”: Scientific herbarium collections

Herbarium

Herbarium = a collection of dried or otherwise preserved plants (and fungi)


41
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Campanula rotundifolia L. coll.
the native diploid (2n=34) race
(including var. lapponica Witasek)
det. JAAKKO NURMI 1995
University of Helsinki, Finland
Lapponia kemensis, par Kittilä,
Ivgg. Hj Hjelt & R. Hult
MUSEUM BOTANICUM
UNIV. HELSINGIENSIS
348439
LECTOTYPE of:
Campanula rotundifolia L.
f. lapponica Witasek
(Mem. Soc. Fauna Flora Fennica 94, 2018.)
Sel. et det. M. Piirainen & J. Nurmi 2018
Botanical Museum, Univ. Helsinki (H)
Herb. Univers.
Helsingiensis

Botanical museum
= Scientific herbarium

- Herbarium = a collection of dried or otherwise preserved plants (and fungi)
- Official herbaria usually belong to universities or institutional (state/city) museums (Finnish herbaria in Index Herbariorum)
- Clear criteria for the specimens
- Permanent storage of specimens
- Collection-based research
- Collections are internationally accessible to scientific study
- Collections are arranged in a way to enable their proper use
- Databases and digital images as part of collections (as well as archives on paper, and paper photographs and slides)

Purpose of the collections …
To document:

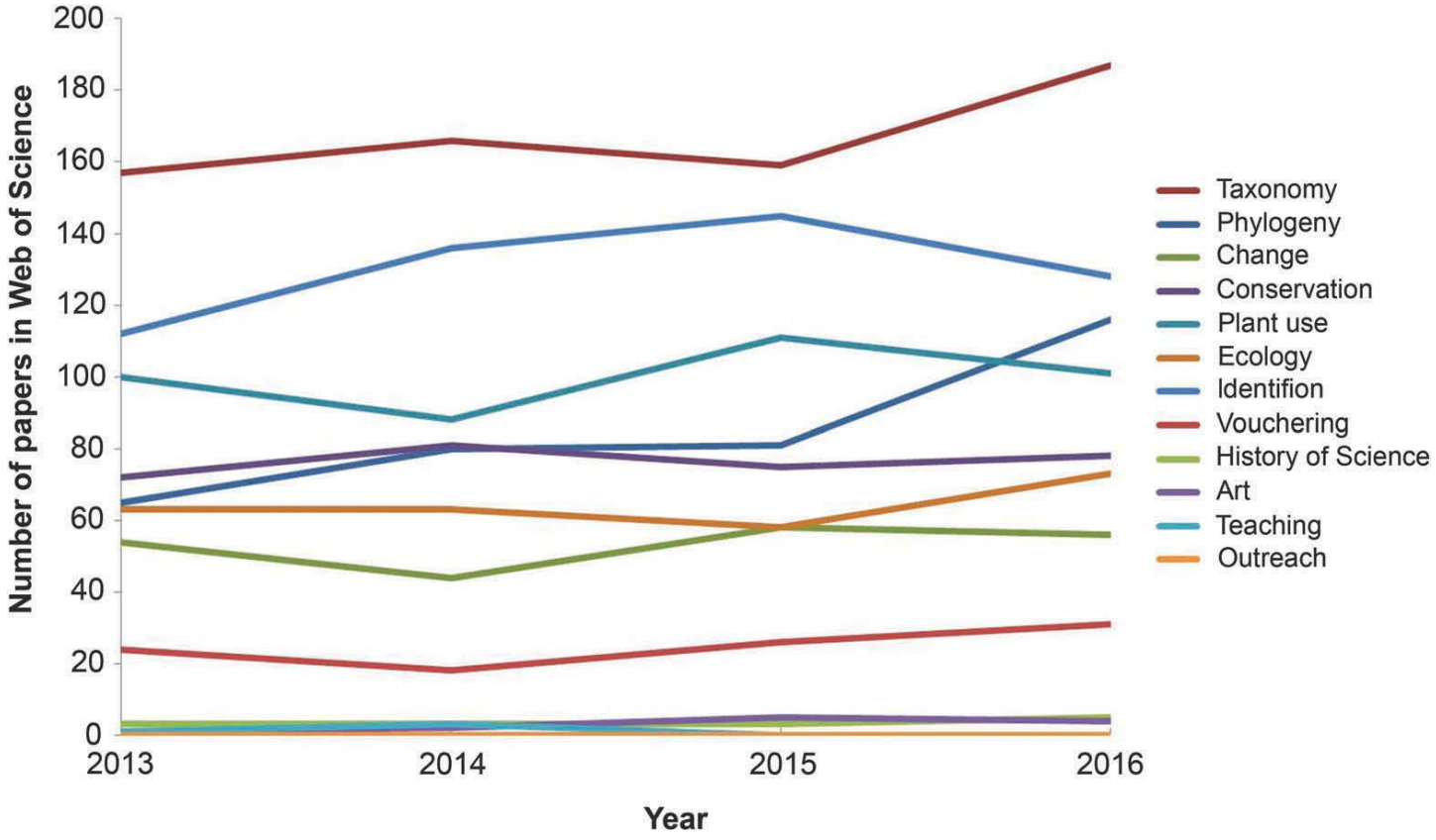
- representative samples of biodiversity of plants and fungi with as good coverage as possible
- structural (morphology, anatomy), chemical and genetic diversity of species
- geographical distribution of species
- temporal changes in distribution (due to natural or human-caused processes)
- ecological information concerning studied taxa (specimen labels)

… Purpose of the collections
To serve as a resource for:

- **taxonomic and systematic research**, i.e. determining morphological and other characteristics of species, delimiting species and other taxa, giving them names and constructing classifications of plants and fungi: **type specimens**
- **phylogenetic research**, i.e. understanding the evolution and evolutionary processes of plants and fungi (DNA, morphology, chemistry…)
- development of local and regional floras: Flora of Satakunta, Flora Nordica, Moss flora of Papua-New Guinea…
- preparing checklists
- verifying identifications (voucher specimens of research projects)
- identification of new specimens (comparison material)
- education at the university level
- worldwide network of biological collections

Number of publications dealing with herbaria in 2013-2016

From: [Carine & al. 2018, Botany Letters]



Other possible research topics

- plant invasions
- research of threatened species
- historical floristic assessments
- distribution of biological diversity (especially data banks): hot spots …
- temporal changes in plant demography and morphology
- pollution (contaminated specimens, remains of contaminants)
- global warming: phenological changes, changes in distribution patterns
- insect outbreaks (damaged specimens)
- chemical compounds, e.g. plant toxicity over space and time
- … future research with new techniques unknown so far

Collections are offered for use by the scientific community

- Science should be free and open
- Specimens are freely accessible to other researches (controlled access)
- Rules for herbarium visitors, herbarium loans and sampling for DNA
- Specimen loans
  - Between institutes, not to private persons
  - Formal request, with purpose of study and list of material needed
  - Some collections are not sent on loan
- Research visits; facilities for the visitors (…bench fee?)
- Students preparing their theses
- Non-professional botanists
- Possible flip sides of opennes: breaking or disappearing of specimens in mail, wearing in the use, theft…
- ”Virtual collections”: databases, digital imaging

https://www.luomus.fi/en/botanical-and-mycological-collections

Paris (P) database: https://science.mnhn.fr/institution/mnhn/collection/p/item/search/form

H: type specimens of vascular plants

Tradition through centuries

- First collections of *Hortus sicci* in Italy early 1500's (medicinal use of plants)
- The oldest extant collection by Gherardo Cibo c. 1532
- http://www.nationaalherbarium.nl/Cade/index.htm
- The oldest acting herbarium in Kassel, Germany (Naturkundemuseum, established 1569)
- 45 acting herbaria established before 1800 (Helsinki 1751)

Herbarium collections are part of our cultural heritage, invaluable and irreplaceable

Index Herbariorum

Worldwide index of scientific herbaria kept by the New York Botanical Garden

- 3324 active herbaria in the world (December 2019)
- 392,353,689 specimens
- in 178 countries
- 12,135 researches as staff members and associates
- Finland: 5 main herbaria = 5,482,701 specimens

Index Herbariorum

The largest herbaria (December 2017)

Up-to-date version in Index Herbariorum

Rank	Organization	Code	Country	Specimens	Year Founded
1	Muséum National d'Histoire Naturelle	P	France	8,000,000	1635
2	The New York Botanical Garden	NY	U.S.A.	7,800,000	1891
3	Royal Botanic Gardens	K	U.K.	7,000,000	1852
4	Naturalis	L, WAG, U	Netherlands	6,900,000	1819, 1829, 1896
5	Missouri Botanical Garden	MO	U.S.A.	6,600,000	1859
6	Conservatoire et Jardin botaniques de la Ville de Genève	G	Switzerland	6,000,000	1824
6	Komarov Botanical Institute of RAS	LE	Russia	6,000,000	1823
7	Naturhistorisches Museum Wien	W	Austria	5,500,000	1807
8	The Natural History Museum	BM	U.K.	5,200,000	1753
9	Harvard University	HUH	U.S.A.	5,005,000	1842
10	Natural History Museum	FI	Italy	5,000,000	1842
16	University of Helsinki	H	Finland	3,350,501	1751

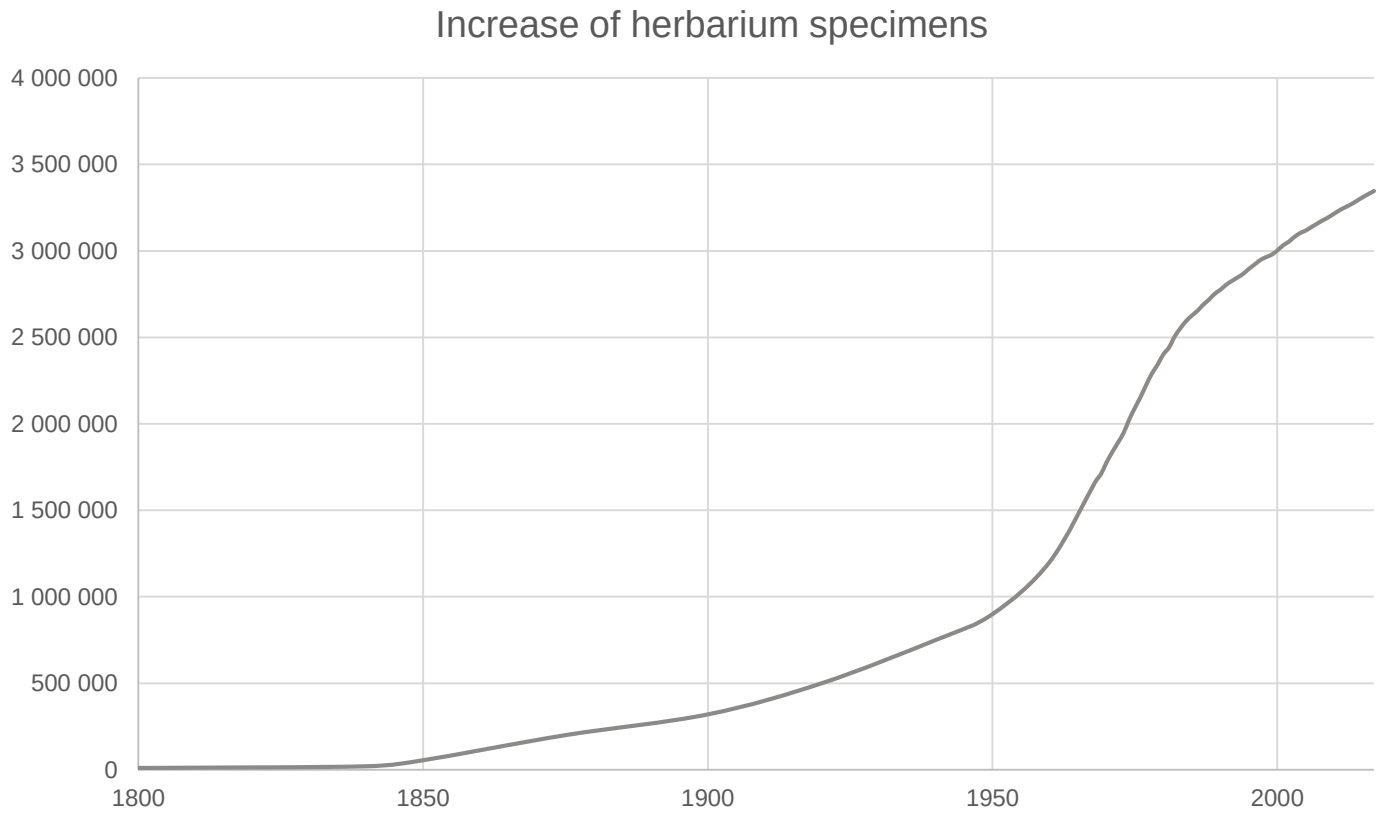
Historical background of H

- Botanical Museum of Helsinki (H)
  - established 1751 in the Academy of Turku (11th oldest)
  - moved to Helsinki after the great fire of Turku 1827
  - most early collections destroyed in the fire

- Important historical acquisitions
  - C.R. Sahlberg, vascular plants 1828 (5,000 specimens)
  - Societas pro Fauna et Flora Fennica Herbarium 1859 (> 50,000?)
  - C. Steven, vascular plants 1860 (100,000?)
  - E. Acharius, lichens 1834 (H-ACH, 5,500)
  - W. Nylander, lichens 1899 (H-NYL, 52,000)
  - S.O. Lindberg, bryophytes (H-SOL, 5,000)
  - V.F. Brotherus, mosses 1925 (H-BR, 110,000)

Botanical Museum, Helsinki (H)

Growth of the collections



Botanical Museum, Helsinki (H)

Amount of specimens in 2019 c. 3,39 million

- Vascular plants 1,813,508
  - Spermatophytes 1,718,657
  - Pteridophytes 94,751
- Bryophytes 622,216
- Fungi 932,169
  - Lichens 457,624
  - Other fungi 472,036
- Algae 25,836
- Zoocecidia (plant galls) 2,509

Large = beautiful?

- Only large herbaria can offer worldwide or systematically representative coverage, especially those in former colonial powers
- Often easier or cheaper to use large collections
- But: Small herbaria may be very important in local scale and in otherwise poorly collected areas
- Other criteria
  - geographical distribution of collections
  - temporal distribution
  - uniqueness of collectors/collections
  - state of curation of collections

Acquisition of new specimens

- Main sources:
  - study-based collections (voucher specimens) by own staff and students
  - donations from private persons
  - donations from state and municipal authorities
  - exchange from other herbaria
  - in rare cases purchasing from private collectors or institutes
  - incorporated herbaria: HSI, HEL, HFR…

Acquisition of new specimens

(according to the Collections Policies of FMNH)

- Collections are accumulated systematically according to specified goals and priorities:
  - 1) Scientifically valuable specimens of a high technical quality which support the strengths of Luomus and are important for current or future research
  - 2) Specimens which complement existing scientifically valuable collections and increase their scope (e.g., represent missing stages of development, add to time series or increase the geographical or taxonomic scope of the collection)
  - 3) Specimens with no immediate research value, but which may serve other social interests such as environmental education or the exhibition of biodiversity

  Threatened or rare species and nomenclatoral type specimens have special interest

Acquisition of new specimens: Critical points

- Facilities for storage are limited, infinite growth is not possible
- Scientific quality and informative value
- Uniqueness of the material – FMNH / national / international level
- How well the material promotes the strengths and aims of the research policy of the museum
- Temporal dimension?
- Geographical covegare?
- Geographical or taxonomic specialization?
- In case of large specimen sets: how much space is needed?
- Different kinds of specimens: herbarium sheets, envelopes, boxes, preservation in liquid, preparates, extracts, seed collections, living plants…
- Only specimens with no conditions on their preservation or use are accepted

Acquisition of new specimens: Critical points 2

- All additions to the collections must be collected in an ethically and legally acceptable way
  - They must fulfill the demands of the legislation of the source country, national Finnish legislation and international treaties (CITES, Nagoya…)
  - When new specimens are accepted to the collections, the needed information on their legacy and possible conditions for their future use are recorded
  - Written account on the origin of the material and possible conditions may be required from the donator

Acquisition of new specimens
Recent focus areas in herbarium H (c. 2010--)

Taxonomic groups:

- Lichens
- Aphyllophoroid fungi (kääväkkäät)
- Bryophytes
- Pteridophytes
- *Asteraceae, Chenopodiaceae, Cyperaceae*

Geography:

- East Fennoscania, boreal vegetation zone worldwide, Newfoundland, Central and East Asia, S Africa

Other focus areas:

- Type specimens
- Threatened and rare species in Finland
- Documentation of distribution of East Fennoscandian species
- Voucher specimens of research projects
- Documentation of the living collections of the Botanic Garden

Qualitative requirements for new specimens

- Well preserved, free of contaminants
- Free of insect or mould damage after collecting
- Sufficient and reliable documentation
  - geography: country, province, municipality, locality
  - habitat
  - collector's view on the origin of the population (native, new introduction…)
  - coordinates (with datum, e.g. WGS84)
  - altitude (a.s.l.)
  - date of collecting
  - collector's name(s), collecting number
  - other relevant information: fresh characteristics (odour, colour…), status of the population, accompanying species, references to publications etc.

  Also: historical value, ethical criteria, legal aspect

Deaccessioning of specimens?

- Part of the old specimens do not meet the standard
  - missing, deficient or unreliable collecting data
  - bad technical quality either originally or by later injury
  - excessive duplicates

  If collecting data seems reliable, it can be databased before deaccesioning

  The specimen may be used and/or cited by earlier study → demand for record of deaccessions?

What to collect?

Check possible local restrictions and required permits in advance in cooperation with local herbaria and authorities !

- Depends on the scope of the study: Taxonomic group / geographical area / habitat / molecular study…
- Voucher specimens
- Collecting permits are needed always in certain areas, and for threatened, protected or very rare species and nature protection areas
- Deside which parts should be collected, and how morphology, size range, and other features of the whole plant can be best represented
- A good collection should comprise adequate samples of all the organs available and all stages of development
- It is important to select the material as to retain as much information as possible
- Special techniques for certain taxonomic and/or physiognomic groups
- Using photography as additional documentation
- Collection may be laborous, so think twice what is needed

How much to collect?

- The local population of the collected species must not be threatened
- A representative sample of the population
- Population samples?
- Documentation of all diagnostic characteristics
- Duplicates – when and how much?
- Try to collect full herbarium sheets whenever possible (very small specimens or fragments may serve as documentation for e.g. floristic study but are usually too little for other use)

Biased collecting?
Possible reasons

Many research methods would need statistically unbiased distribution of collecting - some problematic cases:

- Rare, beautiful, otherwise interesting taxa
- Taxa that are difficult to determine in the field
- Geography: collection concentrates close to herbaria, along roads, in easily accessible lowlands areas (vs. mountains)
- Collecting season (year, decade)
- Annuals/perennials, herbs/shrubs, trees
- Large/spiny/poisonous species, succulents
- Threatened or protected species
- Phylogenetic bias: concentrating on the groups actively studied

… Biased collecting?

- Hot-spot areas especially in Asia, Central America and the Amazonas poorly collected: large spatial and temporal gaps
- Locally restricted collecting by legal regulation may discourage collecting more than reasonable, e.g. in South Africa and Australia

From field to the herbarium
What happens on the way?

- Collecting: field notes, collecting number, proper techniques for the collected taxa
- Pressing/desiccating the specimens
- Deep freezing (preferably at least -30°C)
- Entering collecting data into a specimen label
- Checking/accepting by responsible curators
- Entering label data into museum's database
- Mounting on herbarium sheet / placing in envelope
- Recording in museum's accessions
- Sorting and filing to the collections

How to store?

Biological collections are invaluable and irreplaceable

- isolation from other working areas (offices, labs…)
- protection against UV
- temperature and humidity control
- dust control
- minimized chemical contaminants (e.g. paints, photocopy machines…)
- minimized internal contamination (loose parts on herbarium sheets may represent another specimen)
- pest control
- fire safety
- selection of technical materials used in preparation of the specimens (paper, ink, glue…)

How to store?
Further techical points: UV light

- UV-filtered windows
- UV-filtered lights (bulbs or fluorescent lights)
- Small windows (or no windows)
- Minimized direct light (reflected light contains less UV)
- Storing in closed and sealed steel cabinets

How to store?
Further techical points: temperature

- Lower temperature slows down chemical processes and activity of pest insects
- Every lowered 5°C doubles the theoretical storage life
- Pest insects mainly inactive below +10°C; good temperature relative to pest control below +15°C
- But:
  - Condensing moisture on surfaces when specimens are moved to normal room temperature
  - Herbaria serve also as working areas; 18-20°C ± max. 2°C an acceptable compromise

How to store?
Further techical points: humidity

- Optimal relative air humidity 35-55%, acceptable range ± 3%
- Excessive humidity causes
  - growth of mould
  - tension caused by expansion and contraction
  - activation of acids and bases
  - activation of pest insects