

**BIOLOGY 412: PHYTOGEOGRAPHY – 2009**  
**INTERPRETING THE DISTRIBUTION OF PLANTS**  
**IN SPACE AND TIME**

*“Without geography, you’re nowhere.”*

–Jimmy Buffett

**TIME:** T, Th 0800–0930 hrs                      **LOCATION:** Biosciences Rm. 2449

**INSTRUCTOR:** Dr. Michael W. Hawkes

**OFFICE:** BioSc. 2526                      **PHONE:** 604–822–5430

**EMAIL:** mhawkes@interchange.ubc.ca

**TEXT:** None required, but an excellent reference to the general principles of biogeography that you might want to occasionally consult is:

Lomolino, M. V., B. R. Riddle, & J. H. Brown. 2006. *Biogeography* (3<sup>rd</sup> Ed.).  
Sinauer & Assoc.: Sunderland, Massachusetts. 752 pp.

**OR**

Brown, J.H. & M.V. Lomolino. 1998 (2<sup>nd</sup> ed.). *Biogeography*. Sinauer &  
Assoc.: Sunderland, Massachusetts. 691 pp.

**EVALUATION:** Project: 25%, Mid-term exam: 25%, Final exam: 50%

**GOAL OF THE COURSE:** *To examine pattern & process in plant distribution, with emphasis on both ecological and evolutionary perspectives. To learn to think synthetically in interpreting plant distributions in space and time.*

**IMPORTANT DATES:**

**Thurs. Feb 12: Mid-term exam**

**16-20 Feb: Mid-term break**

**Thurs. 12 March: Project due 0800 hrs in class, no extensions!**

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*“He was a great naturalist, and was keenly aware that fundamental laws of nature could be discovered through the study of distributions.”*

–Brown & Lomolino (referring to Alexander von Humboldt)

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*“Biogeography has become a unifying field, providing an interdisciplinary and integrative understanding of the relationships between the earth and its biota. It provides a bridge, building on solid foundations in natural history, between disciplines of ecology, evolution and conservation.”*

–Robert J. Whittaker & Dov. F. Sax. 2003

**PLANT GEOGRAPHY** is a broad field that attempts to synthesize many disciplines all of which we will touch on in this course:

- Natural History
- Systematics - plant classification & nomenclature: the name game and how taxa are related to each other. Should be based on a Phylogenetic systematic (Cladistic) approach
- Ecology
- Evolution
- Plant reproductive biology: breeding systems are important for establishment and dispersal
- Genetics - the underlying ground rules
- Geology - Earth history
- Paleontology
- Geography & climate

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**OBJECTIVES:**

- To examine the role that biotic and abiotic factors play in ecological biogeography
- To gain an appreciation of Earth's geological history and understand the role of historical biogeography in interpreting plant distributions
- To investigate the relationship between systematics and biogeography (phylogeography)
- To review major features of contemporary plant distributions with emphasis on hot-spots, endemics, and islands
- To understand the role that glaciation has played in plant distributions
- To examine pattern and process in benthic marine algal distributions with a focus on kelp



*Banksia speciosa*, near Esperance, W. Australia. The genus is endemic to Australia. Photo by M.W. Hawkes.

## **BIOLOGY 412: OUTLINE OF LECTURE TOPICS**

**Note:** this is a tentative outline; sequence and topics may vary slightly

### **1. INTRODUCTION**

- Ecological versus Historical Biogeography
- Looking for pattern, trying to understand the underlying process
- Demo. Plant examples for class discussion
- Past, present, and future importance of Biogeography
- Five areas that have resulted in a Renaissance in Biogeography
- Major biogeographic patterns:
  - a. Cosmopolitan
  - b. Disjunct – long-distance dispersal vs vicariance
  - c. Endemic – with discussion of British Columbia endemics
- Synopsis of green plant biodiversity (Phylum level)

### **2. CONTEMPORARY ENVIRONMENTAL SETTING & ECOLOGICAL BIOGEOGRAPHY**

**Abiotic factors affecting plant distribution: Geographic variation in the physical environment**

- Major terrestrial biomes
- The marine environment

**Biotic factors affecting plant distribution:**

- Dispersal
- Breeding system
- Competition & predation
- Other plant-animal interactions
- Patterns with a metabolic basis

### **3. EARTH HISTORY & HISTORICAL BIOGEOGRAPHY**

- Earth history, the geological record and the abyss of deep time
- Dating methods
- Fossils: Types & their formation. Uses of fossils in biogeography and systematics
- Major events in plant evolution
- Plate tectonics & continental drift: Past changes in the physical geography of the earth

### **4. THE RELATIONSHIP BETWEEN SYSTEMATICS AND BIOGEOGRAPHY**

- Inferring a phylogeny for the group. Phylogenetic systematics
- Testing biogeographic hypotheses. Taxon / Area cladograms

## 5. ANGIOSPERM ORIGINS

- Contemporary Angiosperm biodiversity and distribution
- Features of Angiosperms that made them so successful
- Biogeography of primitive Angiosperm families
- Floristic regions of the World

## 6. CONTEMPORARY PATTERNS OF PLANT DISTRIBUTION

### 6A. Islands: Special Cases in the Study of Plant Geography

- Types of islands and unusual features of island floras
- 'New Caledonia: Ultramafic soils and high rates of endemism'
- '*Hawai'i's Endemic Plants*' SLIDE SHOW (Appr. 1hr 15 min), with special mention of the Silversword Alliance, their origin and adaptive radiation in Hawai'i (handout)
- '*New Zealand Flora: A Glimpse of Gondwana?*'
- *Metrosideros* study (linking the floras of New Zealand and Hawai'i)
- '*Australian Flora: A Sea of Evolutionary Novelty Surrounding Islands of Relict Rainforest*'
- *Scaevola* study (linking the floras of Australia and Hawai'i)
- New Guinea & S. E. Asia: A fusion of floras
- *Cyrtandra* study: A test of Huxley's line
- '*Galapagos Islands: A Desert Archipelago*'. With SLIDE SHOW

### 6B. Hybridization & Polyploidy in a Biogeographic Context

### 6C. Ice & Change: Effects of Glaciation on Biogeographic Patterns

- Glacial refugia & recolonization
- Techniques for inferring refugia and migration routes
- The conifer *Fitzroya* in southern S. America

### 6D. Seaweed Biogeography

- Introduction to the marine environment and seaweeds
- Greens (Chlorophyta)
- Browns (Ochrophyta: Phaeophyceae): Laminariales – Ecological Biogeography
- Browns: Laminariales - Historical Biogeography and the sea otter story
- Browns: Fucales
- Browns: Durvilleales
- Reds (Rhodophyta): Solieriaceae phylogeography
- SLIDE SHOW of above examples



**Above:** Silversword (*Argyroxiphium sandwicense* ssp. *sandwicense*) – Endemic to Mauna Kea volcano, Hawaii. **Below:** Prof. Emeritus Bruce Bohm with Mauna Kea Silversword inflorescence. Photos by M.W. Hawkes.



*“The last mile was destitute of vegetation except one plant of the Syginesia tribe, in growth much like a Yucca, with sharp pointed silver coloured leaves and green upright spike of three or four feet producing pendulous branches with brown flowers, truly superb, and almost worth the journey of coming here to see it on purpose.”*

-James Macrae (1825), Scottish botanist, commenting on his discovery of the Mauna Kea Silversword

## TERM ASSIGNMENT

**DUE:** Thurs. 12 March, 0800 hrs in class, **NO EXTENSIONS!**

**GRADE:** 25% of course grade

**SUBMIT:** Both hard copy (i.e. paper) and digital copy (email it as an attachment) of the report

You will be researching a plant genus and writing a short report about it.

Each person in the class will pick a different genus from the list provided on a separate handout. The Instructor must approve your choice. The simplest way to do this is for you to email your top 3 choices to me and I will assign one to you.

**Do not pick a genus without checking with me, or your assignment will not be marked.** Requests for favourite genera, which are not on the list, are also a possibility (with the Instructor's approval).

**Research your genus and provide the following information indicated by the headings in bold: (use these headings and this sequence in your report)**

### **GENUS:**

- Give the Latin name in italics

### **PHYLUM:**

- Give the Phylum that the genus belongs to. E.G. Coniferophyta for conifers, Anthophyta for flowering plants, etc.

### **GENERAL TYPE OF PLANT:**

- E.G. seaweed, moss, fern, horsetail, conifer, flowering plant

### **FAMILY:**

- The botanical family that the genus belongs to. Plant family names typically end in –eae, e.g. the cactus family is Cactaceae

### **# OF SPECIES:**

- Approximate # of species currently included in the genus

### **HABIT:**

- I.E. what does a typical representative look like? Tree? Shrub, Vine? Is it annual or perennial? Include a drawing, or image, of a typical representative of the genus (if there is a lot of variation in the appearance of species then pick one that is of interest to you)

### **GEOGRAPHICAL DISTRIBUTION:**

- Include a map clearly showing the extent of the genus distribution. Label major landmasses or geographic features

**FOSSIL RECORD:**

- If there is one

**PHYLOGENY FOR THE GROUP:**

- I.E. who is related to whom? Give the cladogram if there is one, or else describe the phylogenetic relationships as accurately as possible based on the published literature. Note: this information may be sketchy or missing for your genus, but be sure to do a thorough literature search before concluding this.

**ASPECTS OF ECOLOGY & REPRODUCTION THAT WOULD BE RELEVANT TO DISPERSAL AND ESTABLISHMENT:**

- E.G. separate male and female plants; both sexes on the same plant, but self-incompatible; both sexes on the same plant and self-compatible; vegetative reproduction; special pollinator requirements; special soil chemistry requirements; special habitat requirements. Note: Some of this information may be sketchy or unavailable for your genus.

**PROPOSE AN HYPOTHESIS TO EXPLAIN THE DISTRIBUTION PATTERN:**

- Include both ecological and historical biogeographic aspects in your hypothesis
- How would you go about testing this hypothesis? What additional data would you want to collect?

**LITERATURE CITED:**

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**USEFUL STARTER REFERENCES FOR THIS ASSIGNMENT**

**Print references:**

*Botanica*

This is a horticultural book that is not held in UBC library, but should be available at public libraries. It is up-to-date and gives good basic information on # of species and distribution data.

Maberley, D. J. 2008 (3<sup>rd</sup> Ed.). *Maberley's plant-book. A portable dictionary of plants, their classification and uses.* 1021 pp. Cambridge Univ. Press: Cambridge.

Maberley, D. J. 1997. (2<sup>nd</sup> Ed.). *The plant-book: a portable dictionary of the vascular plants.* 858 pp. Cambridge University Press: Cambridge & New York.

**Access to print journals on-line through Electronic Journals at UBC Library**

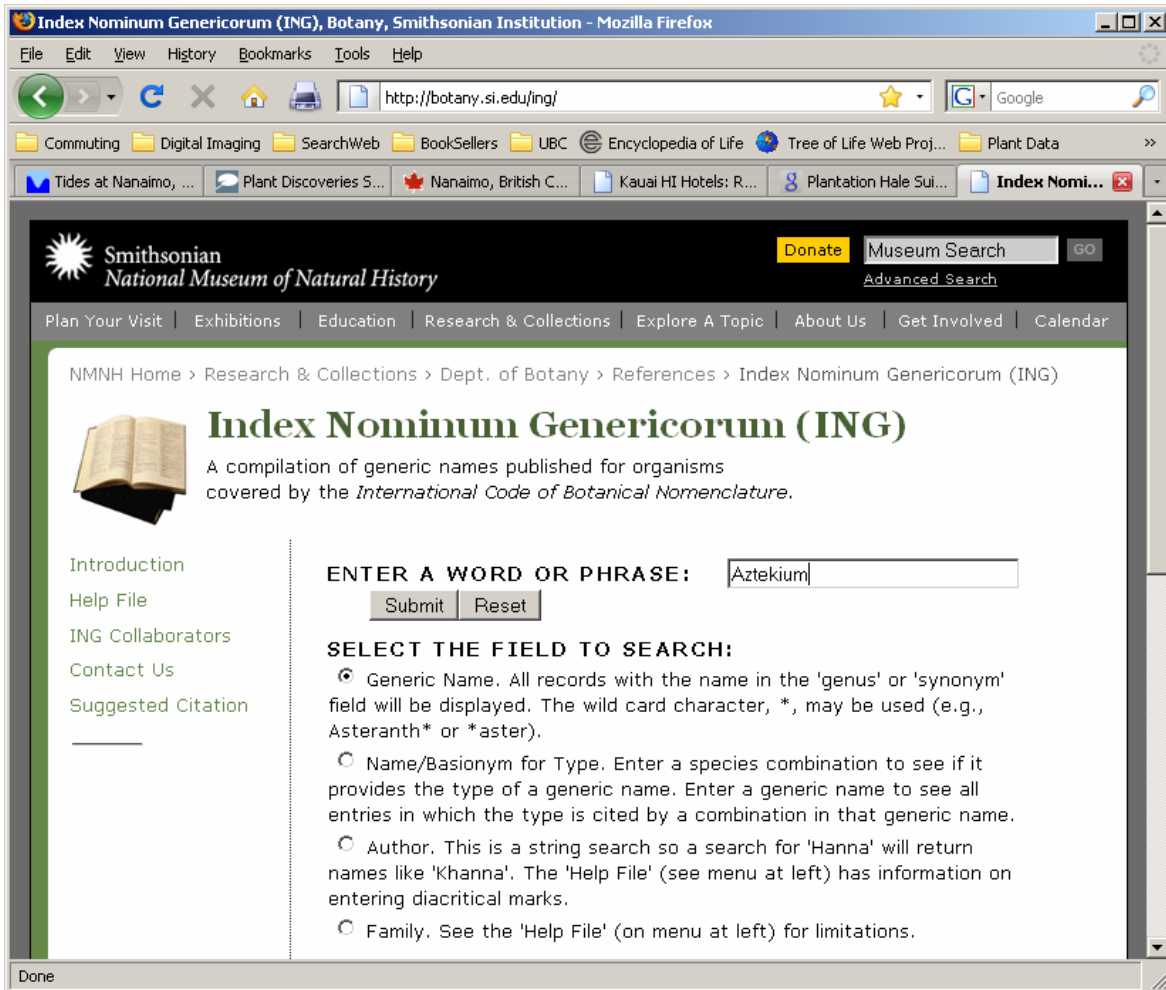
URL: <http://toby.library.ubc.ca/ejournals/ejournals.cfm>

**Web references:**

*Index Nominum Genericorum*. URL: <http://botany.si.edu/ing/>

This site is an excellent starting point to determine the family your genus belongs to and the type of plant it is.

E.G. of search for the generic name *Aztekium*:



**Search Results:**

[C] *Aztekium* Boedeker, *Monatsschr. Deutsch. Kakteen-Ges.* 1: 52. Mar 1929.

T.: *A. ritterii* (Boedeker) Boedeker (*Echinocactus ritterii* Boedeker)  
PHAN.-CACTACEAE (10) 9 Feb 1996

- 1<sup>st</sup> line gives the genus, the authority who described it, and the publication
- 2<sup>nd</sup> line gives the type species of the genus, authorities and a synonym (in brackets)
- 3<sup>rd</sup> line: PHAN = Phanerogam, CACTACEAE = the family

## WRITTEN REPORT GUIDELINES

- **Make sure you consult research journal literature and books in addition to using the web.**
- Report should be word-processed and **3-4 pages long**, including literature cited and any illustrative material you choose to include
- Margins 1" around the top, bottom and sides of each page
- Number the pages
- Captions to any Figures should also be typed
- Single-sided and double-space (exception being the Literature Cited section which can be single-spaced)
- Use a clear font (e.g. Arial) in a 10–12 pt size (I won't mark reports done in a smaller font)
- Use the headings given in the assignment. Since this is a short report, **DO NOT** use Materials & Methods, Results, Discussion, etc as headings
- Any illustrations or diagrams included must be cited as to source e.g. (Hawkes 1998: 2) and require proper captions to be included
- Please be sure to **run a Spellchecker** on the report before submitting it
- Sources for all points of fact must be cited in the body of the report, e.g. Hawkes (2003) reported a disjunct population of Elk Kelp on the Bowie Sea Mount off Haida Gwaii, B.C. Do not use footnotes. All cited references must be included in the Literature Cited section at the end of the report. Note that names of Journals & Books are italicized or underlined, as are all latinized scientific names throughout the text. Here are examples of the format to use for citing references in this course:

### Journal articles

Hawkes, M. W. 2003. Survey of elk kelp on the Bowie Sea Mount, off Haida Gwaii, British Columbia. *Journal of Irreproducible Results* 20: 19–69.

### Books

Avise, J. C. 2000. *Phylogeography. The history and formation of species.* Harvard Univ. Press: Cambridge, Mass.

### Chapter or article in a book

Colinvaux, P. 1993. Pleistocene biogeography and diversity in tropical floras of South America. Pp. 473–499 In: P. Goldblatt (ed.), *Biological relationships between Africa and South America.* Yale Univ. Press: New Haven, Connecticut.

**Electronic references or data**, e.g. email, discussion groups, listserves, Web sites: must cite the author(s) [if known] and give the full URL (Uniform Resource Locator), e.g.

**L. Watson and M. J. Dallwitz. The Families of Flowering Plants.**

<http://delta-intkey.com/angio/>

### USEFUL WEB PAGES

Schatz, G.E. 1996. *Malagasy / Indo-Australo-Malesian Phytogeographic Connections*.

<http://www.mobot.org/MOBOT/Madagasc/biomad1.html>

The International Biogeography Society

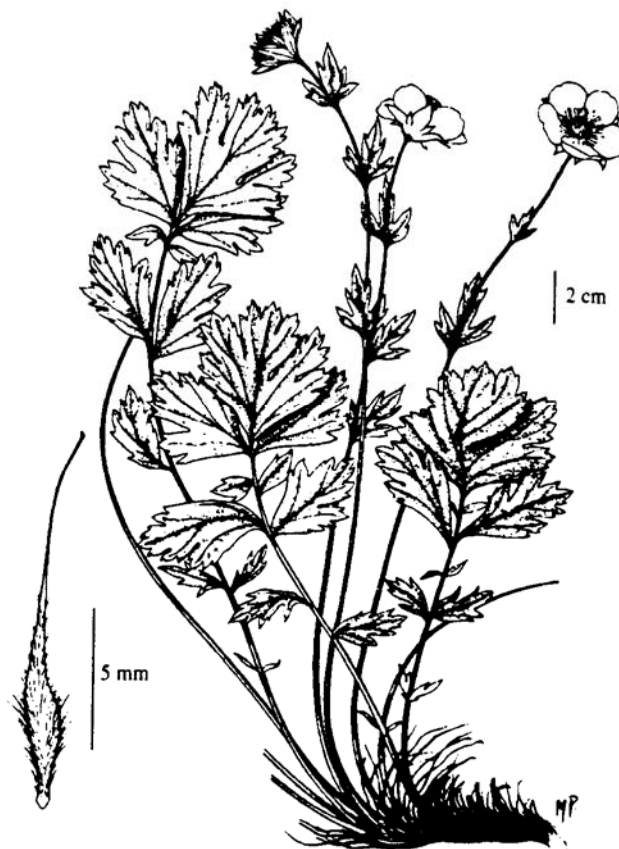
<http://www.biogeography.org/>

Tree of Life. URL: <http://tolweb.org/tree/phylogeny.html>

An excellent site to get the 'big picture' of green plant phylogeny.

### OTHER REFERENCES

Will be sent in a separate pdf.



*Geum schofieldii*: Endemic to Haida Gwaii (Queen Charlotte Islands) and the Brooks Peninsula, Vancouver I., British Columbia. Named in honour of the late Dr. Wilf Schofield, UBC.

**EXPECTED LEARNING OUTCOMES:**

1. Introduction

Students will be able to:

- Distinguish between ecological versus historical biogeography
- Recognize patterns and hypothesize underlying process
- Summarize the five areas that have resulted in a Renaissance in Biogeography
- Describe the 3 major biogeographic patterns and illustrate them with significant plant genera
- Compare long-distance dispersal vs vicariance as mechanisms for disjunct distributions
- Define endemic and illustrate with significant plant genera (from BC and elsewhere)

2. Contemporary Environmental Setting & Ecological Biogeography

Students will be able to:

- Explain how abiotic & biotic factors affect plant distributions
- List plant dispersal mechanisms and give specific plant examples to illustrate
- Compare plant breeding systems and explain their consequences for plant dispersal and establishment
- Describe a plant distribution pattern with a metabolic (physiological) basis

3. Earth History & Historical Biogeography

Students will be able to:

- Describe fossil types & their formation
- Explain the uses of fossils in biogeography and systematics
- Summarize the major events in plant evolution, giving approximate dates and specific plant examples
- Summarize the key points of plate tectonics & continental drift
- Explain, using plant examples, how past changes in the physical geography of the earth have affected plant distributions

4. The Relationship between Systematics and Biogeography

Students will be able to:

- Explain the methodology of phylogenetic systematics and define basic terms like out-group, synapomorphy, apomorphy, cladogram, and parsimony
- Explain the importance of a phylogeny for a group in interpreting biogeographic pattern at different taxonomic ranks (species, genus, family, etc.)
- Analyze Taxon / Area cladograms to test biogeographic hypotheses

## 5. Angiosperm Origins

Students will be able to:

- List hotspots of contemporary Angiosperm biodiversity
- Contrast features of Angiosperms that made them so successful compared to other plant phyla
- List 3 primitive Angiosperm families and summarize their biogeographic patterns

## 6. Contemporary Patterns of Plant Distribution

Students will be able to:

- Explain the origin and types of islands and give plant examples of unusual features of island floras
- Describe how ultramafic soils in New Caledonia have resulted in high rates of endemism
- Hypothesize what other factors may also have led to the high rates of plant endemism in New Caledonia. List some specific plant examples of unusual New Caledonian endemics
- Summarize the evidence for the origin and adaptive radiation of the Hawaiian Silversword Alliance. List the genera involved
- Contrast the evidence for vicariance versus long-distance dispersal to explain the origin of the New Zealand Flora. Cite significant plant genera where appropriate
- Explain, with examples, the statement that the Australian Flora is a sea of evolutionary novelty surrounding islands of relict rainforest
- Summarize mechanisms that result in the fragmentation or fusion of floras and give plant examples
- Compare the Hawaiian and Galapagos Archipelagos in terms of their origins and plant biodiversity with special reference to endemics. Give specific plant examples.
- Describe the major glacial refugia in N. America
- Describe techniques for inferring glacial refugia and plant migration routes and give some specific plant examples
- Summarize global biodiversity hotspots for seaweeds
- Summarize the roles of biotic and abiotic factors in kelp distribution in an ecological and historical time frame
- Analyze a plant biogeographic pattern and supporting data set that they have not encountered before and suggest hypotheses to explain it. Based on other plant case studies, techniques, and data sets discussed during the course, students should be able to identify missing data and recommend further analyses to test their hypotheses

**Written Report:** Students will be able to use the primary journal literature to research a genus of their choice, propose and critique a hypothesis to explain the biogeographic pattern and prepare a written report of their work