

# Rhododendron Research Network

## Report on Steering Committee Activities for 2019

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### 2019 Action Item #1 – Webpage improvements and additions

Led by Bob Weissman

The R-RN web site serves as the primary point of communication and resource sharing, both between network members and between the network and the public.

1. Improve access and clarity of organizational structure, goals and accomplishments.
  - a. Add a governance page denoting R-RN leadership and charter documents.
  - b. Page displaying ARS reports - also available at [www.arsoffice.org](http://www.arsoffice.org)
  - c. Split up stated objectives page to clearly define what is currently being done:
    - i. Page with current Action Items.
    - ii. Page announcing successful completion of action items.
    - iii. Page with more vague/future activities/ideas that we aren't quite working on yet.
2. Develop web-based resources:
  - a. Page for searching publicly available Rhododendron transcriptomes and genomes for BLAST searches.

- b. New articles alert on the home page, with a link to the Mendeley Invite-Only group.
- c. Develop and test chat capabilities.

Progress report

*All items listed in action item 1 were completed.* Working with R-RN Steering Committee members content for the governance pages were created and posted at the R-RN web site. A new page was developed that has past accomplishments, current initiatives, and future activities. A web page was created for R-RN annual reports to the ARS. All the pages were organized and linked to the R-RN home page in a new section titled “Learn More About the Rhododendron Research Network”, (See <http://www.rhodo-research.net/index.htm>)

*Web development for item 2a:*

To gauge what genomic resources would be useful for the R-RN website, eight rhododendron researchers representing Ph.D. students, postdocs, research scientists, and professors were polled. Five of eight researchers responded, and their answers are summarized below:

Question	Responses	#responding
Would having Rhododendron genomes and transcriptomes available for download and online BLASTing at the R-RN website be useful for you and/or other researchers?	Yes (5) One responder highlighted current need for BLASTing rhododendron genomes and downloading genomes	5
If useful, what tools should be provided:		3
online searches by gene name - which would use functional annotations of genomes	Search option by species or gene Metadata for searches	
BLASTing genomes by nucleotide (DNA) or other query sequences	Search options by nucleotide or gene name	
viewing genomes in a genome browser like JBrowse		
	Ways to connect with other <i>Rhododendron</i> researchers	4
	Explain types of studies that could benefit from genomic database	
What other resources or tools would be helpful for <i>Rhododendron</i> researchers host at the R-RN website?	Any kind of information that can be applied across <i>Rhododendron</i> research Datasets for functional traits (like TRY database) and molecular sequence Start with online BLAST tool then see what other tools users want	

Significant strides have been made in developing an online BLAST tool at the R-RN website.

1. An online form has been developed for users to input query sequences or select query files, to select BLAST tools, and to select databases to query against.
2. The online BLAST function currently works with the NCBI database and generates an online output form that includes top hits/matches from the NCBI database and BLAST alignments of query and matched sequences.
3. The next challenge is to link the online BLAST function to *Rhododendron* genomic databases hosted on the R-RN webserver and to generate similar output reports as those generated from the NCBI database. Doing so will depend on identifying or developing suitable code scripts that perform the required functions.

The present status of *Rhododendron* genomic studies has been summarized by Valerie Soza. Please see report in Appendix A.

*Web development for items 2b and 2c:*

The few new items added to the web site during the year were communicated to R-RN members via the R-RN newsletter. In the future as more frequent changes occur, alerts will be posted in a prominent position on the home page.

Draft code has been developed for an online chat function for the web site. The code will be further tested and refined in the coming year.

## 2019 Action Item #2 – Searchable literature database

Led by Juliana Medeiros

In 2019 we began working with volunteers to build an online database of scientific literature on *Rhododendron*, to be freely shared with researchers world-wide via the ARS-affiliated *Rhododendron* Research Network web site and newsletter. We are using the freeware Mendeley platform ([www.mendeley.com](http://www.mendeley.com)) to organize our references. Mendeley facilitates collaboration via “Groups”. Due to constraints on sharing PDFs within this type of social network, we will maintain two types of groups. Both groups will contain the same reference lists.

R-RN network member recruitment and broad use by the ARS community and the public is facilitated by maintaining an “Invite-Only” group. This type of group is visible to the public, and it can be “followed” which will promote our network to Mendeley users who search for the term “*Rhododendron*”. References and comments posted to the group are publicly displayed. Only members of the group are allowed to add content, which will maintain a level of content appropriateness that our members should expect. All network members, R-RN newsletter recipients and ARS members will be invited to join this group, and anyone requesting to join the group will be accepted. R-RN leadership maintains the ability to remove members if necessary.

This type of group does not allow sharing of PDFs between group members, but abstracts can be included.

Collaboration between R-RN network members will be facilitated by maintaining a “Private” group. This type of group is not visible to the public, and cannot be searched within Mendeley. Within a private group, all members can obtain uploaded PDFs freely from inside the Mendeley software. Storage for the entire group is limited to 2 gigabytes, unless all members purchase storage upgrade plans. This group has a limit of 20 members. Only network members will be allowed to request an invitation to this group. If more than 20 members request membership, we will maintain additional private groups.

#### Progress report

1. Worked with Holden volunteers to finish entering Web of Science references. (COMPLETED)
2. Sent invitations in to R-RN members to join the reference group in Jan 2019. (COMPLETED) Only a handful of people have joined the group. Advertising is needed.
3. Worked with ARS volunteers to enter references from Homer Salley literature database (approx. 1800, dates range from early 1900’s to 1992, may be some overlap with Web of Science). (In progress ~75% complete). PLAN TO COMPLETE IN 2020
4. Work with ARS volunteers to enter references from Charles Andrews (approx. 400 references dating from 1571 – early 20<sup>th</sup> century) NOT ADDRESSED, MOVE TO 2020
5. Conduct searches to add all new references on a quarterly basis. (COMPLETED up to October 1, 2019)
6. Maintain .doc, .bib and .xml copies of the database, updated quarterly, to be made available to RRN members upon request. (COMPLETED up to October 1, 2019)

#### 2019 Action Item #3 – Build capacity for Citizen Science

Led by Robbie Hart

Attention has recently been drawn to the value of botanical gardens in phenology monitoring projects, and data from well-documented personal plantings could be equally valuable. In many cases, well-known species are planted across a wide variety of climates and microclimates, offering an excellent opportunity for comparison. In some cases, widely distributed well-documented wild seed collections offer the possibility of studying plants both in their native populations and simultaneously in gardens in diverse climatic situations. Despite the great potential of citizen science, many nuanced aspects of experimental design and data collection need to be considered in advance, to facilitate publication of citizen science findings in peer reviewed scientific journals. In order to begin building this type of opportunity, we plan conduct fact-finding research during 2019 to determine the available resources and potential pitfalls of

a citizen science phenology project. Specifically, Robbie will work with Co-Chairs to produce a report that provides information on the following:

1. Identify gardens and living collections with legacy or ongoing phenological observations that include rhododendrons.
2. Review tools used for distributed phenological data collection and suggest a method for phenological monitoring, chosen to be easy to apply across diverse environments, while at the same time allowing comparison to existing legacy or ongoing data collection initiatives.

Progress Report

No report received.

#### 2019 Action Item #4 - Build data hosting capacity

Led by Valerie Soza

Many excellent resources concerning *Rhododendron* are available on the web, but these resources may be difficult to locate, or they may become abandoned due to lack of support. Over the long term, we expect R-RN to become a premier source for information about rhododendrons, including content like species identification pages, and a data submission portal. Though the value of these resources is obvious, the potential problems of data hosting, like upkeep and cost, are not trivial. Thus, the capacity for data hosting must be built smartly, so our steps in this direction for 2019 will be largely fact-finding. Following this, we expect to be poised to implement larger data hosting goals in 2020. Specifically, Valerie will work with webmaster Bob Weissman and Co-Chairs to produce a report that provides information on the following:

1. Determine what resources are out there and consider which ones we would like to host
2. Determine exactly what it would take to host those resources long-term (staff, cost, etc)
3. Explore logistics of data hosting and potential web-based challenges
4. Explore funding options.

Progress report

#### **1) Determine what resources are out there and consider which ones we would like to host**

The RRN website currently displays two useful resources under Research Tools and Information: a Rhododendron Literature Database and a Rhododendron Hybrid Pedigree Search. Many other online resources exist that are useful for *Rhododendron* researchers. However, these resources may not be apparent to a researcher unless they are in their field of study. Depending on the research, websites that may be useful to the RRN are those that provide databases for images, species information such as those in taxonomic descriptions, nomenclatural changes,

horticultural information, cultivated accessions or available seed sources, plant traits, distribution maps, genome sizes and chromosome numbers, genomic resources and molecular sequence data, digitized herbarium specimens, and DNA and/or tissue banks for *Rhododendron* taxa. Many of these resources are large databases that encompass a variety of plant species. Therefore, if one searches the internet for “rhododendron” and a feature of interest, these online resources may not be included in the results because they are not specific to rhododendrons, but do include records of rhododendrons. For this reason, links to these resources from the RRN webpage will facilitate researchers in finding these resources. Appendix B lists a variety of resources that may be useful to the RRN but is not an exhaustive list. Other RRN members should have the ability to suggest additional resources for the RRN website to highlight.

Based on our 2019 survey of eight RRN members (see 2019 Action #1 Item report), two types of data that were requested to be hosted on the RRN website were functional trait data by 1/5 responders and genomic data by 5/5 responders. Another feature requested was a tool for *Rhododendron* researchers to connect with each other. A similar feature was proposed for the RRN 2019 Action Item #1 as “chat capabilities” on the RRN webpage. The development of these chat capabilities can serve as an online forum for *Rhododendron* researchers to connect with each other as well as to provide suggestions and feedback for RRN objectives. It will be important to discuss with other *Rhododendron* researchers using this online forum as to what data are important for the RRN to host if any. For 2020, we propose to focus on the development of online genomic resources for the RRN website. Future data hosting ideas should be generated after input from more of the RRN community.

- 2) Determine exactly what it would take to host those resources long-term (staff, cost, etc)**
- 3) Explore logistics of data hosting and potential web-based challenges**

Hosting a website is relatively inexpensive and costs around \$10/month for a hosting service (such as DigitalOcean.com or linode.com) for a low-volume server. The actual cost of hosting a website depends on the number of processors, amount of traffic, and amount of memory used. Included with a hosting service is a regular backup plan for the code and contents of the website. However, websites require a programmer to perform regular updates of the database and scripting software, which is crucial for security issues, and is the most costly component to maintaining the website. For performing regular updates of the database and code, an estimate of 1-4 programming hrs/month is needed. Hiring a freelance programmer costs \$25-50/hr. It is most efficient and cost-effective to find someone “in-house” to be the custodian of the code and database and to perform regular maintenance, as this person would be familiar with the code, instead of contracting this out to new programmers. Programming experience is also required to resolve potential bugs with the addition of new features to the website.

Documentation for the website should be created so that new programmers have an understanding of the website development with the following items:

- a) introduction

- b) tech stack/basic requirements for software to run website and database: webserver, database software, how much JavaScript is involved, frameworks, libraries, versions, etc.
- c) documentation for programmer: overall goals and objectives, rationale behind database schema structure, code documented inline, all functions documented, etc.

A major challenge to hosting a website is hacking, as there are multiple attempts per second. If a website is hacked, the website needs to be shut down and files on the server need to be replaced, again requiring a programmer's experience. Software written from scratch is a smaller target for hacking than popular web development software like WordPress.

In considering a data submission portal, there are three options for data submission:

- a) user accounts for every individual
- b) one account for a collator of data to submit
- c) a publicly accessible portal where anyone can submit

A publicly accessible portal would increase the chances of hacking. Therefore, to make the site more secure, it is best to either limit accounts for data deposition to trusted individuals, not to the general public, or to have an online form using CAPTCHAs to differentiate humans from robotic software and to decrease spam and hacking associated with form submission.

Currently, the RRN website's domain name is registered and the American Rhododendron Society (ARS) is paying for the domain name and hosting service (\$6/month at web.com). The RRN website is using a Windows server and includes a Microsoft database (MS SQL) designed for large fields, with the capacity for multiple databases. The hosting service includes 300 GB of data storage for html pages and 7.5 GB for database size.

#### **4) Explore funding options.**

Currently, Bob Weissman is the RRN web master and is developing the RRN website and its features on a voluntary basis. However, if he is no longer able to do this or if any new features are needed that he is unable to develop, the RRN would need to hire an external programmer. In this case, the RRN would need to find sources of funding for such future programming needs. Several options for funding are below:

- 1) Inquire into the ARS and/or RRN community for others with programming experience that are willing to donate their time.
- 2) Include development of features for the RRN website in larger research grant proposals that are submitted by RRN members.
- 3) Create undergraduate work-study positions that seek Computer Science students for development of features on the RRN website.
- 4) A variety of technology grants are available to non-profits. Therefore, one option is for the RRN to apply for 501(c)(3) status so that it can apply for these types of grants for website development. Note: For submitting website/information technology grant proposals, the RRN would need to demonstrate a strong need and long-term plan for the website.

## Appendix A: Rhododendron Genomes Published and Soon-to-be Released

At least 15 rhododendron genomes have been published in the last several years. These genomes include nuclear genomes, which include all of the coding and non-coding DNA sequences in the genome, and transcriptomes, which contain only coding DNA sequences from genes that were turned on at the time of sample collection.

A common tool for searching genomes for particular molecular sequences is the National Center for Biotechnology Information (NCBI) Basic Local Alignment Search (BLAST) tool (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>), which can be used easily on genomes that are deposited in NCBI. However, no assembled *Rhododendron* genomes are deposited in NCBI for researchers to use.

One nuclear genome, *R. delavayi*, and approximately 14 transcriptomes have been published for *Rhododendron* to date). The *R. delavayi* genome is deposited in a repository as a text file with its assembled (scaffold) sequences (<http://gigadb.org/dataset/view/id/100331>), but it is not available with an online BLAST tool, nor is it deposited in NCBI.

Only two *Rhododendron* transcriptomes (*Ledum palustre*, *R. scopulorum*) are available with an online BLAST tool on the 1KP website (<https://db.cngb.org/onekp/>), but are not deposited in NCBI.

For the other 12 rhododendron transcriptomes that have been published, only the raw sequencing data (short 100-base pair sequences) are available on NCBI, but the assembled sequences that comprise transcriptomes are not available for BLAST.

With another upcoming nuclear genome, *R. williamsianum*, and additional transcriptomes, we hope to centralize published *Rhododendron* genomes and transcriptomes on the R-RN website and make them available for users with an online BLAST tool.

### Nuclear genomes, sizes, and availability:

Species	Resource	Size (MB)	Availability	Reference
<i>R. delavayi</i>			<a href="http://gigadb.org/dataset/view/id/100331">http://gigadb.org/dataset/view/id/100331</a>	(Zhang et al. 2017a)
	genome	698		
	CDS	40		
	protein	15		
<i>R. williamsianum</i>			<a href="https://www.ncbi.nlm.nih.gov/bioproject/PRJNA432092">https://www.ncbi.nlm.nih.gov/bioproject/PRJNA432092</a>	(Soza et al. in review)
	genome	541		
	CDS	36		
	protein	13		

## Transcriptomes, tissues, sizes, and availability:

Species	Tissues	Size (MB)	Availability	Reference
<i>R. albiflorum</i>	pooled early and late flower buds, flowers, leaves, fruits, and vegetative buds	233	<a href="https://drive.google.com/uc?export=download&amp;id=1J2yfEIX3b4hX7jRjmlEVwHYTo3awSSq">https://drive.google.com/uc?export=download&amp;id=1J2yfEIX3b4hX7jRjmlEVwHYTo3awSSq</a>	E. Ramage, unpublished data
<i>R. albrechtii</i>	pooled early and late flower buds, flowers, leaves, fruits, and vegetative buds	212		E. Ramage, unpublished data
<i>R. amagianum</i>	pooled flowers and leaves†	UNK	<a href="https://www.ncbi.nlm.nih.gov/sra/DRX054080">https://www.ncbi.nlm.nih.gov/sra/DRX054080</a>	
<i>R. arboreum</i>	pooled flowers and leaves	134	<a href="https://datadryad.org/stash/dataset/doi:10.5061/dryad.2td21">https://datadryad.org/stash/dataset/doi:10.5061/dryad.2td21</a>	Choudhary et al. 2018, 2019
<i>R. beyerinckianum</i>	pooled early and late flower buds, flowers, leaves, fruits, and vegetative buds	265		E. Ramage, unpublished data
<i>R. camtschaticum</i>	pooled early and late flower buds, flowers, leaves, fruits, and vegetative buds	230		E. Ramage, unpublished data
<i>R. delavayi</i>	pooled flowers, flower buds, leaves, and stems	91	<a href="ftp://parrot.genomics.cn/gigadb/pub/10.5524/100001_101000/100331/Unigene/WHYR14030800_B-Unigene.fa.gz">ftp://parrot.genomics.cn/gigadb/pub/10.5524/100001_101000/100331/Unigene/WHYR14030800_B-Unigene.fa.gz</a>	Zhang et al. 2017a
<i>R. edgeworthii</i>	pooled early and late flower buds, flowers, leaves, fruits, and vegetative buds	242		E. Ramage, unpublished data
<i>R. fortunei</i>	pooled blooming flowers and leaves†	UNK		Wang et al. 2018a
<i>R. hainanense</i>	Leaves†	UNK		Zhao et al. 2018
<i>R. latoucheae</i>	pooled stems, leaves, shoot tips, flower buds, flowers, and fruits†	UNK		Xing et al. 2017
<i>R. longipedicellatum</i>	Leaves†	UNK		Li et al. 2018
<i>R. mariesii</i>	pooled blooming flowers and leaves†	UNK		Wang et al. 2018a
<i>R. molle</i>	pooled blooming flowers and leaves†	UNK		Wang et al. 2018a
<i>R. molle</i>	pooled flower buds and flowers†	UNK		Xiao et al. 2018
<i>R. molle</i>	pooled early and late flower buds, flowers, leaves, fruits, and vegetative buds	219		E. Ramage, unpublished data
<i>R. obtusum</i>	leaves†	UNK		Fang et al. 2017
<i>R. pulchrum</i>	pooled flower buds and flowers†	UNK		Wang et al. 2018b
<i>R. rex</i>	leaves†	UNK		Zhang et al. 2017b
<i>R. scopulorum</i>	leaves	48	<a href="https://sites.google.com/a/ualberta.ca/onekp/">https://sites.google.com/a/ualberta.ca/onekp/</a>	
<i>R. simsii</i>	pooled blooming flowers and leaves†	UNK		Wang et al. 2018a
<i>Ledum palustre</i> ( <i>R. tomentosum</i> )	leaves	42	<a href="https://sites.google.com/a/ualberta.ca/onekp/">https://sites.google.com/a/ualberta.ca/onekp/</a>	

†Assembled transcriptome not available

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## Appendix B: Online Resources for Links from the RRN Website

### **Rhododendron-specific species and/or image databases:**

American Rhododendron Society (ARS) Plant Database

[https://www.rhododendron.org/search\\_intro.asp](https://www.rhododendron.org/search_intro.asp)

The ARS Plant Database is an identification tool that contains information on flower color, flower/truss description, fragrance, bloom time, foliage description, plant habit, height, cold hardiness temp, elepidote or lepidote, subgenus, section, subsection, and geographical origin as well as a photo.

Danish Chapter of the ARS

<http://www.rhododendron.dk/alfabet.html>

A great resource for photos of *Rhododendron* taxa, as well as species information.

Edinburgh Rhododendron Monographs

[https://data.rbge.org.uk/service/factsheets/Edinburgh\\_Rhododendron\\_Monographs.xhtml](https://data.rbge.org.uk/service/factsheets/Edinburgh_Rhododendron_Monographs.xhtml)

Website provides species, subspecies and variety descriptions along with notes on distribution, habitat, and nomenclature for about 1,000 *Rhododendron* species.

German Genebank Rhododendron

<https://www.bundessortenamt.de/rhodo/?job=rhodo>

The website provides descriptions for all *Rhododendron* species and cultivars which exist in botanical gardens, state and public establishments, and in private collections in Germany.

Hirsutum.info: About Rhododendrons, Azaleas, and Vireyas; a virtual arboretum

<http://hirsutum.info/>

The purpose of this website is to give an overview (photos and information) of as many *Rhododendron* species and cultivars (hybrids) as possible. Information for each taxon includes subgenus, section, subsection, synonyms, common names, cultivation history, description

history, origin, corolla shape, leaf shape, habit, deciduousness, bloom time, hardiness, flower color, height, natural hybrids, clones/selections, and photos.

Vireya Rhododendrons

<http://www.vireya.net/>

The Vireya Rhododendrons website includes a gallery that holds ~1000 images of vireyas, an archive that contains over 50 selected works on vireya culture and comprehensive listings of named hybrids, a species database, and information on the history, distribution, classification and cultivation of vireya rhododendrons.

Western North American Rhododendron Species Project (WNARSP)

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

WNARSP provides species descriptions, images, and distribution maps for native *Rhododendron* species of the western United States and Canada.

### **General plant databases with species information and images:**

Burke Herbarium Image Collection

<http://biology.burke.washington.edu/herbarium/imagecollection.php>

The image collection provides photographs and information for vascular plants, macrofungi, and lichenized fungi of Washington state, including distribution maps, species descriptions, and synonymy.

Calflora

<https://www.calflora.org/>

Calflora provides species information, distribution maps, and images for California plants.

Encyclopedia of Life (EOL)

<https://eol.org/pages/39881308>

EOL provides species information, maps, and images for all life on Earth.

Lady Bird Johnson Wildflower Center

<https://www.wildflower.org/plants/>

Website provides images and information on species native to North America, including plant characteristics, bloom information, distribution, growing conditions, value to beneficial insects, propagation, and where to acquire species.

NatureServe Explorer

<http://explorer.natureserve.org/servlet/NatureServe?init=Species>

NatureServe Explorer provides conservation status, taxonomy, distribution, and life history information for more than 70,000 plants, animals, and ecological communities and systems in the United States and Canada.

United States Department of Agriculture (USDA) Plants Database

<https://plants.sc.egov.usda.gov/java/>

The PLANTS Database provides standardized information about vascular plants, mosses, liverworts, hornworts, and lichens of the U.S. and its territories, including general information, distribution maps, images, synonyms, classification, legal status, and wetland status.

### **Molecular databases:**

DNA Data Bank of Japan (DDBJ)

<https://www.ddbj.nig.ac.jp/services-e.html>

DDBJ maintains databases for nucleotide sequences deposited from all organisms.

European Molecular Biology Laboratory – European Bioinformatics Institute (EMBL-EBI)

<https://www.ebi.ac.uk/>

EMBL-EBI maintains databases for nucleotide and protein sequences deposited from all organisms.

National Center for Biotechnology Information (NCBI)

<https://www.ncbi.nlm.nih.gov/>

NCBI maintains databases for nucleotide and protein sequences deposited from all organisms.

### **Specific plant trait databases:**

Index to Plant Chromosome Numbers (IPCN)

<http://www.tropicos.org/Project/IPCN>

IPCN provides gametophytic and/or sporophytic counts of chromosomes from published chromosome reports on plants.

Plant DNA C-values Database

<http://data.kew.org/cvalues/>

DNA amount in the unrepliated gametic nucleus of an organism is referred to as its C-value, and available reports for genome size according to C-value can be found here.

TRY Plant Trait Database

<https://www.try-db.org/TryWeb/About.php>

Database includes a variety of plant trait data, which can be obtained upon request.

### **General plant image galleries:**

CalPhotos

<https://calphotos.berkeley.edu/>

CalPhotos is a collection of photos from plants, animals, fossils, people, and landscapes from around the world.

**Online Floras:**

Electronic Atlas of the Flora of British Columbia

<http://ibis.geog.ubc.ca/biodiversity/eflora/index.shtml>

Flora of China

[http://www.efloras.org/florataxon.aspx?flora\\_id=2&taxon\\_id=128386](http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=128386)

Flora of North America

[http://www.efloras.org/florataxon.aspx?flora\\_id=1&taxon\\_id=128386](http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=128386)

Flora of Pakistan

[http://www.efloras.org/florataxon.aspx?flora\\_id=5&taxon\\_id=128386](http://www.efloras.org/florataxon.aspx?flora_id=5&taxon_id=128386)

Jepson eFlora, Flora of California

[http://ucjeps.berkeley.edu/cgi-bin/get\\_IJM.pl?key=8986](http://ucjeps.berkeley.edu/cgi-bin/get_IJM.pl?key=8986)

World Flora Online

<http://www.worldfloraonline.org/search?query=Rhododendron>

**Living collections:**

The Arboretum and Botanical Garden, University of Bergen, Norway:  
<https://uib.gardenexplorer.org/>

Botanic Gardens Conservation International (BGCI)  
[https://www.bgci.org/plant\\_search.php](https://www.bgci.org/plant_search.php)

Royal Botanic Garden Edinburgh (RBGE)  
<https://data.rbge.org.uk/search/livingcollection/>

UC Botanical Garden  
<https://webapps.cspace.berkeley.edu/botgarden/search/search/>

#### **DNA banks:**

Integrated Digitized Biocollections (iDigBio)  
<https://www.idigbio.org/genetic-resources>

iDigBio is actively compiling a list of DNA banking facilities and genetic resources repositories in the United States that maintain collections of nucleic acid extracts (DNA or RNA) or preserved tissues suitable for genetic and genomic studies of biodiversity.

New York Botanical Garden Steere Herbarium  
[http://sweetgum.nybg.org/science/dna-bank/?\\_ga=2.163545087.2132268815.1549233986-934713550.1549233986](http://sweetgum.nybg.org/science/dna-bank/?_ga=2.163545087.2132268815.1549233986-934713550.1549233986)

Royal Botanic Gardens Kew DNA Bank  
<https://dnabank.science.kew.org/search>

**Seed banks:**

Botanic Gardens Conservation International (BGCI)

[https://www.bgci.org/plant\\_search.php](https://www.bgci.org/plant_search.php)

Royal Botanic Gardens Kew Millennium Seed Bank

<http://apps.kew.org/seedlist/>

United States Department of Agriculture (USDA) Germplasm Resources Information Network (GRIN)

<https://www.ars-grin.gov/>

**Tissue banks:**

Botanic Gardens Conservation International (BGCI)

[https://www.bgci.org/plant\\_search.php](https://www.bgci.org/plant_search.php)

Integrated Digitized Biocollections (iDigBio)

<https://www.idigbio.org/genetic-resources>

iDigBio is actively compiling a list of DNA banking facilities and genetic resources repositories in the United States that maintain collections of nucleic acid extracts (DNA or RNA) or preserved tissues suitable for genetic and genomic studies of biodiversity.

Missouri Botanical Garden

<http://www.missouribotanicalgarden.org/plant-science/plant-science/william-l-brown-center/wlbc-resources/wlbc-databases/dna-bank.aspx>

New York Botanical Garden Steere Herbarium

[http://sweetgum.nybg.org/science/dna-bank/?\\_ga=2.163545087.2132268815.1549233986-934713550.1549233986](http://sweetgum.nybg.org/science/dna-bank/?_ga=2.163545087.2132268815.1549233986-934713550.1549233986)

### **Taxonomy:**

Catalogue of Life

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

Search Annual Checklist for accepted names and synonyms.

International Plant Names Index (IPNI)

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

Integrated Taxonomic Information System (ITIS)

<https://www.itis.gov/>

The Plant List

<http://www.theplantlist.org/tpl1.1/search?q=Rhododendron>

World Flora Online

<http://www.worldfloraonline.org/search?query=Rhododendron>

### **Online herbarium collections:**

Australasian Virtual Herbarium

<https://avh.chah.org.au/>

Biodiversity of the Hengduan Mountains

<http://hengduan.huh.harvard.edu/fieldnotes/specimens/search/search.zpt?action=search&st=Rhododendron>

Consortium of California Herbaria

<http://ucjeps.berkeley.edu/consortium/>

Consortium of Pacific Northwest Herbaria

<http://www.pnwherbaria.org/data/search.php>

Fairchild Tropical Botanic Garden Virtual Herbarium

<http://www.virtualherbarium.org/vh/db/main.php>

<http://www.virtualherbarium.org/vh/othersystems.html>

Global Biodiversity Information Facility (GBIF)

<https://www.gbif.org/>

Harvard University Herbaria

[http://kiki.huh.harvard.edu/databases/specimen\\_index.html](http://kiki.huh.harvard.edu/databases/specimen_index.html)

Integrated Digitized Biocollections (iDigBio)

<https://www.idigbio.org/portal/search>

JSTOR Global Plants

<https://plants.jstor.org/>

New York Botanical Garden C. V. Starr Virtual Herbarium

<http://sweetgum.nybg.org/science/vh/>

Royal Botanic Garden Edinburgh (RBGE)

<https://data.rbge.org.uk/search/herbarium/>

Royal Botanic Gardens Kew Herbarium

<http://apps.kew.org/herbcat/navigator.do>

SEINet Network of North American Plant Herbaria (Arizona-New Mexico)

<http://swbiodiversity.org/seinet/collections/index.php>

Singapore Herbarium

<https://herbaria.plants.ox.ac.uk/bol/sing>

SouthEast Regional Network of Expertise and Collections (SERNEC)

<http://sernecportal.org/portal/>

Symbiota Portals

<http://symbiota.org/docs/symbiota-introduction/active-symbiota-projects/>