

I. APPENDIX A. A COMPLETE REPRODUCIBLE WORKFLOW, FROM A SPECIES LIST TO A PHYLOGENY, AND DISTRIBUTION MAP.

If you aren't familiar with a complete workflow in R, it may be difficult to visualize the process. In R, everything is programmatic, so the whole workflow can be in one place, and be repeated whenever necessary. The following is a workflow for taxize, going from a species list to a phylogeny.

First, install taxize

```
install.packages("taxize")
```

Then load it into R

```
library(taxize)
```

Most of us will start out with a species list, something like the one below. Note that each of the names is spelled incorrectly.

```
splist <- c("Helanthus annuus", "Pinos contorta", "Collomia grandiflorra", "Abies magnificaa",
            "Rosa californica", "Datura wrighti", "Mimulus bicolour", "Nicotiana glauca",
            "Maddia sativa", "Bartlettia scapposa")
```

There are many ways to resolve taxonomic names in taxize. Of course, the ideal name resolver will do the work behind the scenes for you so that you don't have to do things like fuzzy matching. There are a few services in taxize like this we can choose from: the Global Names Resolver service from EOL (see function *gnr_resolve*) and the Taxonomic Name Resolution Service from iPlant (see function *tnrs*). In this case let's use the function *tnrs*.

```
# The tnrs function accepts a vector of 1 or more
splist_tnrs <- tnrs(query = splist, getpost = "POST", source_ = "iPlant_TNRS")

# Remove some fields
(splist_tnrs <- splist_tnrs[, !names(splist_tnrs) %in% c("matchedName", "annotations",
  "uri")])
```

	submittedName	acceptedName	sourceId	score
3	Helanthus annuus	Helianthus annuus	iPlant_TNRS	0.98
1	Pinos contorta	Pinus contorta	iPlant_TNRS	0.96
4	Collomia grandiflorra	Collomia grandiflora	iPlant_TNRS	0.99
5	Abies magnificaa	Abies magnifica	iPlant_TNRS	0.98
10	Rosa californica	Rosa californica	iPlant_TNRS	0.99
9	Datura wrighti	Datura wrightii	iPlant_TNRS	0.98
7	Mimulus bicolour	Mimulus bicolor	iPlant_TNRS	0.98
8	Nicotiana glauca	Nicotiana glauca	iPlant_TNRS	1.00
6	Maddia sativa	Madia sativa	iPlant_TNRS	0.97
2	Bartlettia scapposa	Bartlettia scaposa	iPlant_TNRS	0.98

```
# Note the scores. They suggest that there were no perfect matches, but
# they were all very close, ranging from 0.77 to 0.99 (1 is the highest).
# Let's assume the names in the 'acceptedName' column are correct (and
# they should be).
```

```
# So here's our updated species list
(splist <- as.character(splist_tnrs$acceptedName))
```

```
[1] "Helianthus annuus"      "Pinus contorta"        "Collomia grandiflora"
[4] "Abies magnifica"       "Rosa californica"      "Datura wrightii"
[7] "Mimulus bicolor"       "Nicotiana glauca"      "Madia sativa"
[10] "Bartlettia scaposa"
```

Another thing we may want to do is collect common names for our taxa.

```
tsns <- get_tsn(searchterm = splist, searchtype = "sciname", verbose = FALSE)
comnames <- lapply(tsns, getcommonnamesfromtsn)

# Unfortunately, common names are not standardized like species names, so
# there are multiple common names for each taxon
sapply(comnames, length)

[1] 3 3 3 3 3 3 3 3 3 3

# So let's just take the first common name for each species
comnames_vec <- do.call(c, lapply(comnames, function(x) as.character(x[1, "comname"])))

# And we can make a data.frame of our scientific and common names
(allnames <- data.frame(spname = splist, comname = comnames_vec))
```

	spname	comname
1	Helianthus annuus	common sunflower
2	Pinus contorta	lodgepole pine
3	Collomia grandiflora	largeflowered collomia
4	Abies magnifica	golden fir
5	Rosa californica	California wildrose
6	Datura wrightii	sacred thorn-apple
7	Mimulus bicolor	yellow and white monkeyflower
8	Nicotiana glauca	tree tobacco
9	Madia sativa	coast tarweed
10	Bartlettia scaposa	Bartlett daisy

Another common task is getting the taxonomic tree upstream from your study taxa. We often know what family or order our taxa are in, but it we often don't know the tribes, subclasses, and superfamilies. taxize provides many avenues to getting classifications. Two of them are accessible via a single function (*classification*): the Integrated Taxonomic Information System and uBio; and via the Catalogue of Life (see function *col.classification*)

```
# As we already have Taxonomic Serial Numbers from ITIS, let's just get
# classifications from ITIS. Note that we could use uBio instead.
class_list <- classification(tsns)
sapply(class_list, nrow)

[1] 12 11 12 11 12 12 12 12 12 12

# And we can attach these names to our allnames data.frame
library(plyr)
gethiernames <- function(x) {
  temp <- x[, c("rankName", "taxonName")]
  values <- data.frame(t(temp[, 2]))
  names(values) <- temp[, 1]
  return(values)
}
class_df <- ldply(class_list, gethiernames)
allnames_df <- merge(allnames, class_df, by.x = "spname", by.y = "Species")

# Now that we have allnames_df, we can start to see some relationships
# among species simply by their shared taxonomic names
allnames_df[1:2, ]
```

spname	comname	Kingdom	Subkingdom	Infrakingdom
--------	---------	---------	------------	--------------

```

1 Abies magnifica      golden fir Plantae Viridaeplantae Streptophyta
2 Bartlettia scaposa Bartlett daisy Plantae Viridaeplantae Streptophyta
  Division      Subdivision Infradivision      Class Superorder
1 Tracheophyta Spermatophytina Gymnospermae      Pinopsida      <NA>
2 Tracheophyta Spermatophytina Angiospermae Magnoliopsida Asteranae
  Order      Family      Genus
1 Pinales    Pinaceae      Abies
2 Asterales  Asteraceae Bartlettia

# Ah, so Abies and Bartlettia are in different infradivisions, but share
# taxonomic names above that point.

```

However, taxonomy can only get you so far. Shared ancestry can be reconstructed from molecular data, and phylogenies created. Phylomatic is a web service with an API that we can use to get a phylogeny.

Using the species list, with the corrected names, we can now search for occurrence data. The Global Biodiversity Information Facility (GBIF) has the largest collection of records data, and has a API that we can interact with programmatically from R. First, we need to install rgbif.

```

# Install rgbif
install.packages("devtools")
library(devtools)
install_github("rgbif", "ropensci")

```

Now we can search for occurrences for our species list and make a map.

```

phylogeny <- phylomatic_tree(taxa = as.character(allnames$sname), taxnames = TRUE,
  get = "POST", informat = "newick", method = "phylomatic", storedtree = "R20120829",
  taxaformat = "slashpath", outformat = "newick", clean = "true", parallel = TRUE)

```

Retrieving data for species ' Helianthus annuus '

Retrieving data for species ' Pinus contorta '

Retrieving data for species ' Collomia grandiflora '

Retrieving data for species ' Abies magnifica '

Retrieving data for species ' Rosa californica '

Retrieving data for species ' Datura wrightii '

Retrieving data for species ' Mimulus bicolor '

Retrieving data for species ' Nicotiana glauca '

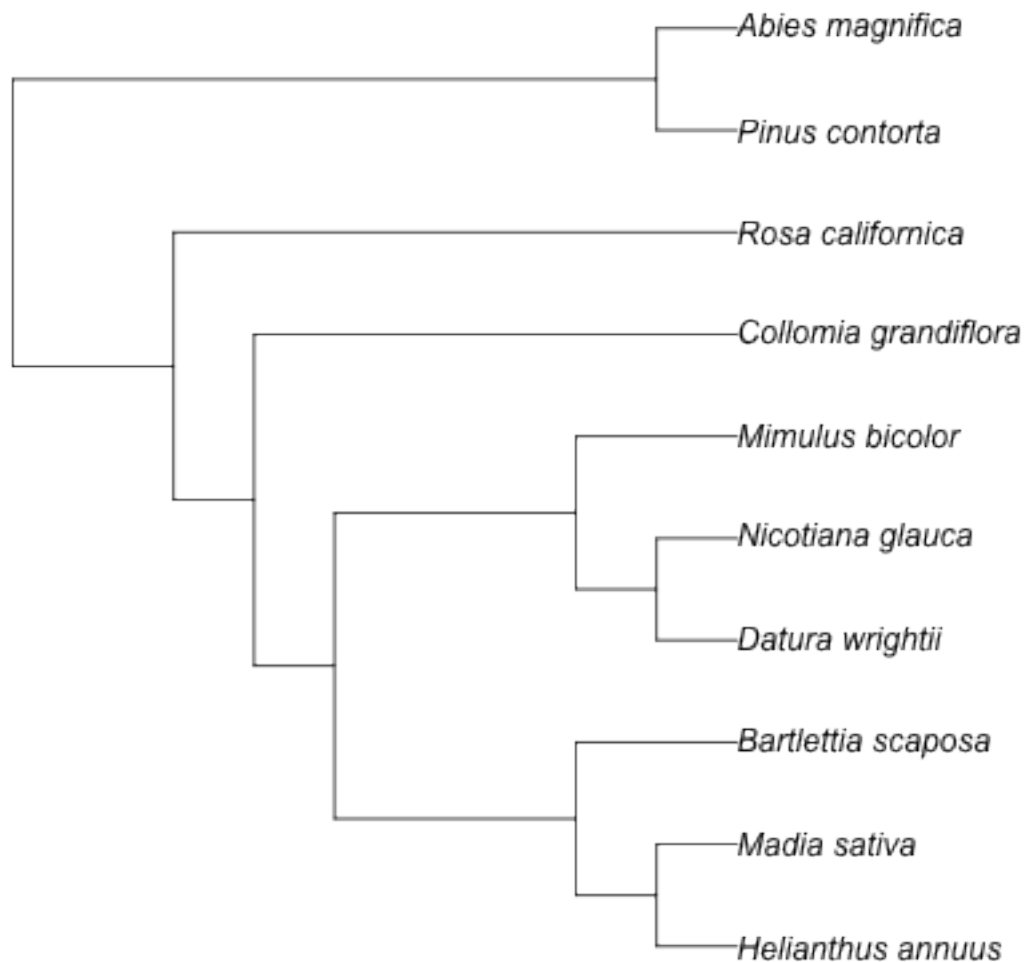
Retrieving data for species ' Madia sativa '

Retrieving data for species ' Bartlettia scaposa '

```

phylogeny$tip.label <- capwords(phylogeny$tip.label, onlyfirst = TRUE)
plot(phylogeny)

```



```

library(rgbif)
library(ggplot2)

occurr_list <- occurrencelist_many(as.character(allnames$spname), coordinatestatus = TRUE,
  maxresults = 100, removeZeros = TRUE, fixnames = "changealltorig")

# Make a map
p <- gbifmap(occurr_list) + guides(col = guide_legend(title = "", nrow = 2,
  byrow = TRUE)) + theme(legend.position = "bottom", legend.key = element_blank())
p

```

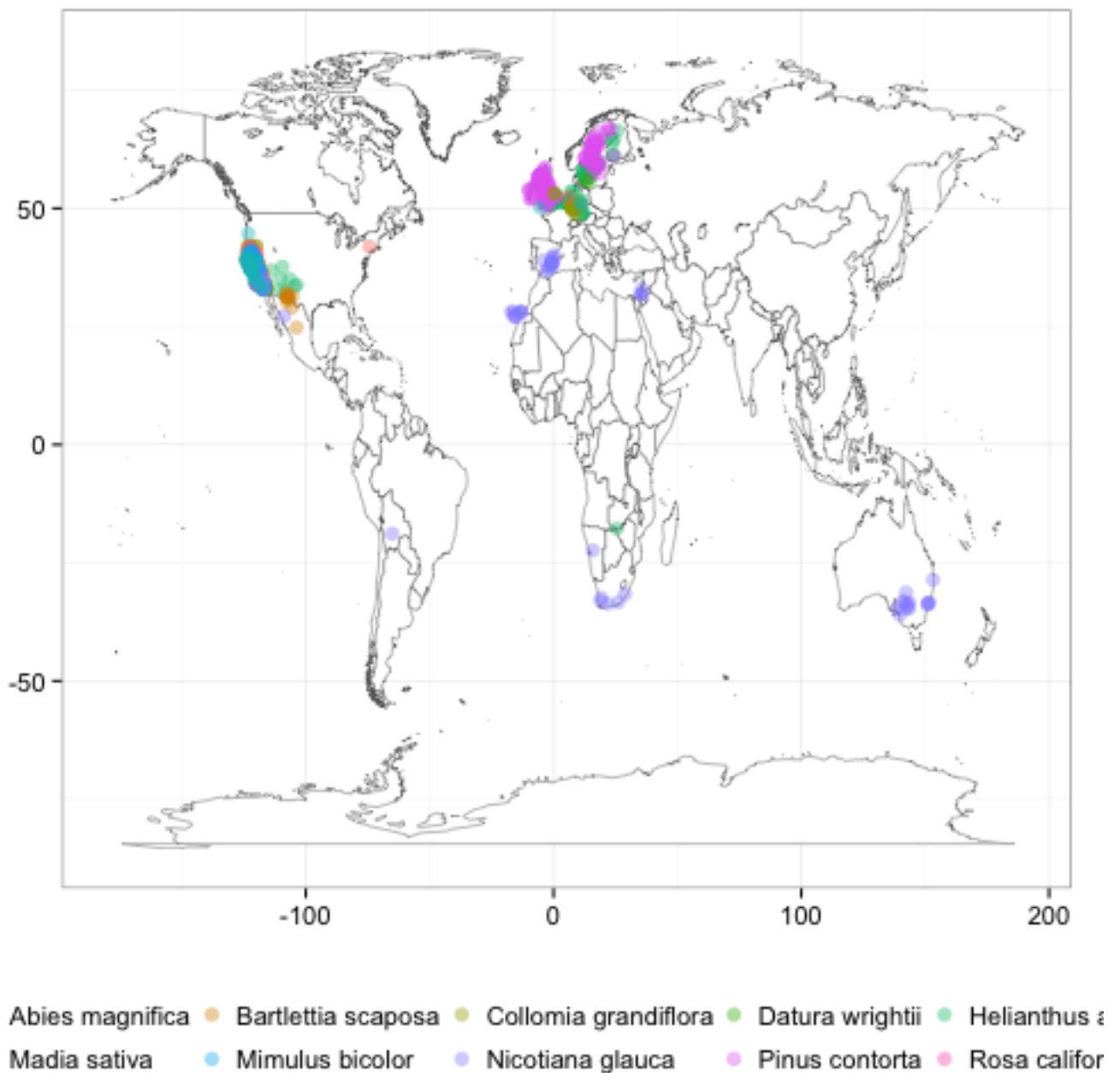


FIG. 2. a map...