Getting Data Science with R and ArcGIS

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https://github.com/scw/r-devsummit-2017-talk

High Quality PDF (4MB)

Resources Section

Data Science

Data Science

- A much-hyped phrase, but effectively is about the application of statistics and machine learning to real-world data, and developing formalized tools instead of one-off analyses. Combines diverse fields to solve problems.

Data Science

What’s a data scientist?

> *“A data scientist is someone who is better at statistics than any software engineer and better at software engineering than any statistician.”*
> — *Josh Wills*

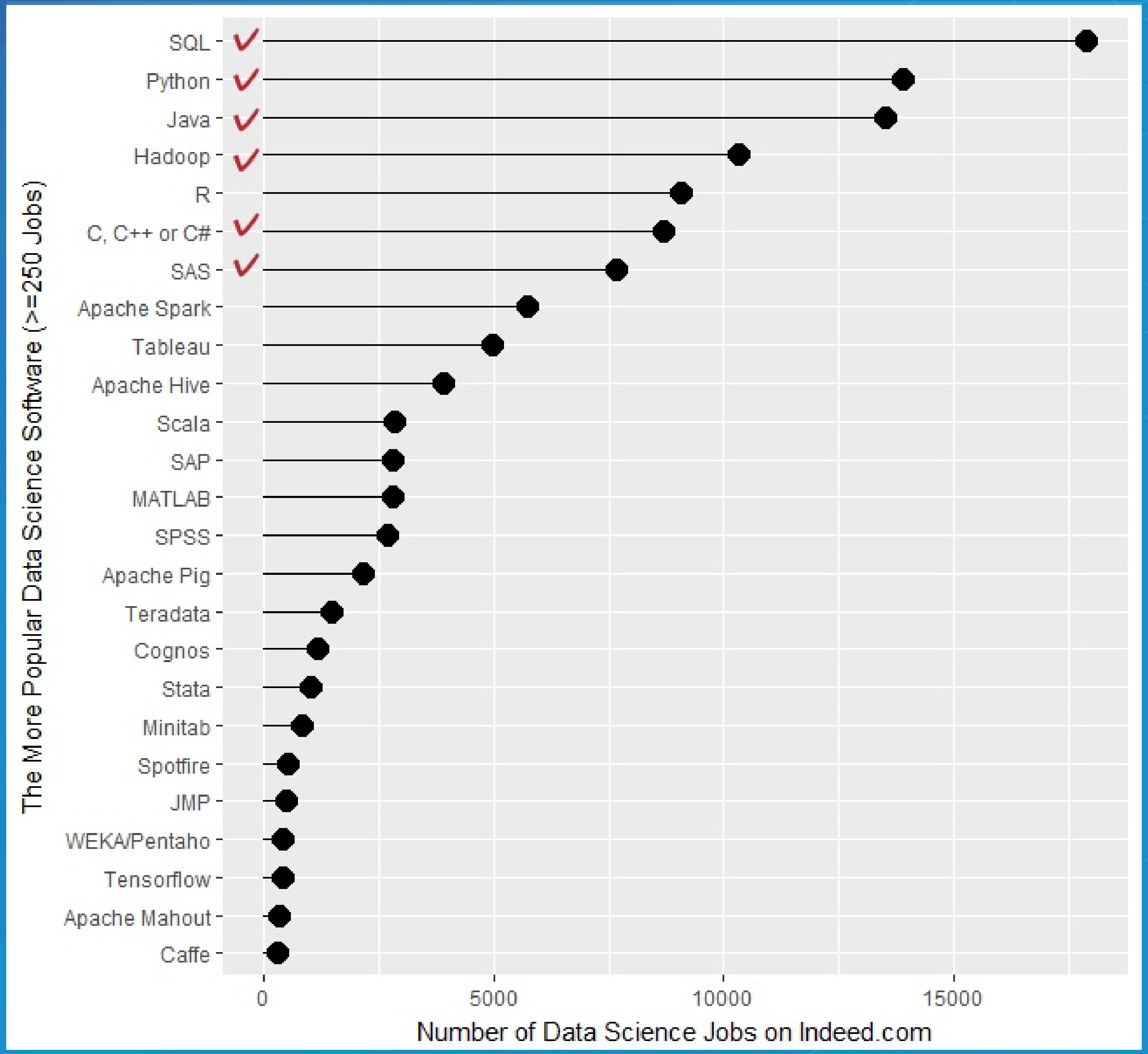
Data Science

Us geographic folks also rely on knowledge from multiple domains. We know that spatial is more than just an `x` and `y` column in a table, and how to get value out of this data.

Data Science Languages

- Python (SciPy stack, Jupyter, scikit-learn, …)
- C++ (Tensorflow, Shark, MLC++)
- Java (Spark MLlib, Weka)
- **R** (ML task view)
- Many workflows require combining components from multiple environments.

Data Science Jobs



R4Stats, DS job report

CONDA

- Industry standard for package management in the data science context, built by Continuum Analtyics
- Started with Python, but as shown in the R segment of the plenary, it can be used to support R, and hybrid workflows which connect multiple languages.
- Technology partner of Esri, have a talk tomorrow: Exploring Continuum Analytics’ Open-Source Offerings
  - Thurs 10:30AM, Mesquite G-H

R

Esri and R?

- Integration via ArcGIS–R bridge
- Joined R Consortium and R Foundation
- More to come — GIS has historically been more coupled with Python

Why R?

- Powerful core data structures and operations
  - Data frames, functional programming
- Unparalleled breadth of statistical routines
  - The *de facto* language of Statisticians
- CRAN: 6400 packages for solving problems
- Versatile and powerful plotting

- We assume basic proficiency programming
- See resources for a deeper dive into R

R Data Types

Data types you’re used to seeing…

Numeric - Integer - Character - Logical - timestamp

… but others you probably aren’t:

vector - matrix - data.frame - factor

Data Frames

- Treats tabular (and multi-dimensional) data as a *labeled*, *indexed* series of observations. Sounds simple, but is a game changer over typical software which is just doing 2D layout (e.g. Excel)

Data Types

```r
# Create a data frame out of an existing source
df.from.csv <- read.csv(
    "data/growth.csv",
    header=TRUE)
```

Data Types

```r
# Create a data frame from scratch
quarter <- c(2, 3, 1)
person <- c("Goodchild",
        "Tobler",
        "Krige")

met.quota <- c(TRUE, FALSE, TRUE)
df <- data.frame(person,
            met.quota,
            quarter)
```

Data Types

```
R> df
     person met.quota quarter
1 Goodchild      TRUE       2
2    Tobler     FALSE       3
3     Krige      TRUE       1
```

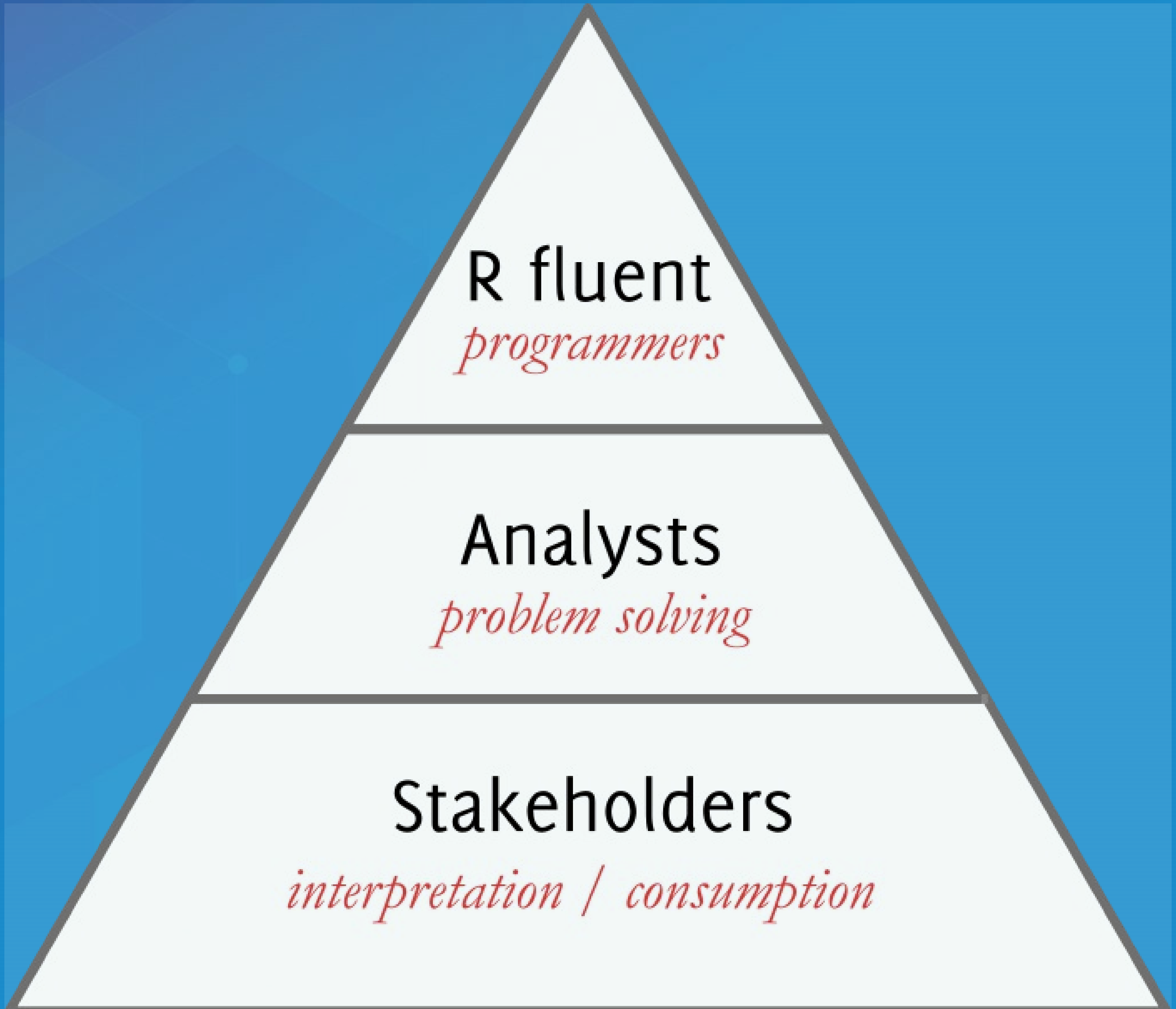
sp Types

- 0D: SpatialPoints
- 1D: SpatialLines
- 2D: SpatialPolygons
- 3D: Solid
- 4D: Space-time

Entity + Attribute model

R — ArcGIS Bridge

R — ArcGIS Bridge



R fluent

programmers

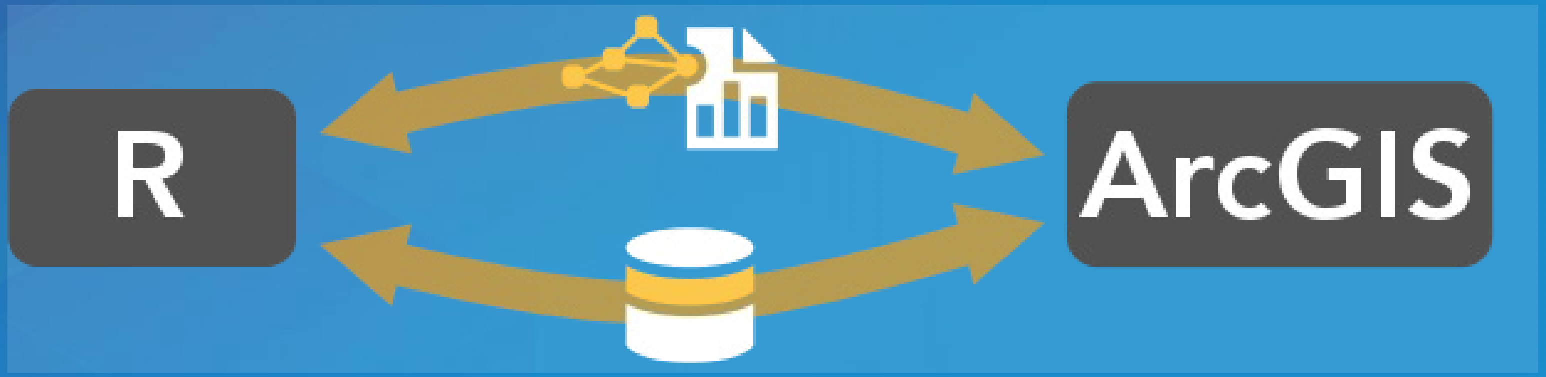
Analysts

problem solving

Stakeholders

interpretation / consumption

R — ArcGIS Bridge



- ArcGIS developers can *create tools and toolboxes* that integrate ArcGIS and R
- ArcGIS users can *access R* code through geoprocessing scripts
- R users can *access organizations GIS' data*, managed in traditional GIS ways

https://r-arcgis.github.io

R–ArcGIS Bridge

Store your data in ArcGIS, access it quickly in R, return R objects back to ArcGIS native data types (e.g. geodatabase feature classes).

Knows how to convert spatial data to `sp` objects.

Package Documentation

Demo: Getting Started

ArcGIS vs R Data Types

ArcGIS	R	Example Value
Address Locator	Character	Address Locators\\MGRS
Any	Character	
Boolean	Logical	
Coordinate System	Character	"PROJCS[\"WGS_1984_UTM_Zone_19N\"...
Dataset	Character	"C:\\workspace\\projects\\results.shp"
Date	Character	"5/6/2015 2:21:12 AM"
Double	Numeric	22.87918

ArcGIS vs R Data Types

ArcGIS	R	Example Value
Extent	Vector (xmin, ymin, xmax, ymax)	c(0, -591.561, 1000, 992)
Field	Character	
Folder	Character	full path, use with e.g. file.info()
Long	Long	19827398L
String	Character	
Text File	Character	full path
Workspace	Character	full path

Access ArcGIS from R

Start by loading the library, and initializing connection to ArcGIS:

```
# load the ArcGIS-R bridge library
library(arcgisbinding)
# initialize the connection to ArcGIS. Only needed when running directly from R.
arc.check_product()
```

Access ArcGIS from R

First, select a data source (can be a feature class, a layer, or a table):

```r
input.fc <- arc.open('data.gdb/features')
```

Then, filter the data to the set you want to work with (creates in-memory data frame):

```r
filtered.df <- arc.select(input.fc,
                    fields=c('fid', 'mean'),
                    where_clause="mean < 100")
```

This creates an *ArcGIS data frame* – looks like a data frame, but retains references back to the geometry data.

Access ArcGIS from R

Now, if we want to do analysis in R with this spatial data, we need it to be represented as `sp` objects. `arc.data2sp` does the conversion for us:

```
df.as.sp <- arc.data2sp(filtered.df)
```

`arc.sp2data` inverts this process, taking `sp` objects and generating ArcGIS compatible data frames.

Access ArcGIS from R

Finished with our work in R, want to get the data back to ArcGIS.
Write our results back to a new feature class, with `arc.write`:

```
arc.write('data.gdb/new_features', results.df)
```

Access ArcGIS from R

WKT to proj.4 conversion:

```
arc.fromP4ToWkt, arc.fromWktToP4
```

Interacting directly with geometries:

```
arc.shapeinfo, arc.shape2sp
```

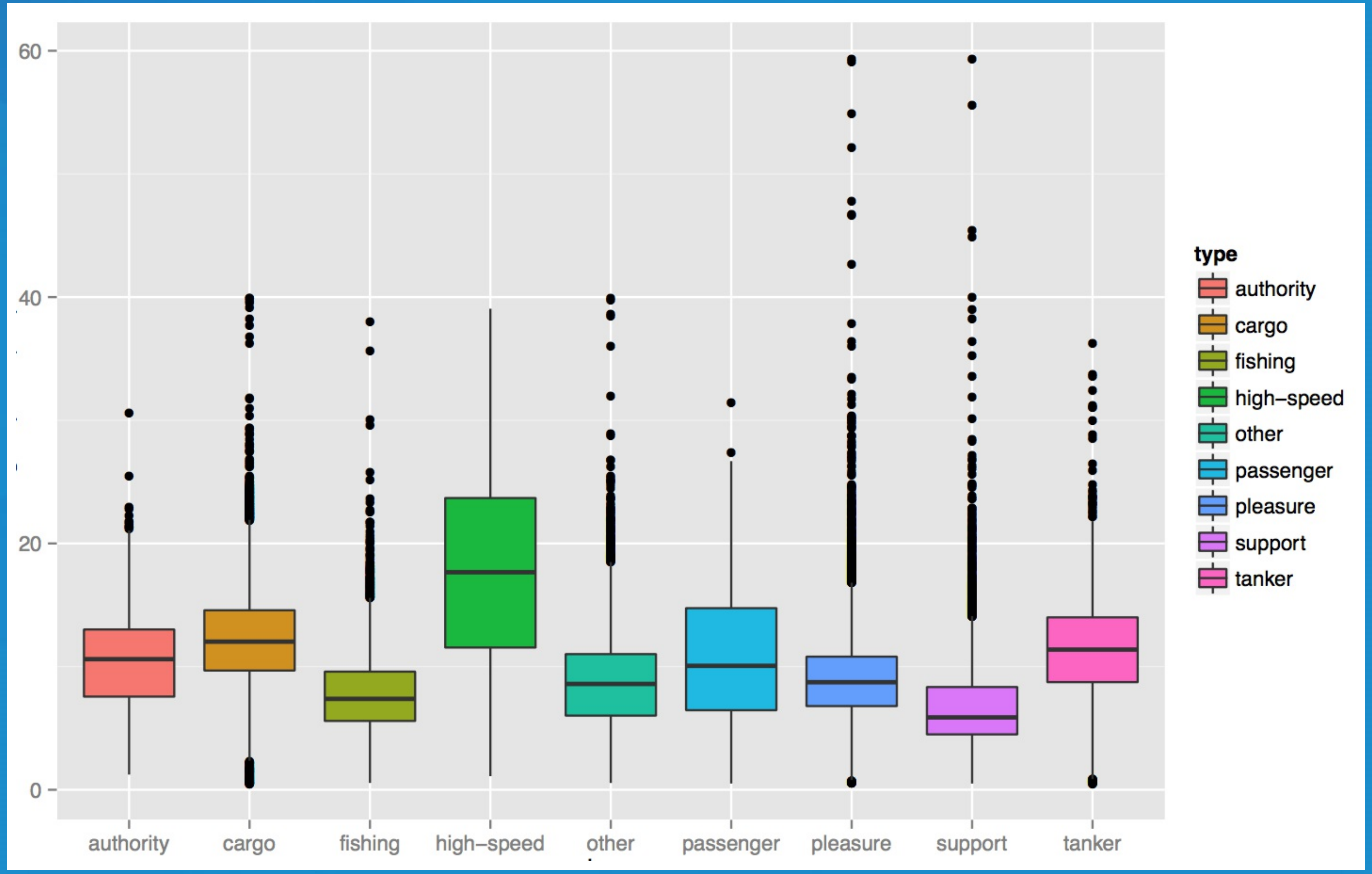
Geoprocessing session specific:

```
arc.progress_pos, arc.progress_label, arc.env (read only)
```

Data Science with R

Hadley Stack

- Hadley Wickham
- Developer at R Studio, Professor at Rice University
- ggplot2, scales, dplyr, devtools, many others
- New, in collaboration with Wes McKinney: feather



Statistical Formulas

```
fit.results <- lm(pollution ~ elevation + rainfall + ppm.nox + urban.density)
```

- Domain specific language for statistics
- Similar properties in other parts of the language
- caret for model specification consistency

Literate Programming

> *I believe that the time is ripe for significantly better documentation of programs, and that we can best achieve this by considering programs to be works of literature.*
> *— Donald Knuth, "Literate Programming"*

- packages: RMarkdown, Roxygen2
- Jupyter notebooks

Development Environments

- RStudio
- jupyter *née IPython*
- R Tools for Visual Studio

- Best of class tools for interacting with data.

dplyr Package

```
Batting %.%
  group_by(playerID) %.%
  summarise(total = sum(G)) %.%
  arrange(desc(total)) %.%
  head(5)
```

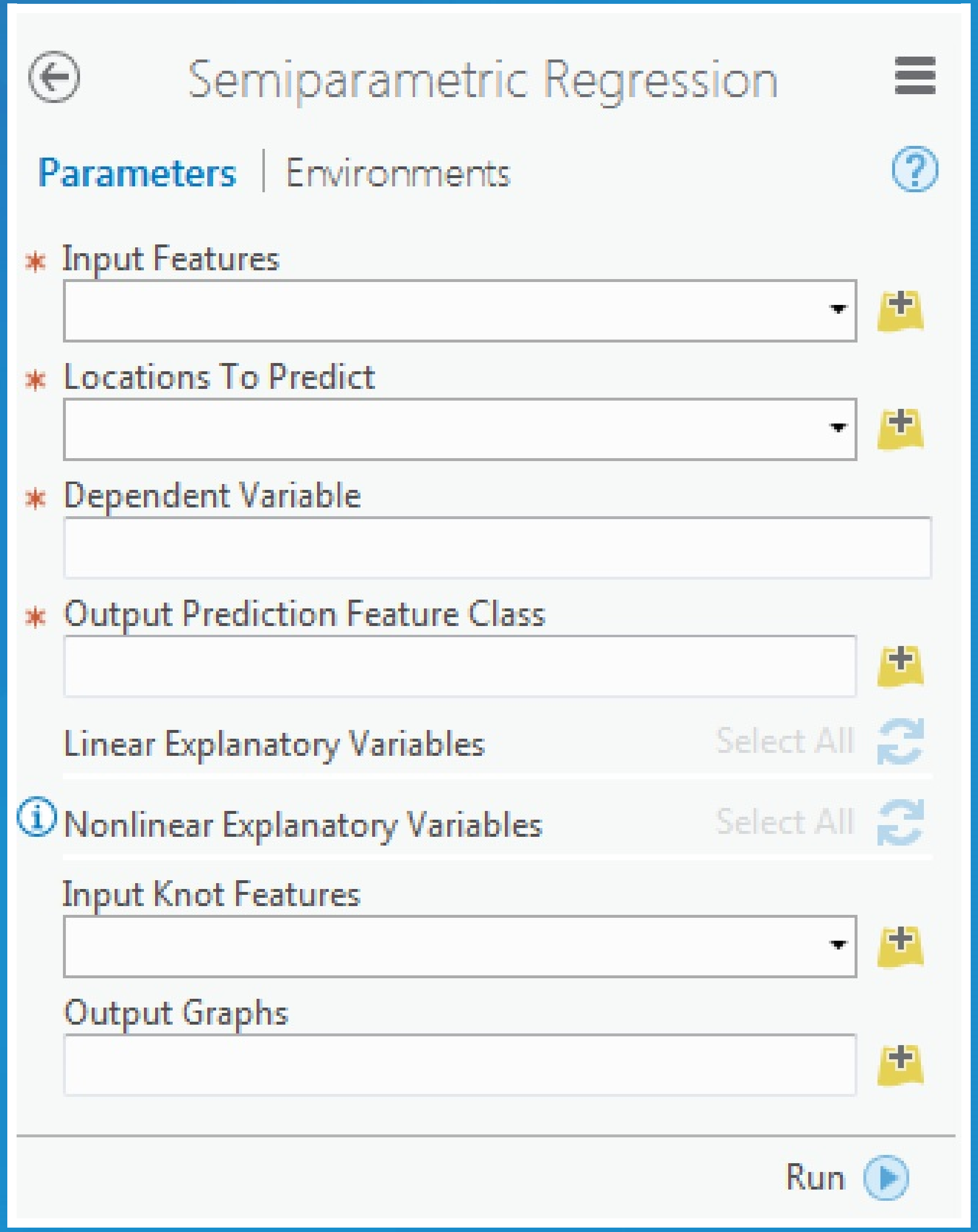
Introducing dplyr

R Challenges

- Performance issues
- Not a general purpose language
- Lacks purely UI mode of interaction (e.g. plots must be manually specified)
- Programmer only. There is shiny, but R is first and foremost a language that expects fluency from its users

R–ArcGIS Bridge Deep Dive

Building R Script Tools



Semiparametric Regression

Parameters | Environments

✱ Input Features

✱ Locations To Predict

✱ Dependent Variable

✱ Output Prediction Feature Class

Linear Explanatory Variables

Nonlinear Explanatory Variables

Input Knot Features

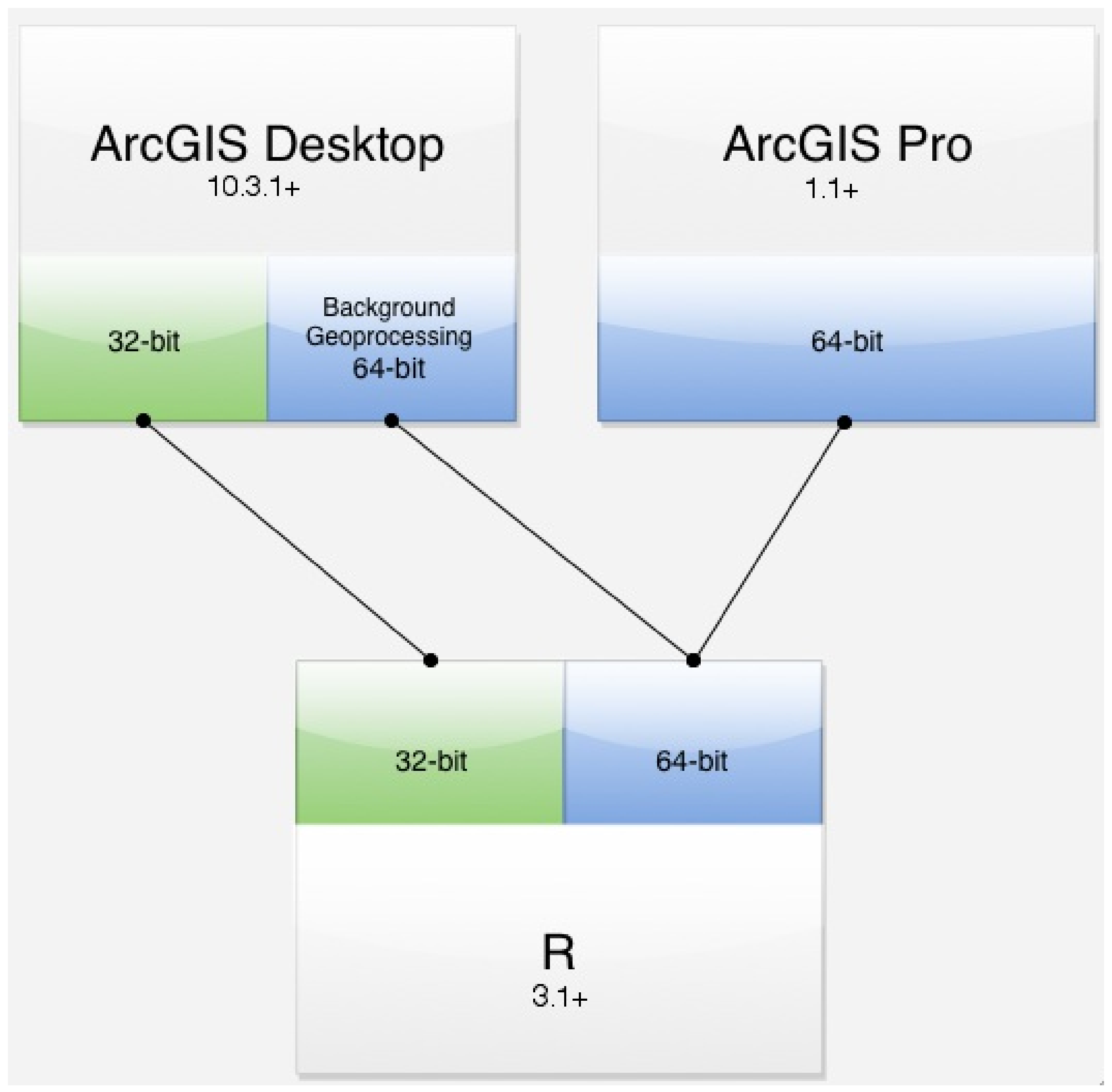
Output Graphs

Demo: R-ArcGIS bridge

How To Install

- Install with the R bridge install
- Detailed installation instructions

Where Can I Run This?



Where Can I Run This?

- Now:
  - First, install R 3.1 or later
  - ArcGIS Pro (64-bit) 1.1 or later
  - ArcMap 10.3.1 or later:
    - 32-bit R by default
    - 64-bit R available via Background Geoprocessing
  - ArcGIS Server 10.3.1+ / ArcGIS Enterprise

What’s Next?

- Conda for managing R environments
  - Starting at Pro 2.0, can be installed as any other package
- Raster support

Resources

Training Resources

- Learn Lesson: Analyze Crime Using Statistics and the R-ArcGIS bridge
- Web Course 1: Using the R-ArcGIS bridge
- Web Course 2: Integrating R Scripts into ArcGIS Geoprocessing Tools

Other Sessions

- Integrating Open-source Statistical Packages with ArcGIS earlier today, 2016 video
- Harnessing the Power of Python in ArcGIS Using the Conda Distribution yesterday, 2016 video
- Scientific Programming with the SciPy Stack earlier today, 2015 video
- Getting Data Science with R and ArcGIS 2016 video

R

Looking for a package to solve a problem? Use the CRAN Task Views.

Tons of good books and resources on R available, check out the RSeek engine to find resources for the language which can be difficult to locate because of the name.

R Packages by Hadley Wickham

Spatial R / Data Science

- An Introduction to Staistical Learning (PDF) website A free and accessible version of the classic in the field, *Elements of Statistical Learning*.
- Getting Started in Data Science

ArcGIS + R

- UC Plenary Demo: Statistical Integration with R
    - Demo of SSN: spatial modeling on stream networks
- Cam Plouffe (Esri CA) ran an R ArcGIS Workshop, covers materials in more depth.

Materials

Courses:

- High Performance Scientific Computing
- The Data Scientist’s Toolbox

Books:

- Spatial Statistical Data Analysis for GIS Users Konstantin Krivoruchko (GA creator)
  - Too big to print. Tons of useful stuff, covers both R and ArcGIS extensively.

Packages

Clustering demo covers mclust and sp.

- Tree-based models, e.g. CART
- Time series data, e.g. Little Book of R

R ArcGIS Extensions

- R ArcGIS Bridge
- Marine Geospatial Ecology Tools (MGET)
  - Combines Python, R, and MATLAB to solve a wide variety of problems
- Geospatial Modeling Environment
  - An R flavored language for spatial analysis

Conferences

- useR! Conference
  - useR 2016 is being held July 5-7 in Brussels, Belgium
- Open Data Science Conference (ODSC)
  - Many happening around world, some upcoming ones:
  - ODSC East May 3-5 in Boston
  - ODSC West Nov 2-4 in San Francisco

Closing

Outreach

- Resources and outreach – connect the dots, want this to be outreach so we can build up more R + ArcGIS people who aren't as common as our core language folks.
- Future of the project, questions

Community

- Open source project, different ethos
- Contributions are the currency
    - That said, major uptake in the commercial space:
    - Microsoft R (bought Revolution Analytics); R Studio

Thanks

- R team: Dmitry Pavlushko, Steve Kopp, Mark Janikas; today's speakers
    - Contact Us
- Geoprocessing Team

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THE
SCIENCE
OF
WHERE