R Graphics: What's in it for You?

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Overview

- R can draw plots ...
- ... but so can lots of other software.

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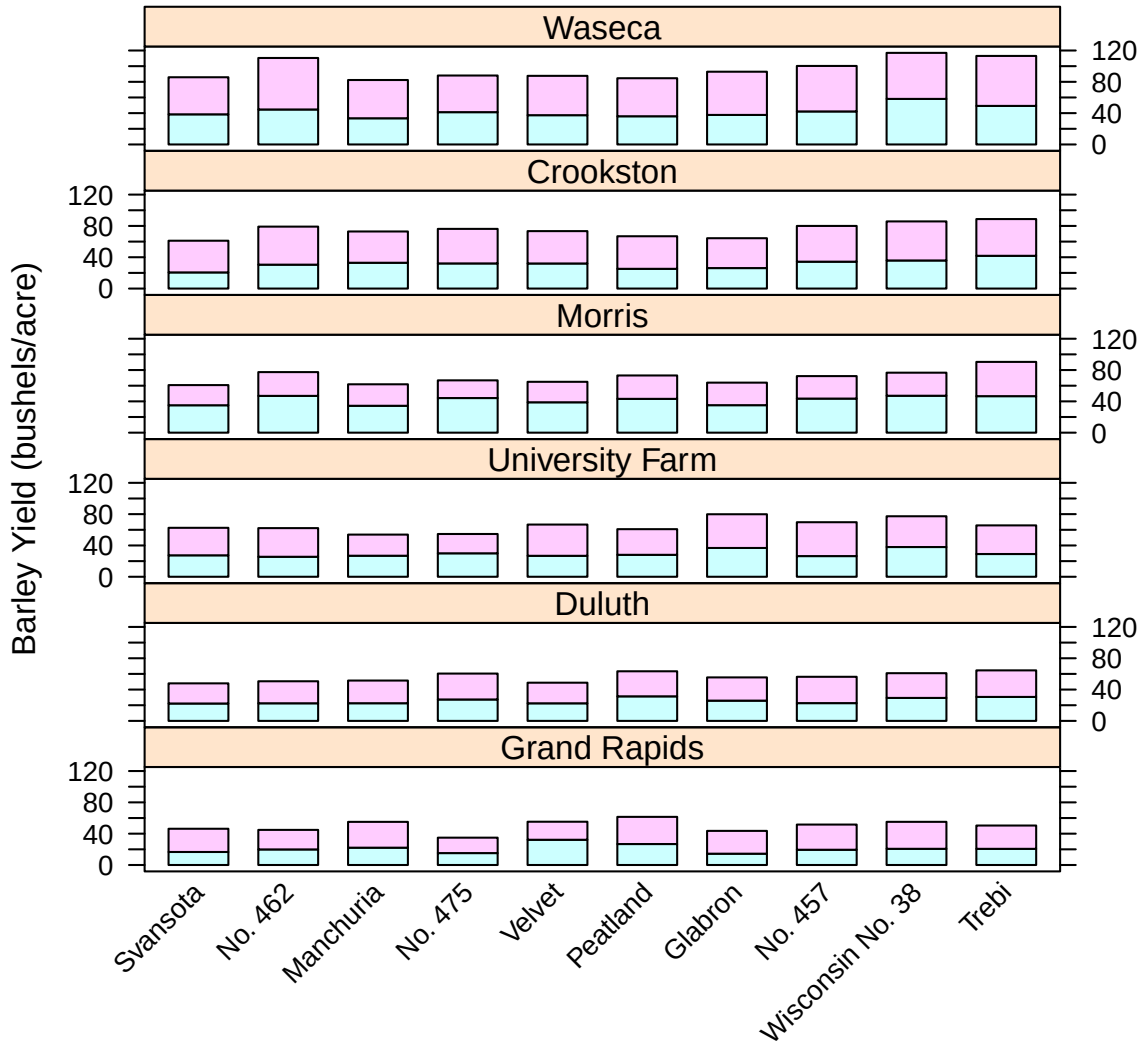
- ... but so can lots of other software.
- So why use R?
- **Customisable, extensible, programmable** graphics

R Plots

- R can draw a wide range of plots.



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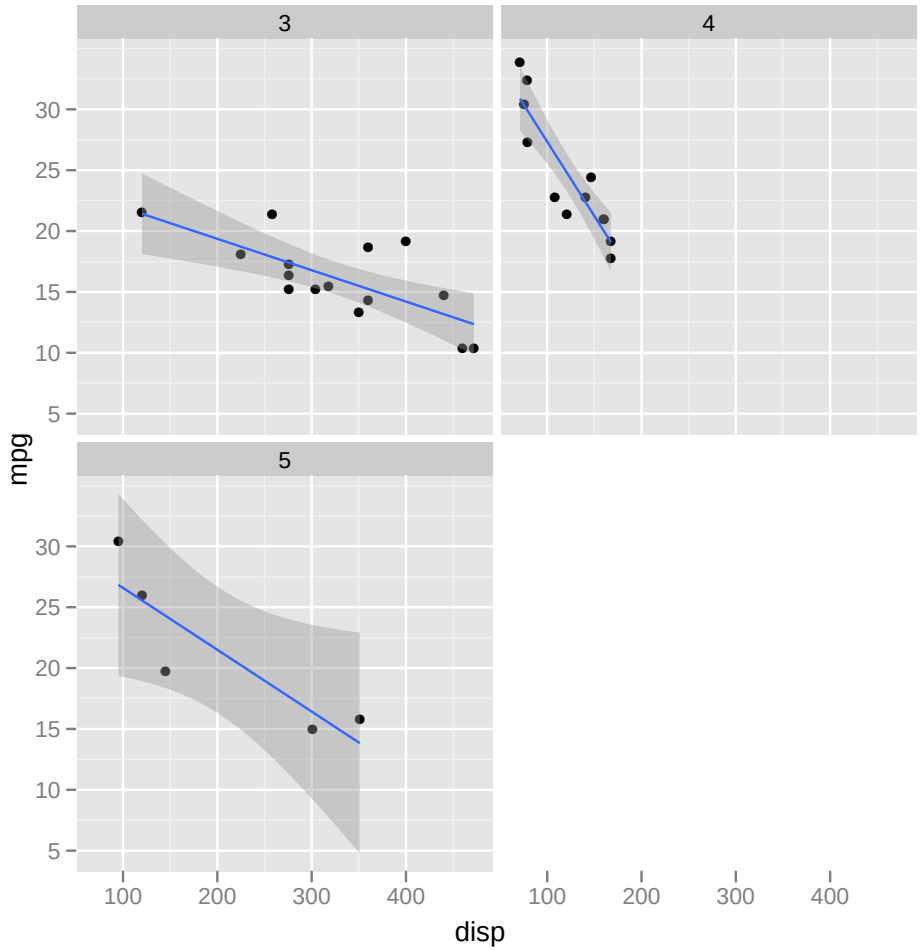

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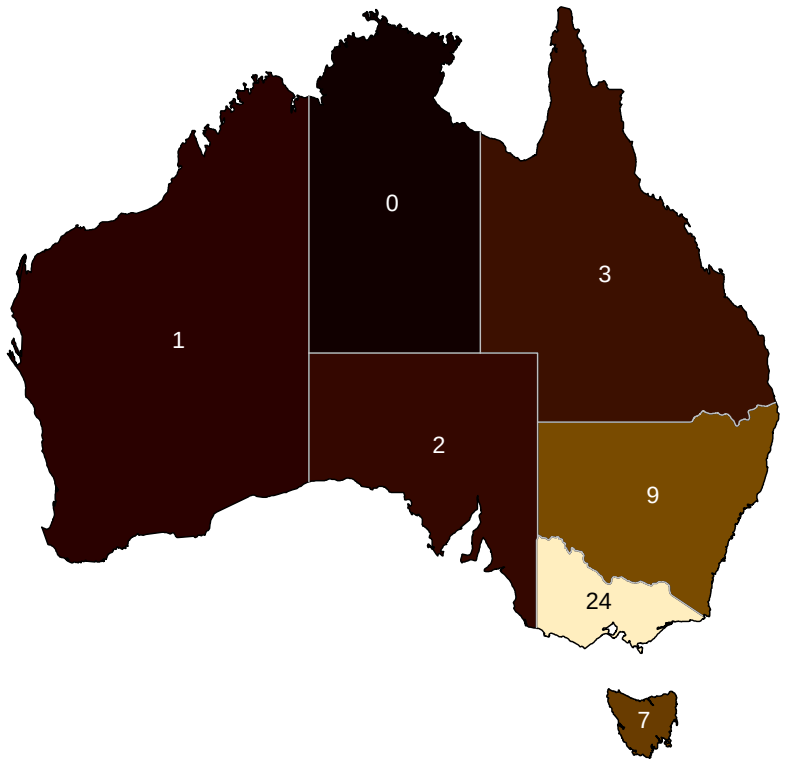

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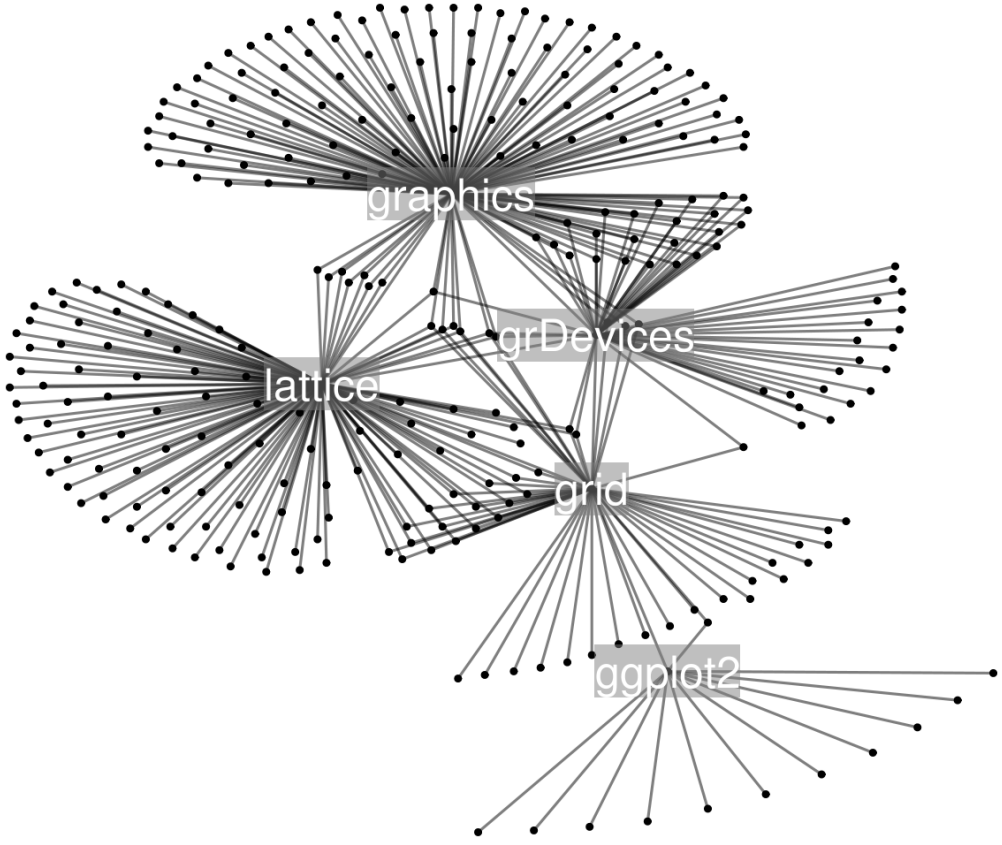


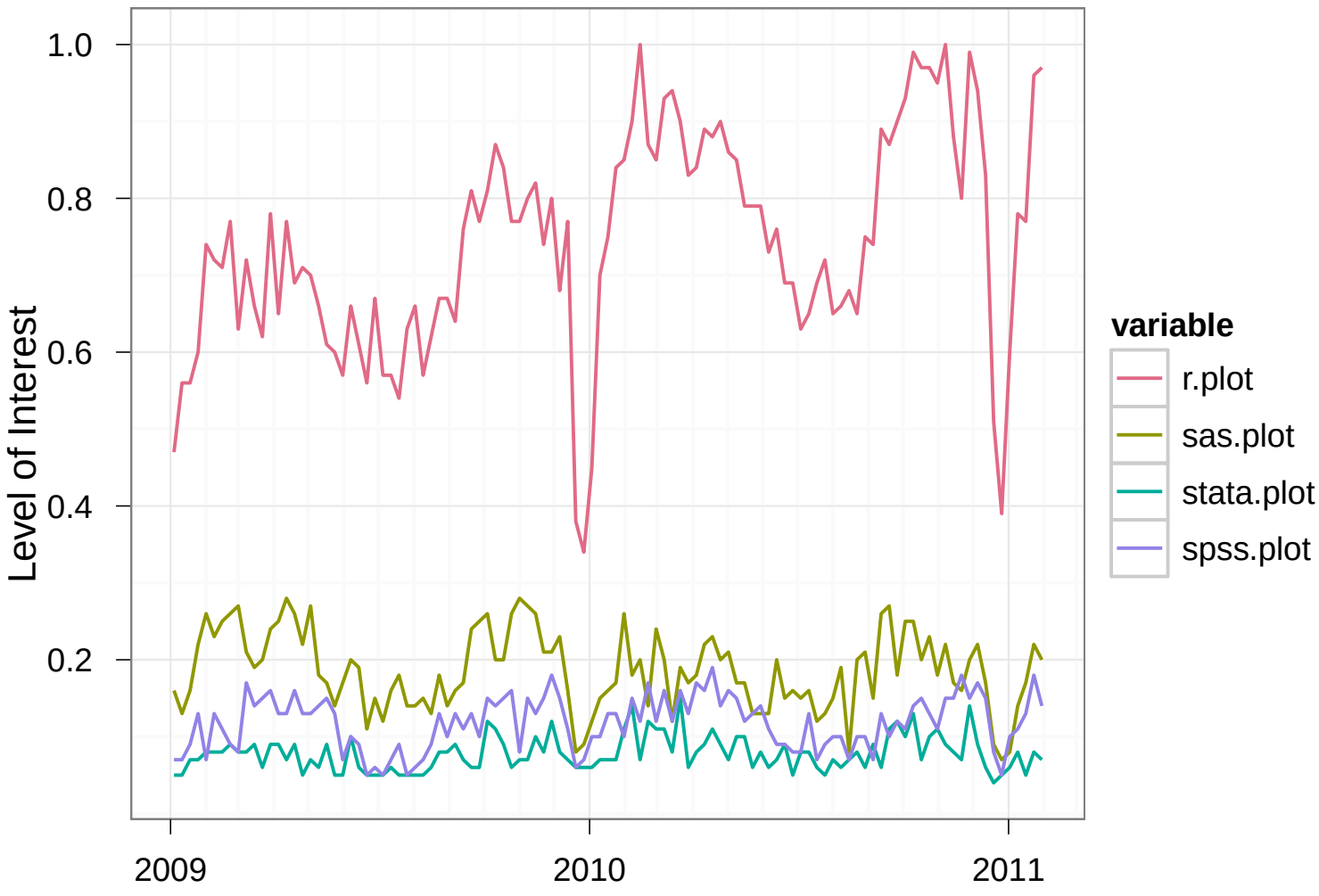
R Plots

- We could argue about which software package has the widest range of plots, but that's just a spitting contest.
- A more interesting question is this:

  If the software cannot already create the plot that you want, what are your options?

- One way to characterise R graphics is that it aims to provide you with **lots** of options.
- R graphics is **permissive**.

An Example


Level of Interest
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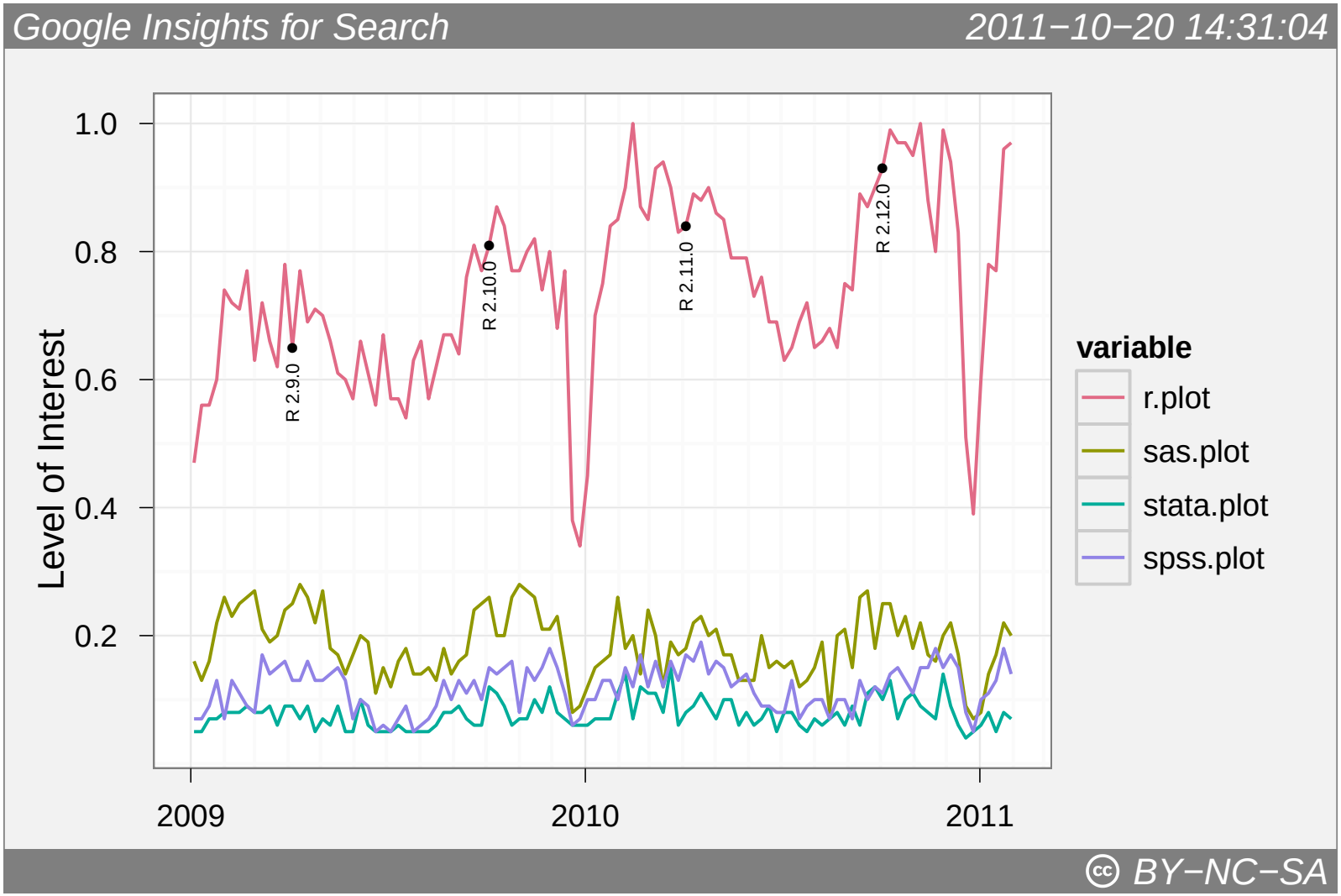
r.plot
sas.plot
stata.plot
spss.plot

An Example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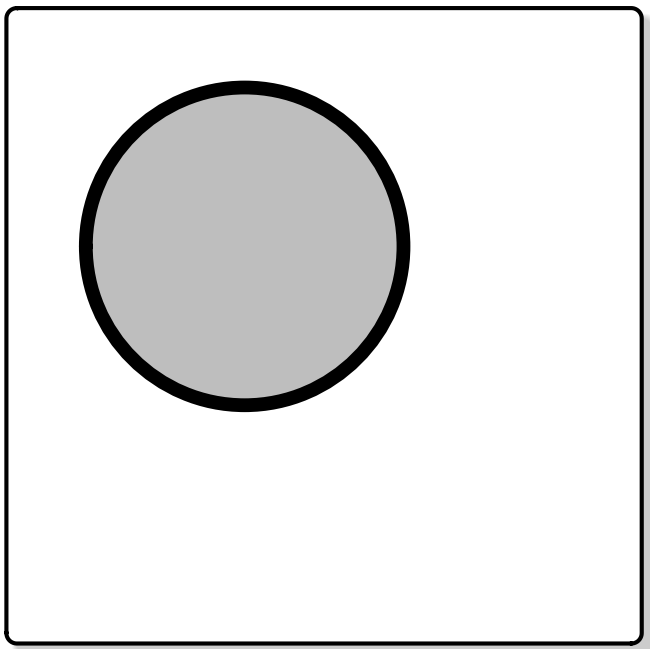
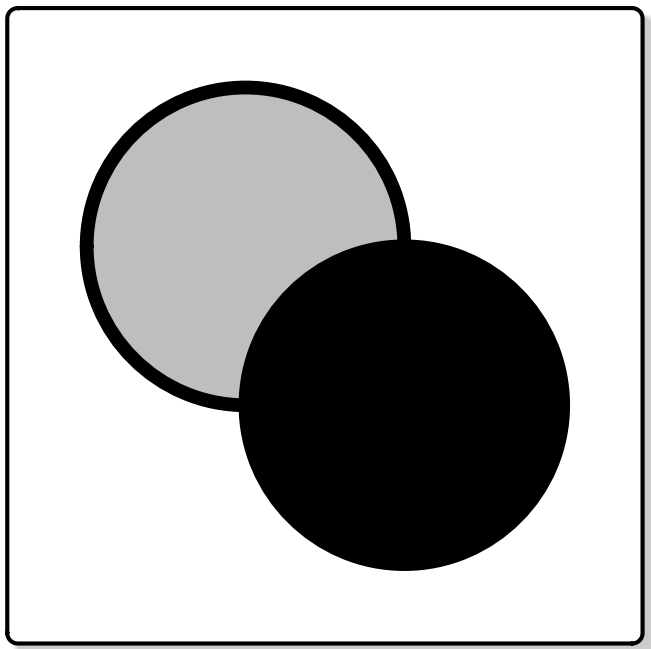
Why Use R?

- What are the features that R graphics provides that make this sort of customisation possible?
- In order to do it (in a simple, yet flexible and sophisticated and rational and reproducible fashion) we need **six** important features:
  1. The ability to write graphics **code**.
  2. The ability to draw simple shapes (**low-level graphics**).
  3. The ability to draw complex shapes (**modern graphics**).
  4. Access to multiple **coordinate systems**.
  5. The ability to arrange graphical components in a **layout**.
  6. The ability to **query** graphical **objects**.

2 Low-level Graphics

- R follows a "painters model" so that you can always add more ink to the page (on top of what is already there).





- A plot is just a whole lot of ink all at once.

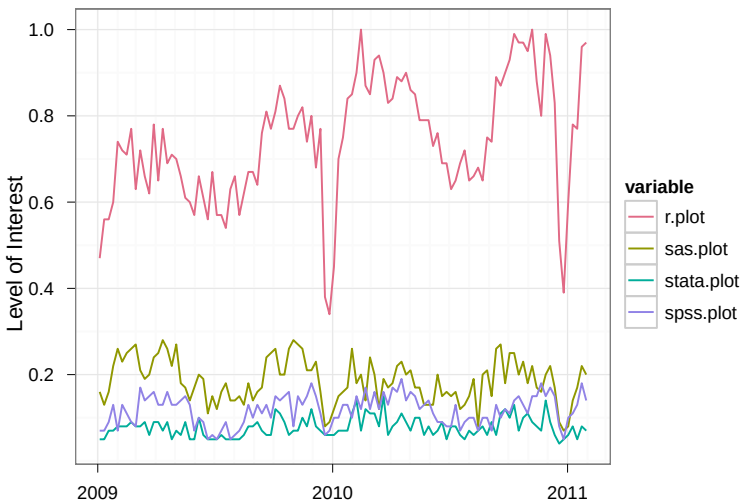
2 Low-level Graphics

- R follows a "painters model" so that you can always add more ink to the page (on top of what is already there).

```
> xyplot( ... )
> grid.text( ... )
```

- A plot is just a starting point.

An Example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An Example


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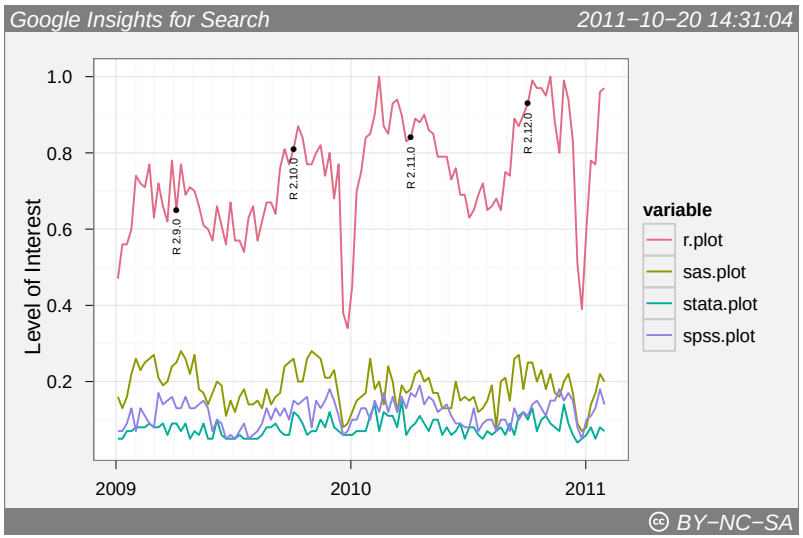
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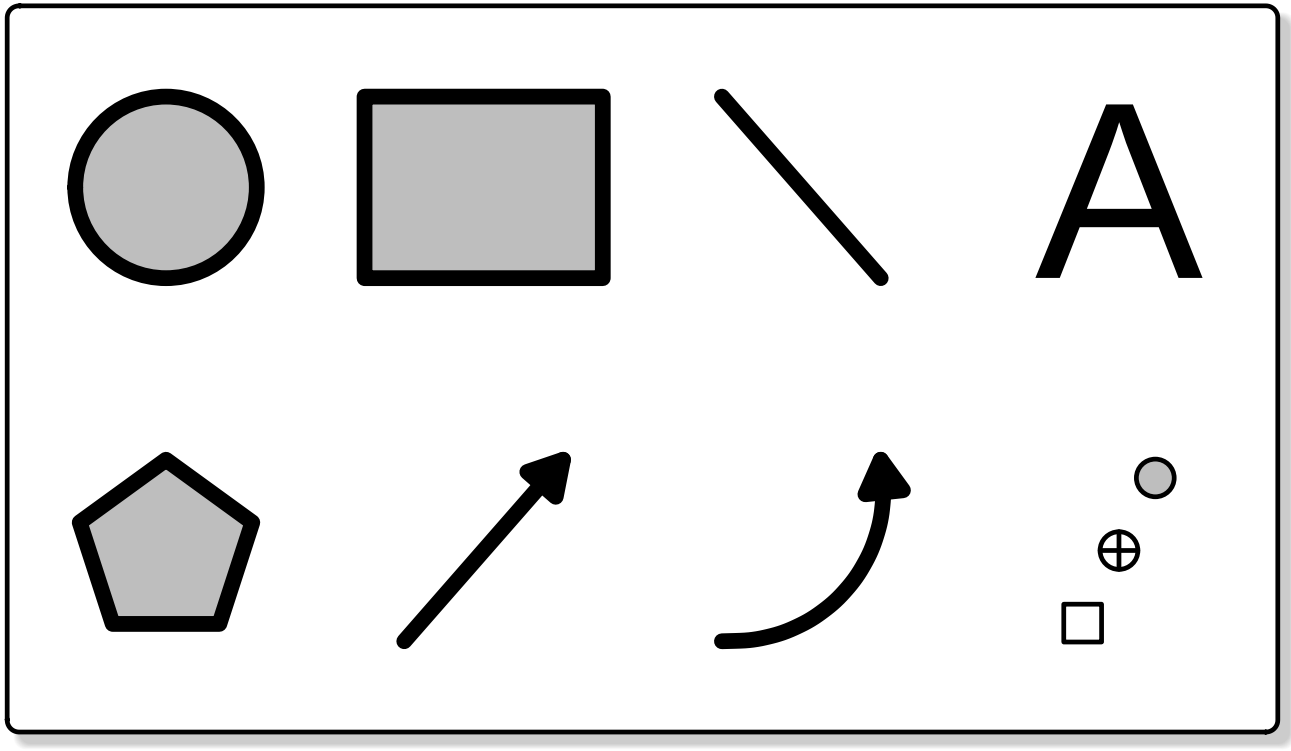
2 Low-level Graphics

- R provides basic drawing primitives.



- A plot is just a whole lot of basic primitives (neatly arranged).

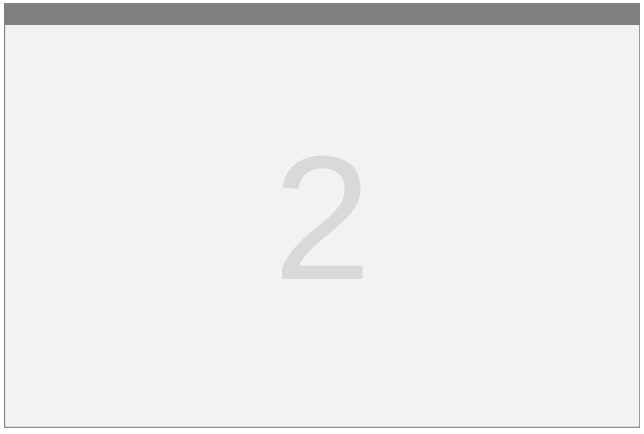
2 Low-level Graphics

- R provides basic drawing primitives.

```
> grid.circle(x = 0.5,
              y = 0.5,
              r = 0.1,
              gp=gpar(col = "black",
                      lwd = 10,
                      fill = "grey"))
```

An Example


1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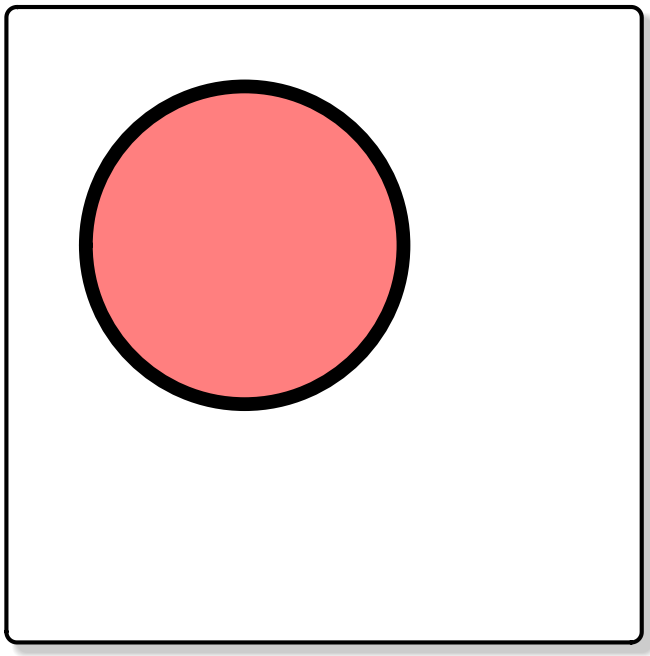
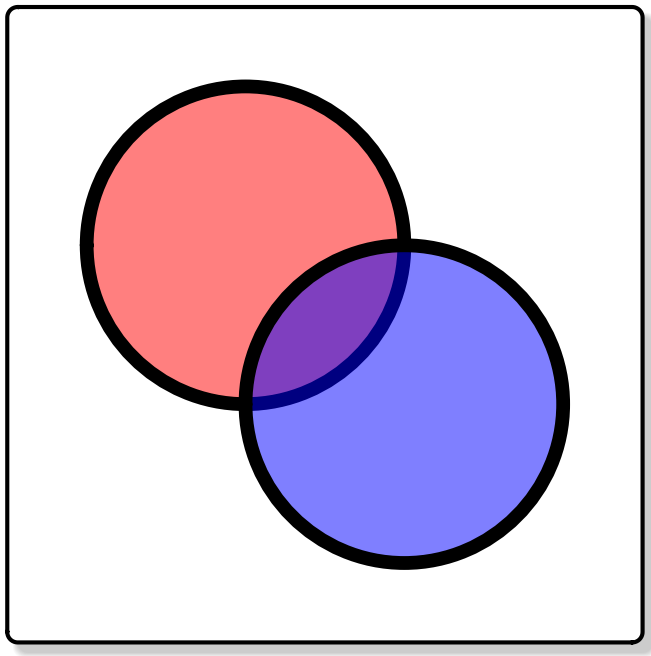
3 Modern Graphics

- R provides features for general graphics (not just for plots) like alpha channels, complex paths, and raster images.





3 Modern Graphics

- R provides features for general graphics (not just for plots) like alpha channels, complex paths, and raster images.

```
> grid.circle(x = 0.5,
              y = 0.6,
              r = 0.2,
              gp=gpar(lwd = 10,
                      rgb(red = 1, green = 0, blue = 0,
                          alpha = 0.5)))
```

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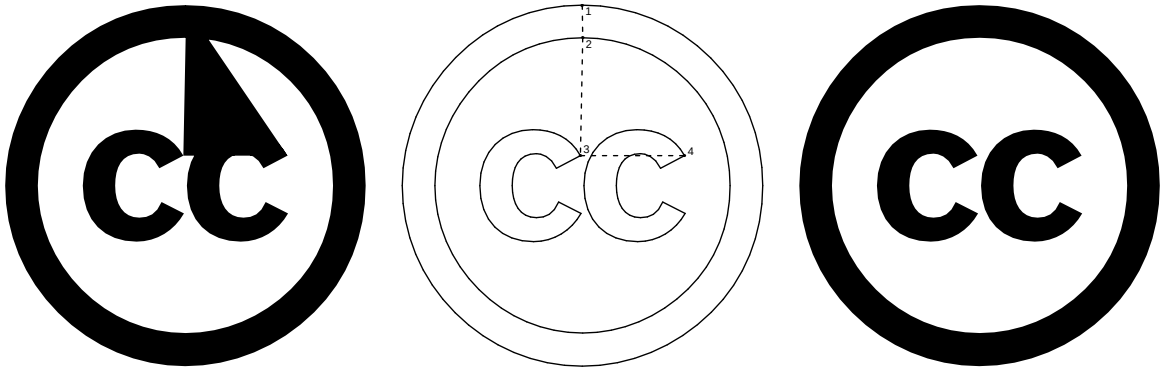
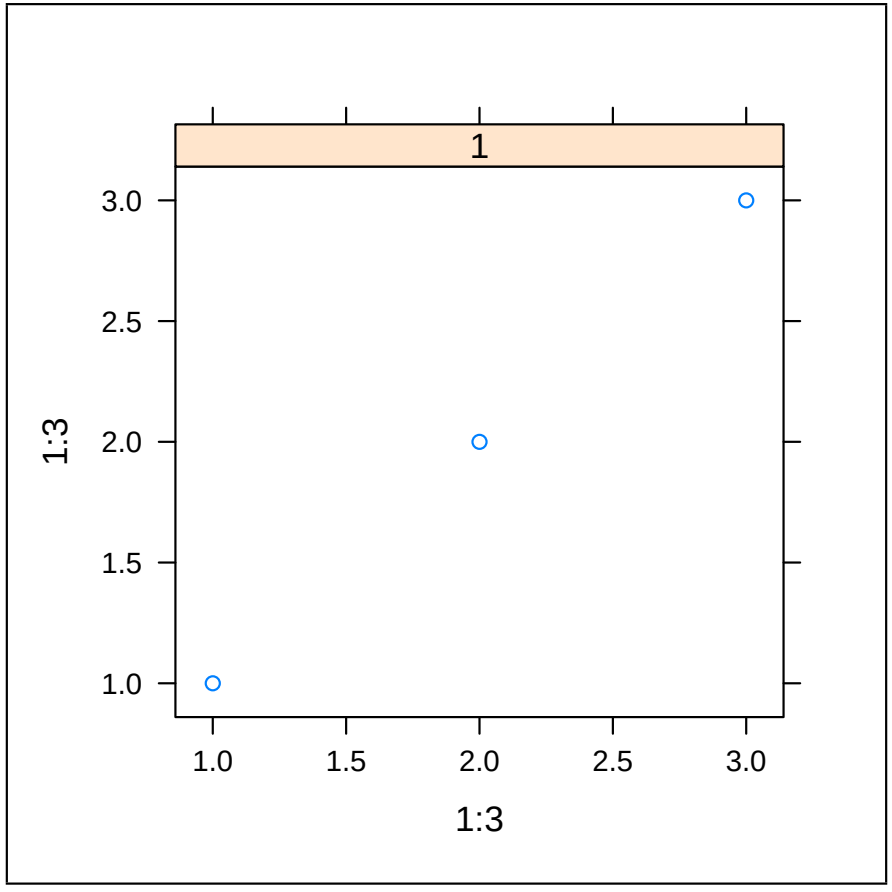
```
> library("png")
> Rlogo <- readPNG(system.file("img", "Rlogo.png",
                                package = "png"))
> grid.raster(Rlogo,
              x = 0.5, y = 0.5,
              width = 0.8)
```

An Example



4 Coordinate Systems

- Drawing a plot requires working in multiple coordinate systems.



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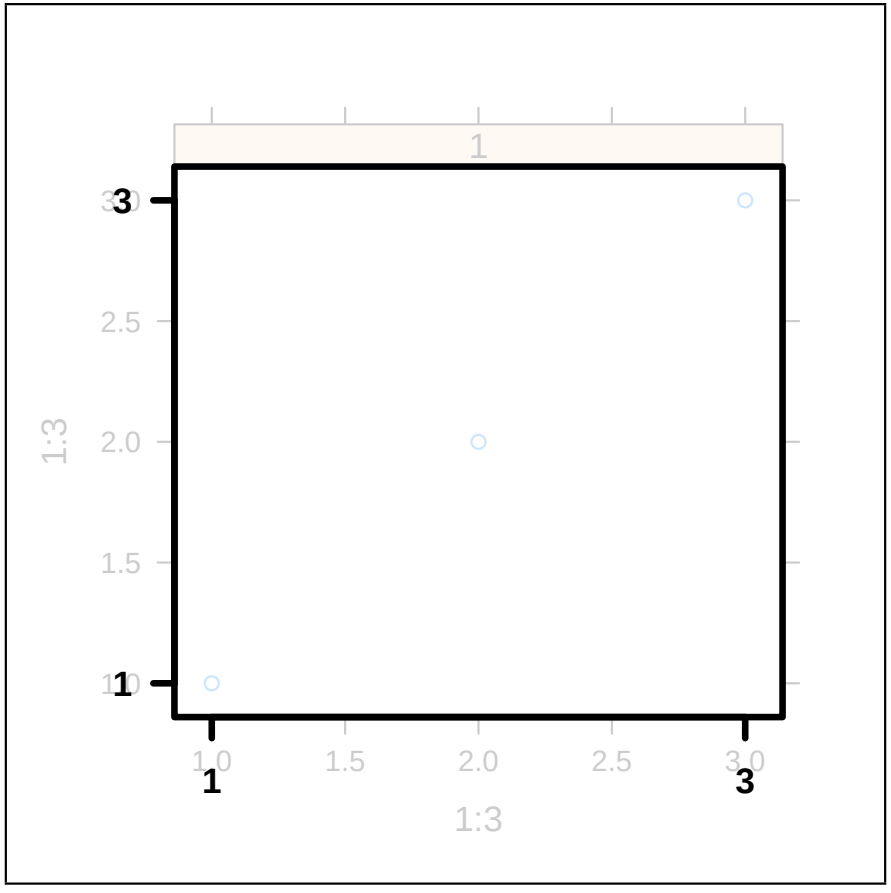

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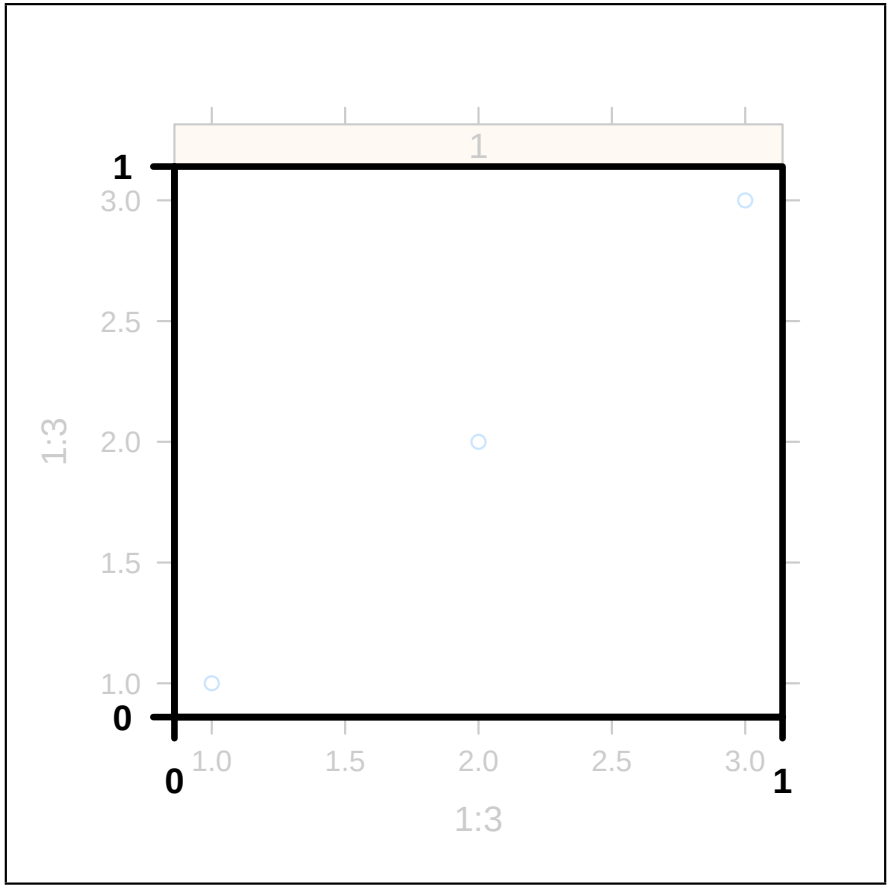

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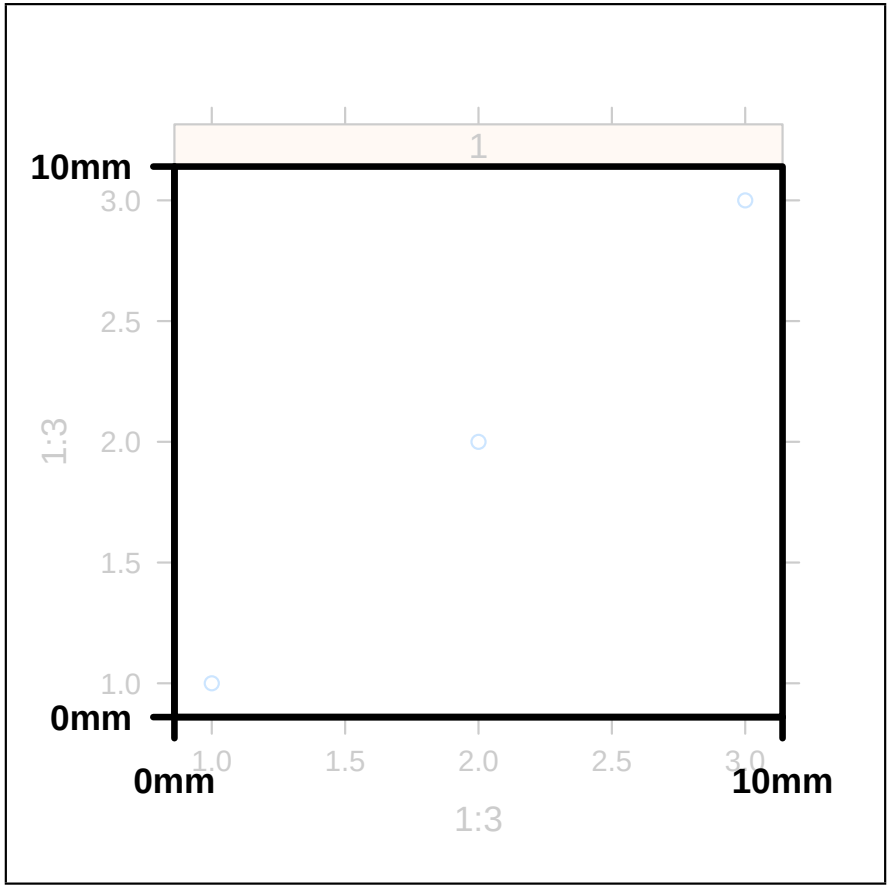

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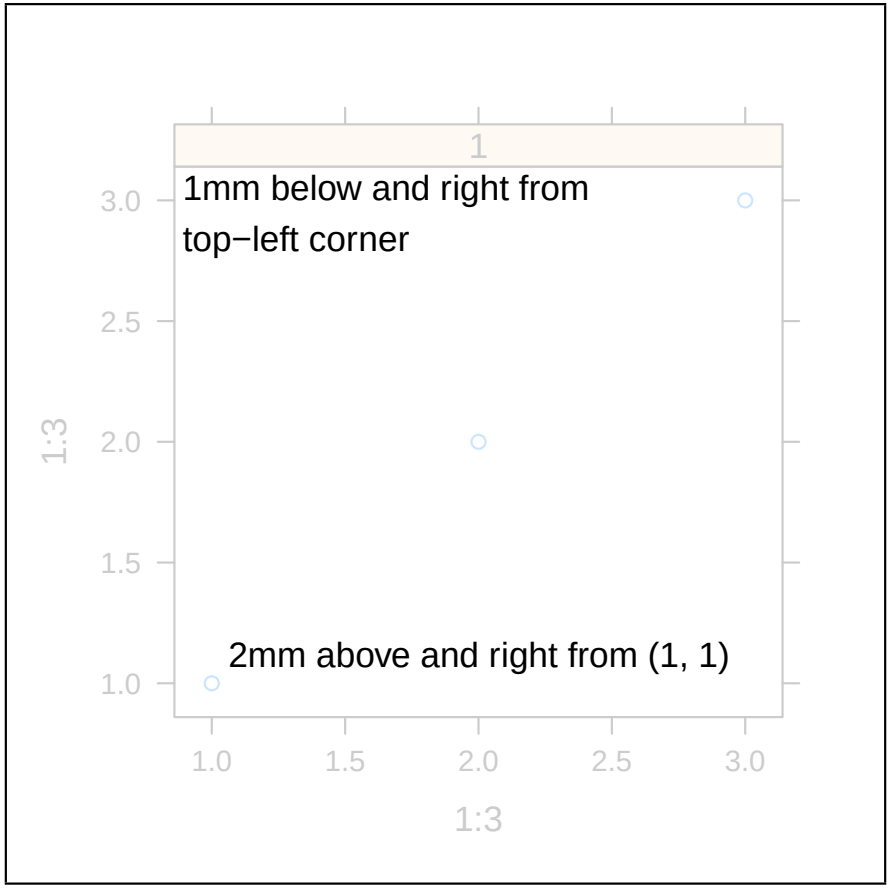


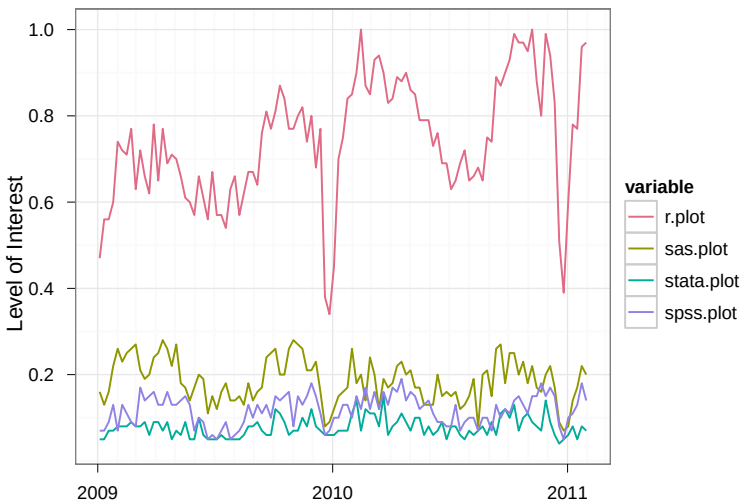
4 Coordinate Systems

- Drawing a plot requires working in multiple coordinate systems.

```
> grid.text("1mm below and right from top-left corner",
            x = unit(0, "npc") + unit(1, "mm"),
            y = unit(1, "npc") - unit(1, "mm"),
            just = c("left", "top"))

> grid.text("2mm above and right from (1, 1)",
            x = unit(1, "native") + unit(2, "mm"),
            y = unit(1, "native") + unit(2, "mm"),
            just = c("left", "bottom"))
```

An Example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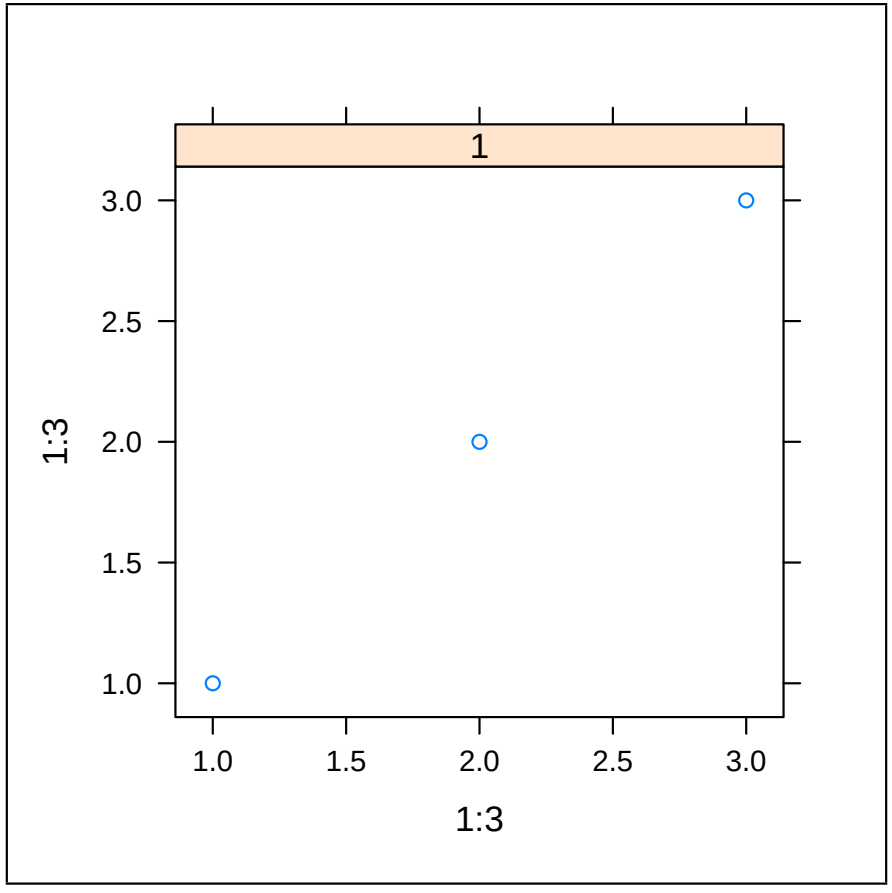
5 Layout

- Drawing a plot requires being able to arrange multiple coordinate systems.



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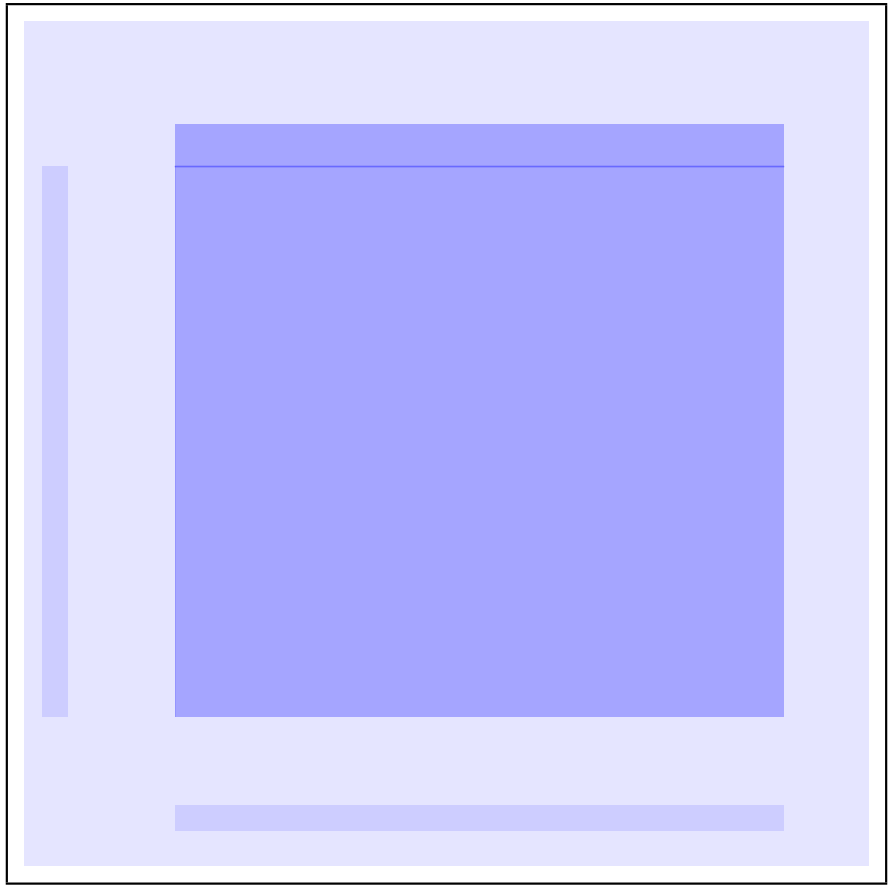

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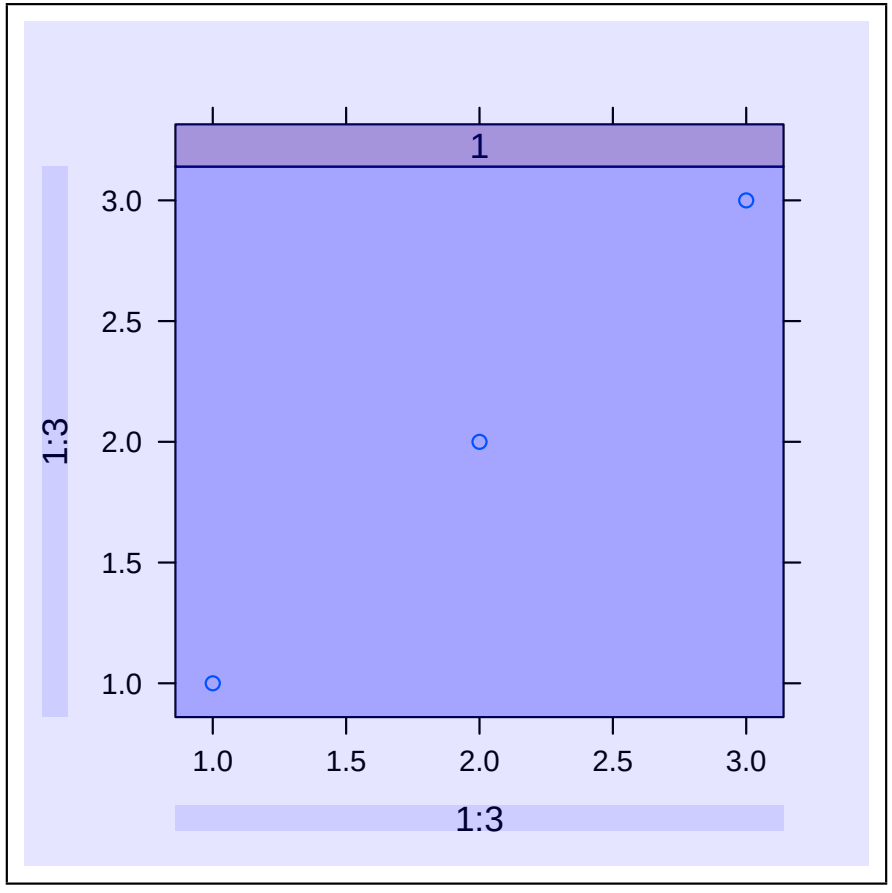
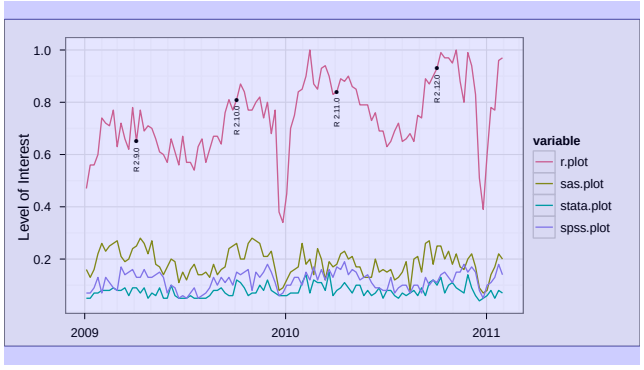


5 Layout

- Drawing a plot requires being able to arrange multiple coordinate systems.

```
> pushViewport(viewport(width = 0.5, height = 0.5,
                        name = "plotvp"))
> upViewport(1)
> downViewport("plotvp")
```

An Example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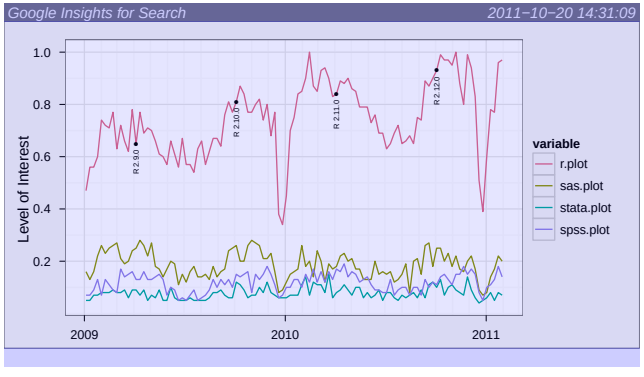
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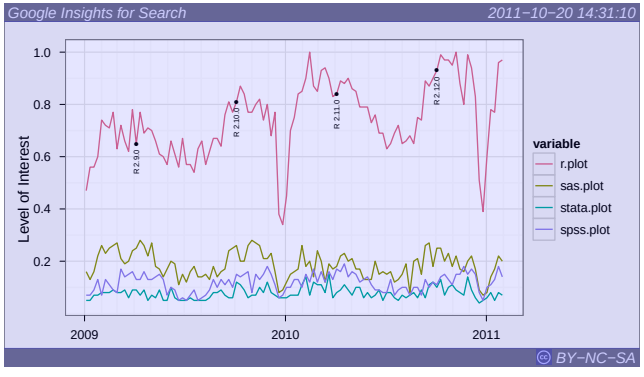
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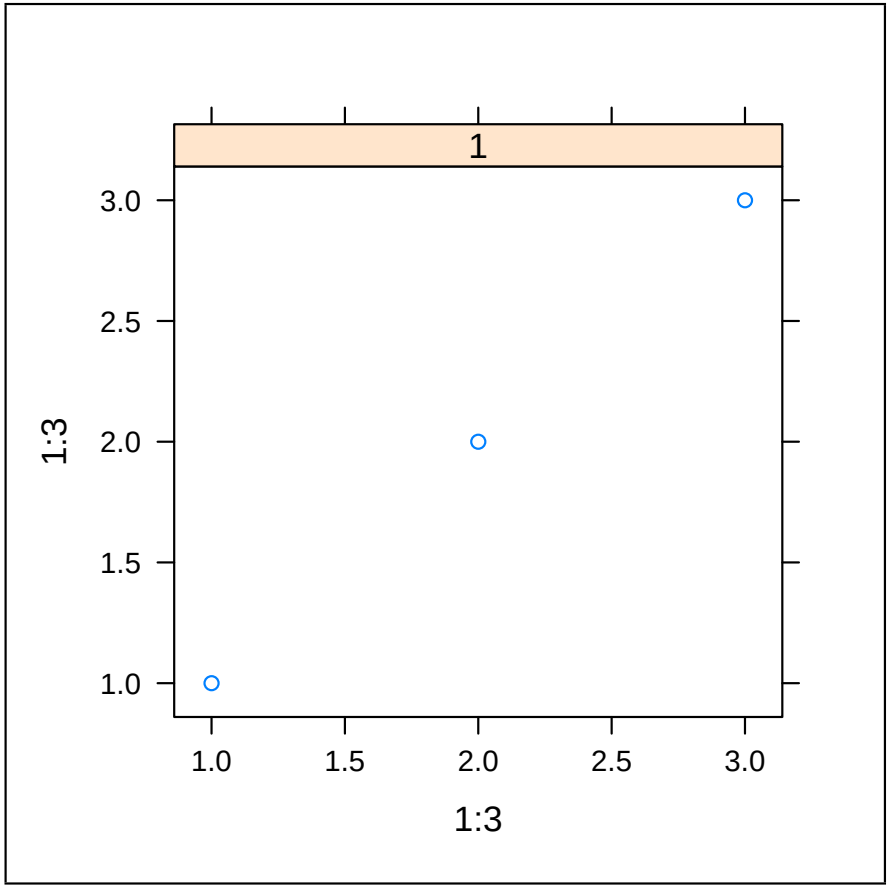
6 Graphical Objects

- In R graphics, it is possible to access, query and modify components of a plot.

```
plot_01.background
plot_01.xlab
plot_01.ylab
plot_01.ticks.top.panel.1.1
plot_01.ticks.left.panel.1.1
plot_01.ticklabels.left.panel.1.1
plot_01.ticks.bottom.panel.1.1
plot_01.ticklabels.bottom.panel.1.1
plot_01.ticks.right.panel.1.1
plot_01.xyplot.points.panel.1.1
plot_01.border.panel.1.1
plot_01.bg.strip.1.1
plot_01.fg.strip.1.1
plot_01.textl.strip.1.1
plot_01.border.strip.1.1
```



6 Graphical Objects

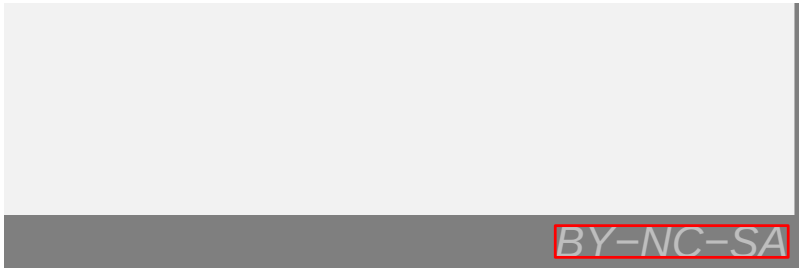
- In R graphics, it is possible to access, query and modify components of a plot.

```
> grid.text("BY-NC-SA",
            x = unit(1, "npc") - unit(1, "mm"),
            just = c("right"),
            name = "cclabel")

> ccx <- unit(1, "npc") - unit(1, "mm") -
         grobWidth("cclabel")

> grid.edit("cclabel", gp=gpar(fontface="bold"))
```

An Example



A Bit of Razzmatazz

Dynamic and Interactive Demo

1 Code for Graphics

- We create an image in R using **code**.

1 Code for Graphics

- We create an image in R using **code**.

```
library(EBImage)
trim <- function(col) {
    if (any(col < 0 | col > 1)) {
        col[col < 0] <- 0
        col[col > 1] <- 1
    }
    col
}
as.raster.Image <- function(x) {
    # For now, bail if there is more than one image
    if (getNumberOfFrames(x, "render") > 1)
        stop("Cannot handle multiple frames")
    image <- imageData(x)
    # Either a grey scale or a color image
    if (colorMode(x) == 0) { # Grayscale
        r <- grey(image)
        dim(r) <- dim(image)
    } else { # Color
        r <- rgb(aperm(trim(image[,,1])),
                 aperm(trim(image[,,2])),
                 aperm(trim(image[,,3])))
        dim(r) <- dim(image)[2:1]
    }
    r
}
tree <- as.raster(readImage("/scratch/TealBay/tree.jpg"))
rock <- as.raster(readImage("/scratch/TealBay/rock.jpg"))
rope <- as.raster(readImage("/scratch/TealBay/rope.jpg"))
sand <- as.raster(readImage("/scratch/TealBay/sand.jpg"))
gull <- as.raster(readImage("/scratch/TealBay/gull.jpg"))
hill <- as.raster(readImage("/scratch/TealBay/hill.jpg"))
sign <- as.raster(readImage("/scratch/TealBay/sign.jpg"))
pohu <- as.raster(readImage("/scratch/TealBay/pohu.jpg"))

library(grid)
imageLayout <- grid.layout(4, 5,
                           widths=c(2, 1.5, 2, 1, 2.5),
                           heights=c(2.5, .5, 2, 1),
                           respect=TRUE)
margin <- unit(20, "mm")
drawImage <- function(c, r, img=NULL, rot=FALSE, width=NULL, height=NULL,
                      ...) {
    pushViewport(viewport(layout.pos.col=c,
                          layout.pos.row=r),
                 viewport(width=unit(1, "npc") - margin,
                          height=unit(1, "npc") - margin))
    if (is.null(img)) {
        grid.rect()
    } else {
        if (rot) {
            pushViewport(viewport(width=convertUnit(unit(1, "npc"),
                                    "npc", "y", "dimension", "x", "dimension"),
                                  height=convertUnit(unit(1, "npc"),
                                    "npc", "x", "dimension", "y", "dimension"),
                                  angle=90,
                                  clip=TRUE))
        } else {
            pushViewport(viewport(clip=TRUE))
        }
        grid.raster(img, width=width, height=height, ...)
        # grid.rect()
        popViewport()
    }
    popViewport(2)
}
```

```
jpeg("tealbay.jpg", width=3600, height=2400)
grid.newpage()
grid.rect(gp=gpar(col=NA, fill="white"))
pushViewport(viewport(width=unit(1, "npc") - margin,
                      height=unit(1, "npc") - margin,
                      layout=imageLayout))
pushViewport(viewport(layout.pos.col=1:4))
grid.rect(width=unit(1, "npc") + margin,
          height=unit(1, "npc") + margin,
          gp=gpar(col=NA, fill="white"))
popViewport()
drawImage(1, 1, tree, width=2)
drawImage(1, 2:3, rock, height=1, y=1, just="top")
drawImage(2, 1:3, rope, TRUE, width=1, y=.45)
drawImage(1:3, 4, sand, width=1, height=1.5, y=0, just="bottom")
drawImage(3, 2:3, gull, width=2, y=0, just="bottom")
drawImage(3:5, 1, hill, width=1.5, y=1, vjust=.85)
drawImage(4:5, 2, sign, width=2, vjust=.605)
drawImage(4:5, 3:4, pohu, height=1, x=1, just="right")
popViewport()
dev.off()
```

1 Code for Graphics

- This means that ...
  - we have a record of what we did.
  - we can easily repeat what we did.
  - we can create a similar image by slightly modifying what we did.
  - we can create lots of images easily (batch jobs).
  - we can easily and accurately show someone else what we did (and they can do exactly what we did, or something similar).
  - we can generate plot content on-the-fly (e.g., time stamps).
  - we can express complex ideas (edit all graphical objects that match a pattern).

1 Code for Graphics

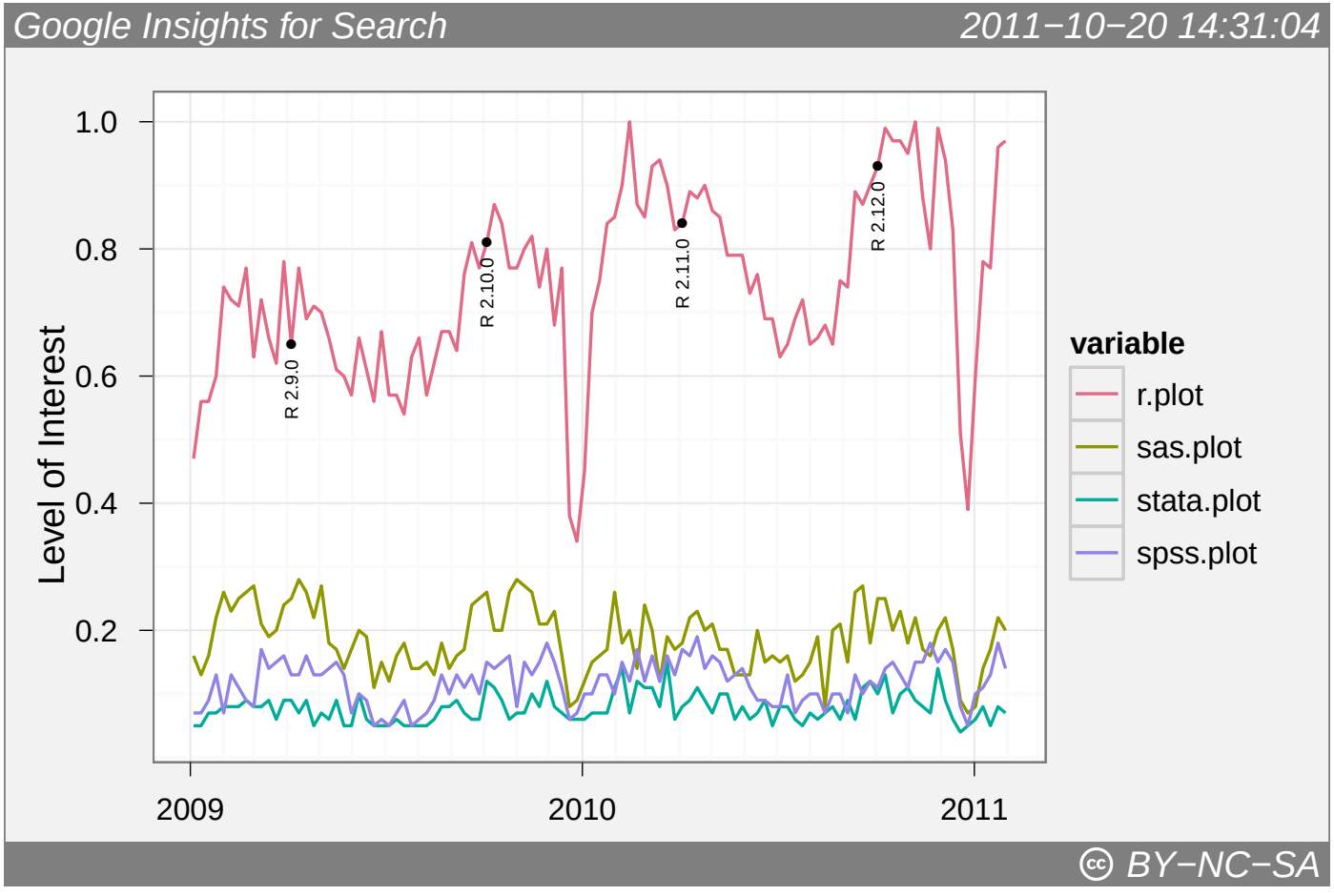
- Because R is a programming language, we can encapsulate code in functions or even packages.
- It also doesn't hurt that R is a **statistical** programming language.
  - We can add a least-squares line to a plot.
- It hurts even less that R is **open source**.
  - We can easily share and build on each other's code.

An Example

```
> plotframe("Title goes here")
```

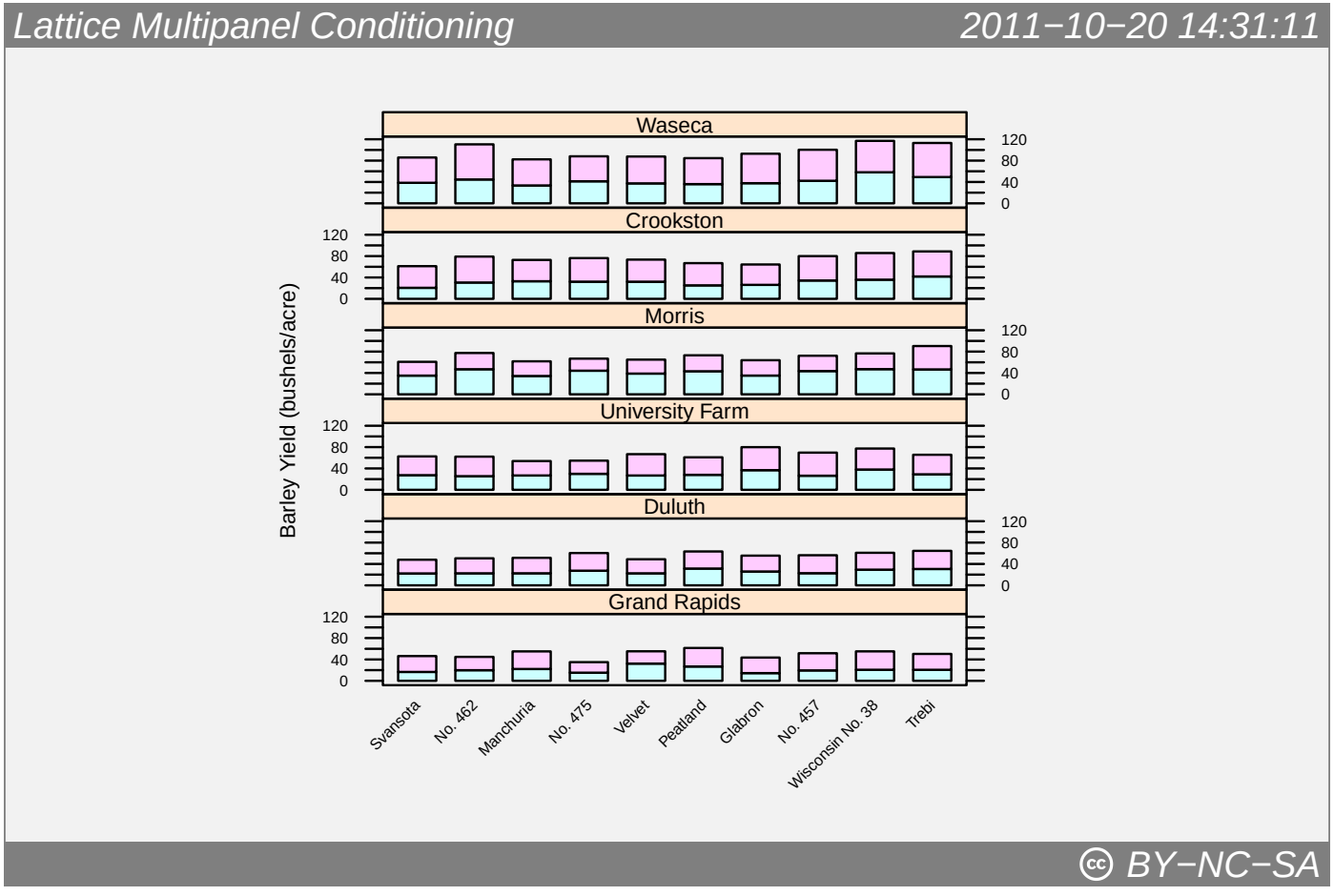
An Example

```
> plotframe("Google Insights for Search")
> ggplot( ... )
```



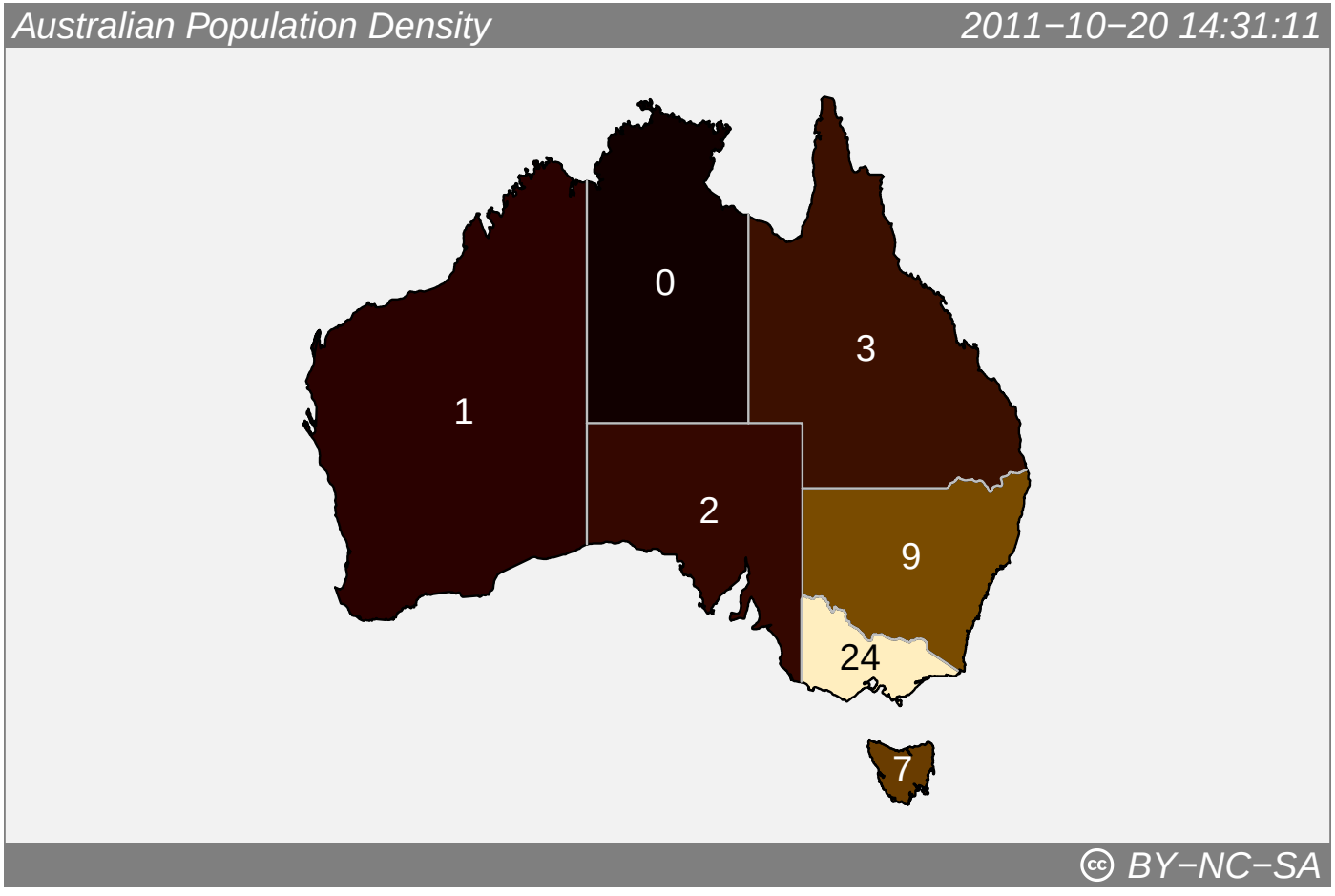
An Example

```
> plotframe("Lattice Multipanel Conditioning")
> xyplot( ... )
```



An Example

```
> plotframe("Australian Population Density")
> oz( ... )
```

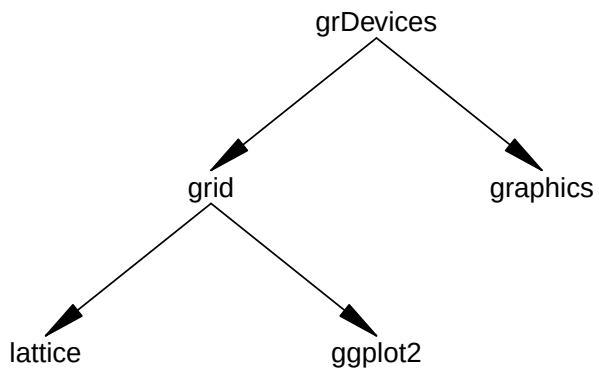


Summary

- Why use R?
  - Because if R can't already do what you want, it gives you lots of tools so you can do it yourself.
  - Customisability:
    - Because of the painters model.
    - Because you can draw basic shapes.
    - Because you have access to coordinate systems.
    - Because you have access to graphical objects.
  - Extensibility:
    - Because you can write code.
    - Because you can see others' code.
    - Because you have access to the same tools that others use.
  - Programmability:
    - Because you write code to draw stuff.
    - Because R is a programming language.
    - Because R is a graphics language.

Caveats

- Although it is possible with R to produce 3D plots and animated plots and interactive plots, those are typically provided by connecting R to external graphics systems.
- The **core** R graphics system is focused on **static 2D** plots.



- Most of the examples have been **grid**-based graphics.
- (Almost) all of these examples can be achieved (with a little more effort) in "traditional" graphics.

Further Reading

- "R Graphics"
  http://www.stat.auckland.ac.nz/~paul/RGraphics/rgraphics.html
- "R Graphics, Second Edition"
  http://www.stat.auckland.ac.nz/~paul/RG2e/
- "Lattice: Multivariate Data Visualization with R"
  http://lmdvr.r-forge.r-project.org/
- "ggplot2: Elegant Graphics for Data Analysis"
  http://had.co.nz/ggplot2/book/

- The Graphics CRAN Task View
  http://cran.r-project.org/web/views/Graphics.html
- The R Graphics Gallery
  http://addictedtor.free.fr/graphiques/
- The R Graphical Manual
  http://www.oga-lab.net/RGM2/

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- The Google Search data are from `http://www.google.com/insights/search/`

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- **graph** (maintained) by Seth Falcon (Bioconductor).
- **gridBase** by Paul Murrell.
- **gridSVG** by Paul Murrell and Simon Potter.
- **grImport** by Paul Murrell and Richard Walton.
- **lattice** by Deepayan Sarkar.
- **maps** (maintained) by Ray Brownrigg.
- **oz** (maintained) by Kurt Hornik.
- **png** by Simon Urbanek.
- **reshape** by Haldey Wickham.
- **Rgraphviz** (maintained) by Kasper Hansen (Bioconductor).