

## Chapter 25. Avoid Line Drawings

Whenever possible, visualize your data with solid, colored shapes rather than with lines that outline those shapes. Solid shapes are more easily perceived as coherent objects, are less likely to create visual artifacts or optical illusions, and more immediately convey amounts than do outlines. In my experience, visualizations using solid shapes are both clearer and more pleasant to look at than equivalent versions that use line drawings. Thus, I avoid line drawings as much as possible. However, I want to emphasize that this recommendation does not supersede the principle of proportional ink (Chapter 17).

Line drawings have a long history in the field of data visualization because throughout most of the 20th century, scientific visualizations were drawn by hand and had to be reproducible in black and white. This precluded the use of areas filled with solid colors, including solid grayscale fills. Instead, filled areas were sometimes simulated by applying hatch, cross-hatch, or stipple patterns. Early plotting software imitated the hand-drawn simulations and similarly made extensive use of line drawings, dashed or dotted line patterns, and hatching. While modern visualization tools and modern reproduction and publishing platforms have none of the earlier limitations, many plotting applications still default to outlines and empty shapes rather than filled areas. To raise your awareness of this issue, here I'll show you several examples of the same figures drawn with both lines and filled shapes.

The most common and at the same time most inappropriate use of line drawings is seen in histograms and bar plots. The problem with bars drawn as outlines is that it is not immediately apparent which side of any given line is inside a bar and which side is outside. As a consequence, in particular when there are gaps between bars, we end up with a confusing visual pattern that detracts from the main message of the figure (Figure 25-1). Filling the bars with a light color, or with gray if color reproduction is not possible, avoids this problem (Figure 25-2).

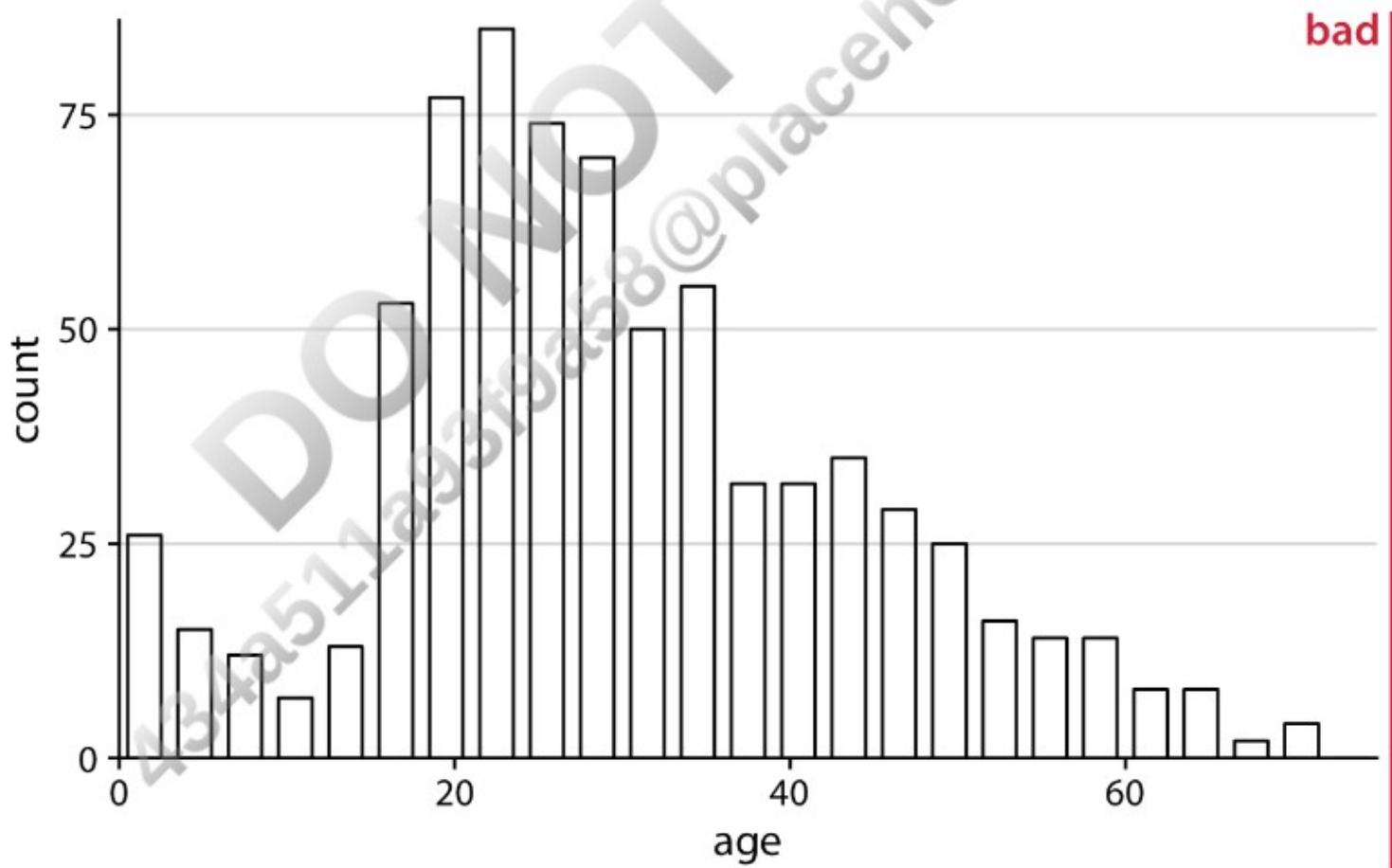


Figure 25-1. Histogram of the ages of Titanic passengers, drawn with empty bars. The empty bars create a confusing visual pattern. In the center of the histogram, it is difficult to tell which parts are inside of bars and which parts are outside. Data source: Encyclopedia Titanica.

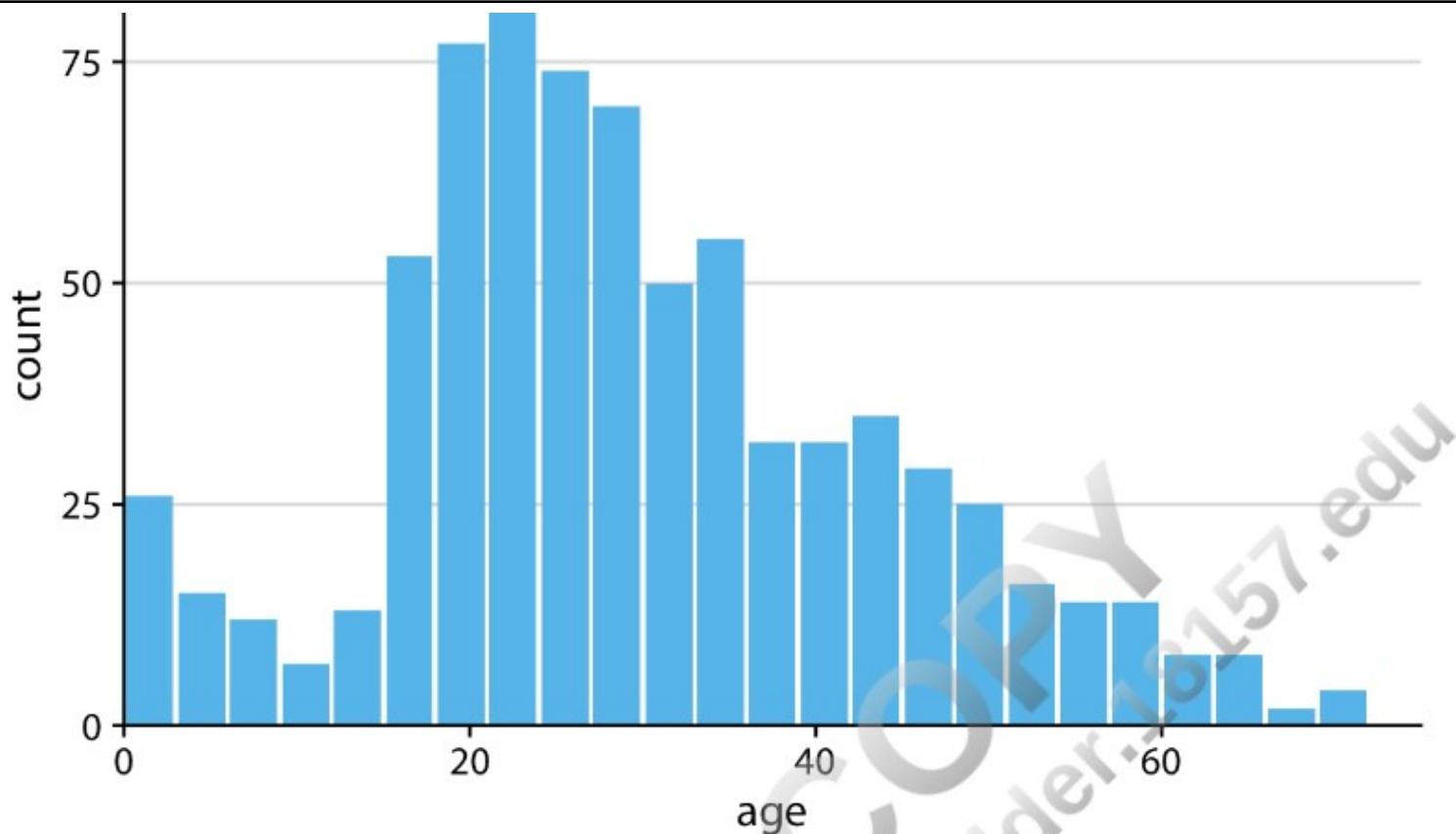
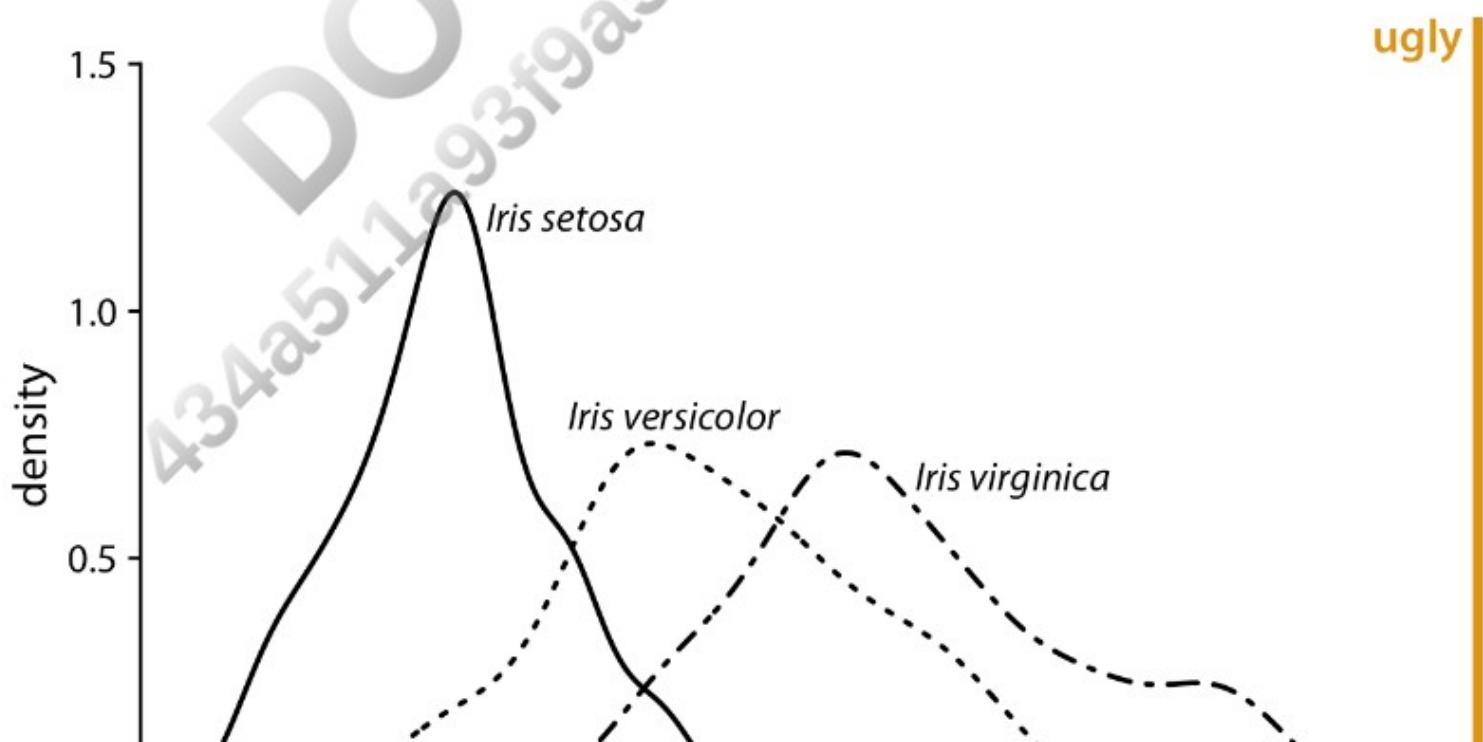


Figure 25-2. Histogram of the ages of Titanic passengers. This is the same histogram as in Figure 25-1, now drawn with filled bars. The shape of the age distribution is much more easily discernible in this variation of the figure. Data source: Encyclopedia Titanica.

Next, let's take a look at an old-school density plot. I'm showing density estimates for the sepal length distributions of three species of *Iris*, drawn entirely in black and white as a line drawing (Figure 25-3). The distributions are shown just by their outlines, and because the figure is in black and white I'm using different line styles to distinguish them. This figure has two main problems. First, the dashed line styles do not provide a clear separation between the area under the curve and the area above it. While the human visual system is quite good at connecting the individual line elements into a continuous line, the dashed lines nevertheless look porous and do not serve as a strong boundary for the enclosed area. Second, because the lines intersect and the areas they enclose are not shaded, it is difficult to segment the different densities from the six distinct shape outlines. This effect would have been even stronger had I used solid rather than dashed lines for all three distributions.



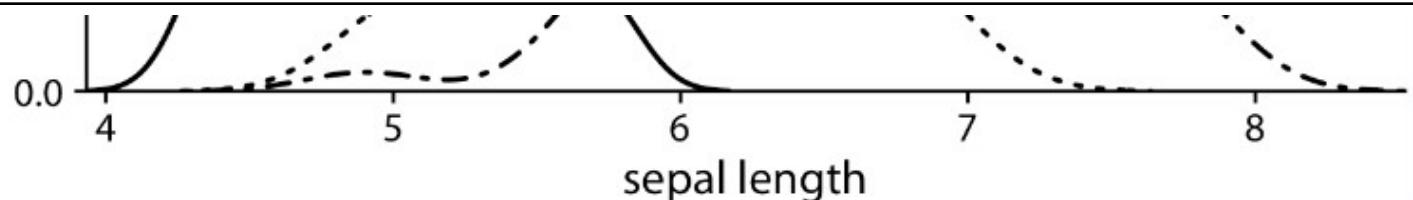


Figure 25-3. Density estimates of the sepal lengths of three different Iris species. The broken line styles used for *Iris versicolor* and *Iris virginica* detract from the perception that the areas under the curves are distinct from the areas above them. Data source: [Fisher 1936].

We can attempt to address the problem of porous boundaries by using colored lines rather than dashed lines (Figure 25-4). However, the density areas in the resulting plot still have little visual presence. Overall, I find the version with filled areas (Figure 25-5) the most clear and intuitive. It is important, however, to make the filled areas partially transparent, so that the complete distribution for each species is visible.

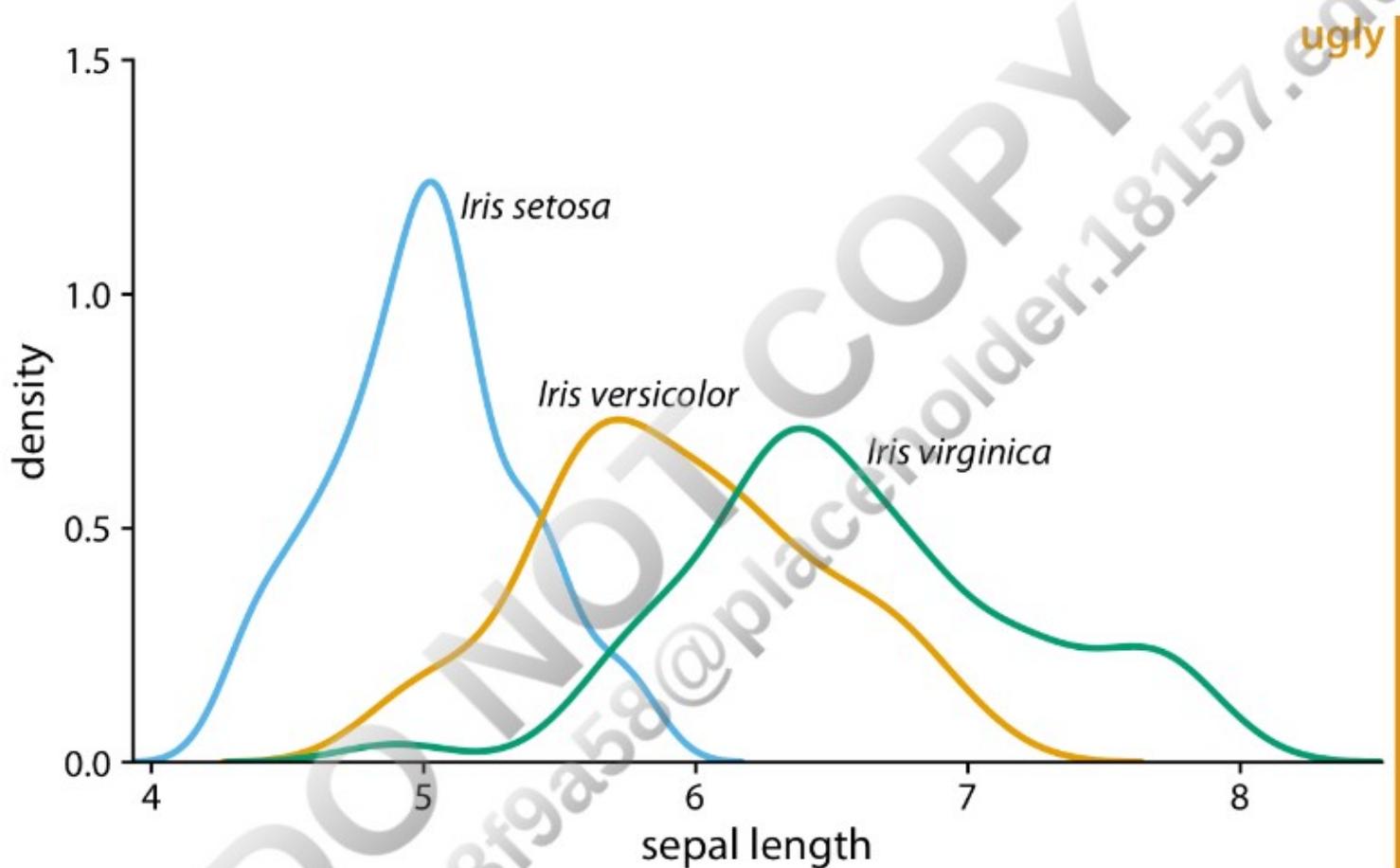
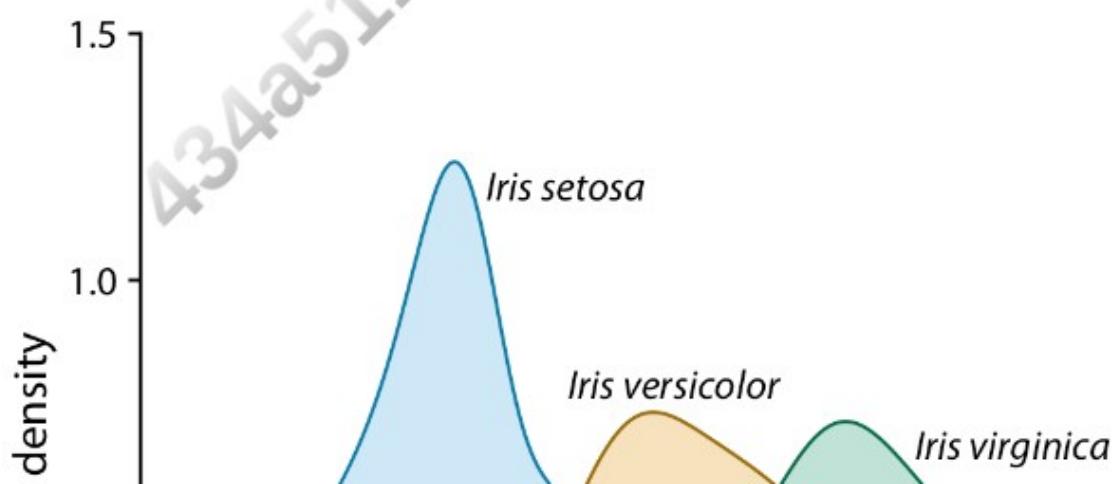


Figure 25-4. Density estimates of the sepal lengths of three different Iris species. By using solid, colored lines we have solved the problem of Figure 25-3 that the areas below and above the lines seem to be connected. However, we still don't have a strong sense of the size of the area under each curve. Data source: [Fisher 1936].



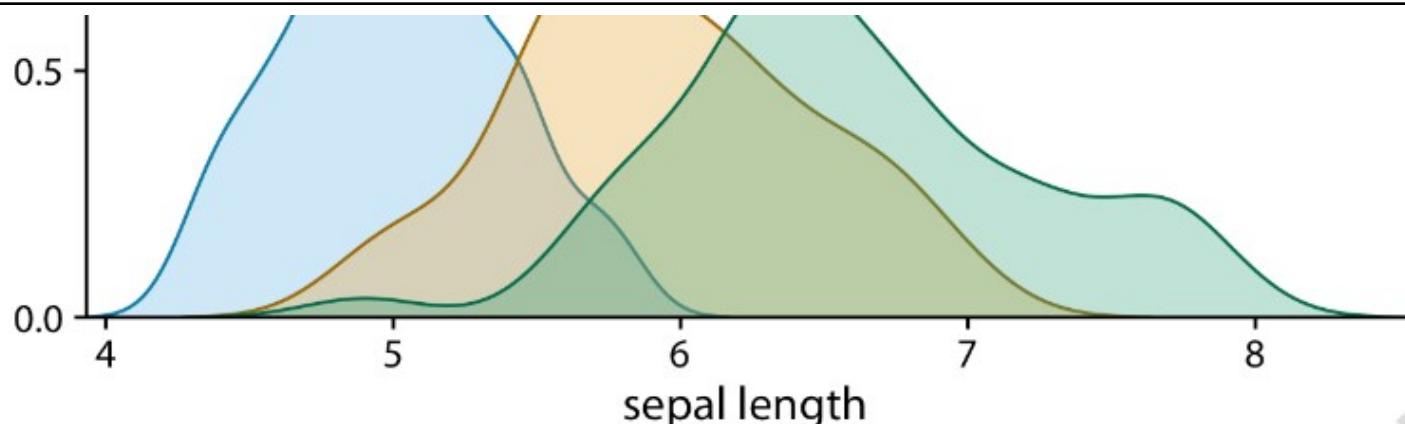


Figure 25-5. Density estimates of the sepal lengths of three different Iris species, shown as partially transparent shaded areas. The shading helps us perceive the three density curves as three distinct objects. Data source: [Fisher 1936].

Line drawings also arise in the context of scatterplots, when different point types are drawn as open circles, triangles, crosses, etc. As an example, consider Figure 25-6. The figure contains a lot of visual noise, and the different point types do not strongly separate from each other. Drawing the same figure with solidly colored shapes addresses this issue (Figure 25-7).

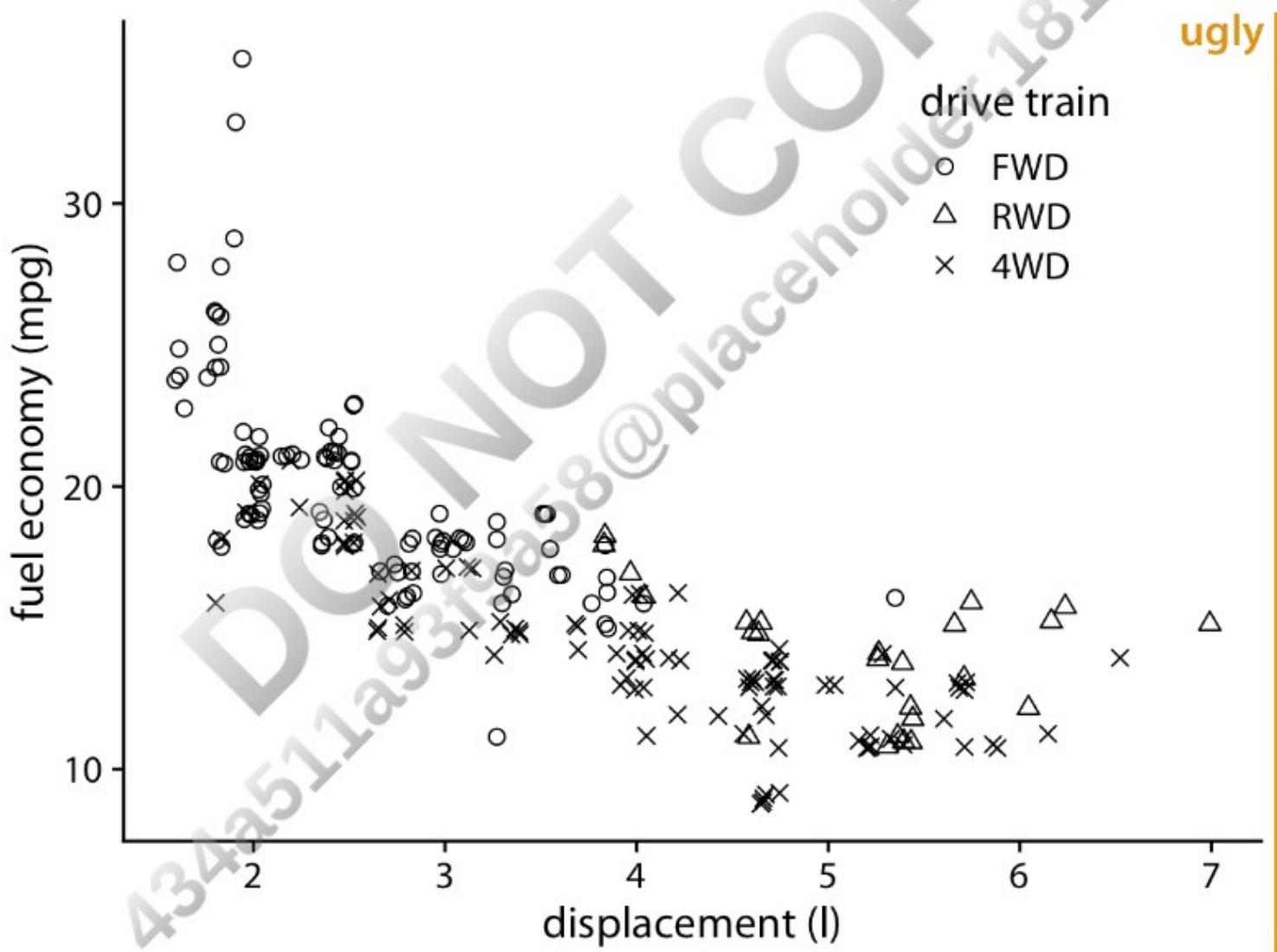


Figure 25-6. City fuel economy versus engine displacement, for cars with front-wheel drive (FWD), rear-wheel drive (RWD), and all-wheel drive (4WD). The different point styles, all black-and-white line-drawn symbols, create substantial visual noise and make it difficult to read the figure. Data source: US Environmental Protection Agency (EPA), <https://fueleconomy.gov>.

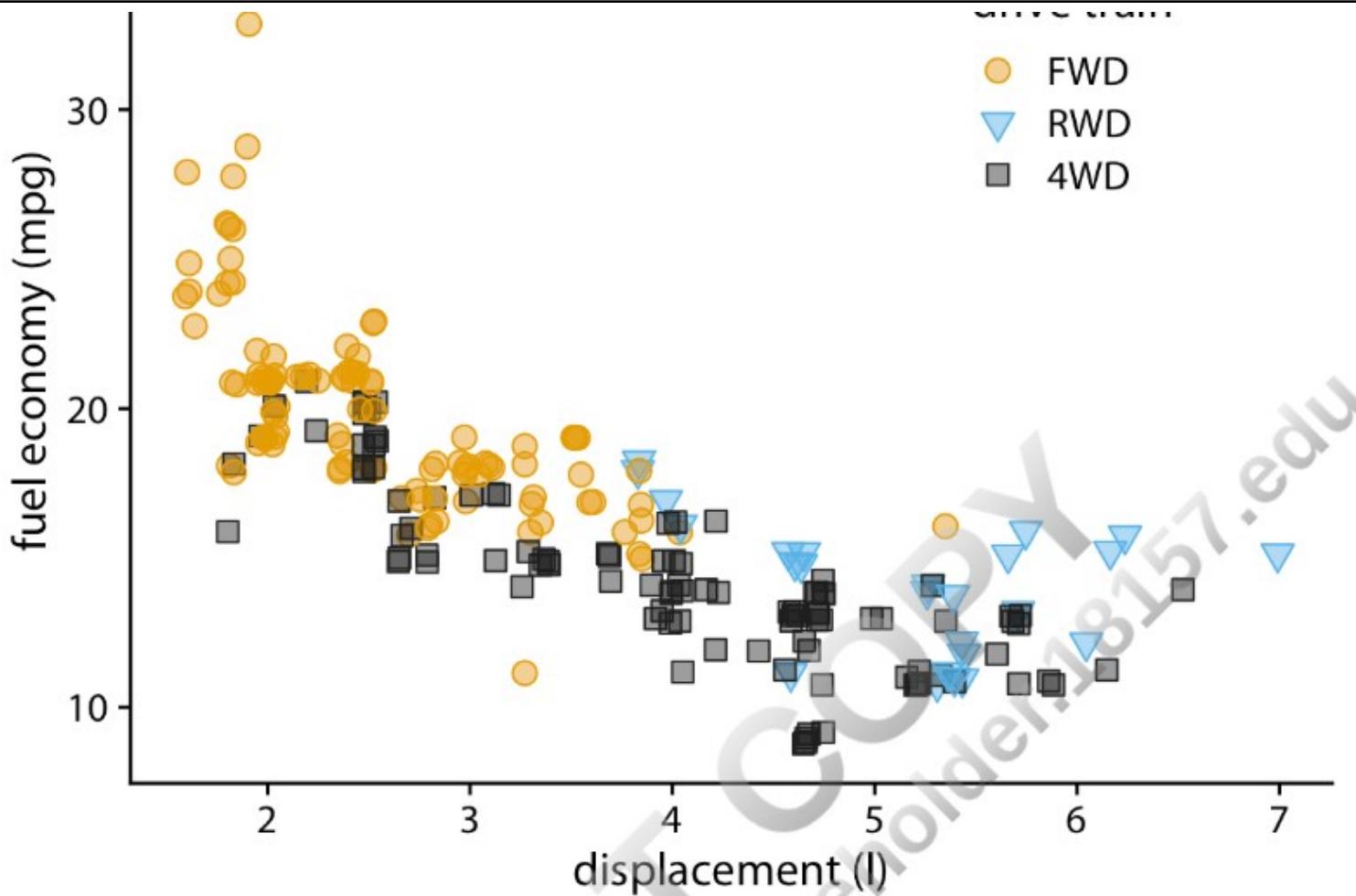
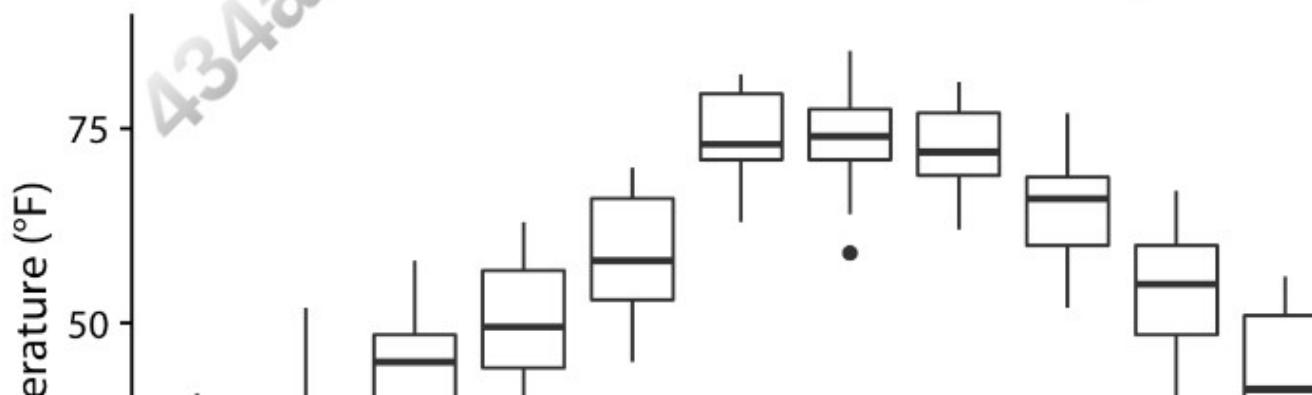


Figure 25-7. City fuel economy versus engine displacement. By using both different colors and different solid shapes for the different drive-train variants, this figure visually separates the drive-train variants while remaining reproducible in grayscale if needed. Data source: EPA.

I strongly prefer solid points over open points, because the solid points have much more visual presence. The argument that I sometimes hear in favor of open points is that they help with overplotting, since the empty areas in the middle of each point allow us to see other points that may be lying underneath. In my opinion, the benefit of being able to see overplotted points does not, in general, outweigh the detriment of the added visual noise of open symbols. There are other approaches for dealing with overplotting; see [Chapter 18](#) for some suggestions.

Finally, let's consider boxplots. Boxplots are commonly drawn with empty boxes, as in [Figure 25-8](#). I prefer a light shading for the box, as in [Figure 25-9](#). The shading separates the box from the plot background, and it helps in particular when we're showing many boxplots right next to each other, as is the case in Figures 25-8 and 25-9. In [Figure 25-8](#), the large number of boxes and lines can again create the illusion of background areas outside of boxes being actually on the inside of some other shape, just as we saw in [Figure 25-1](#). This problem is eliminated in [Figure 25-9](#). I have sometimes heard the critique that shading the inside of the box gives too much weight to the center 50% of the data, but I don't buy that argument. It is inherent to the boxplot, shaded box or not, to give more weight to the center 50% of the data than to the rest. If you don't want this emphasis, then don't use a boxplot. Instead, use a violin plot, jittered points, or a sina plot ([Chapter 9](#)).



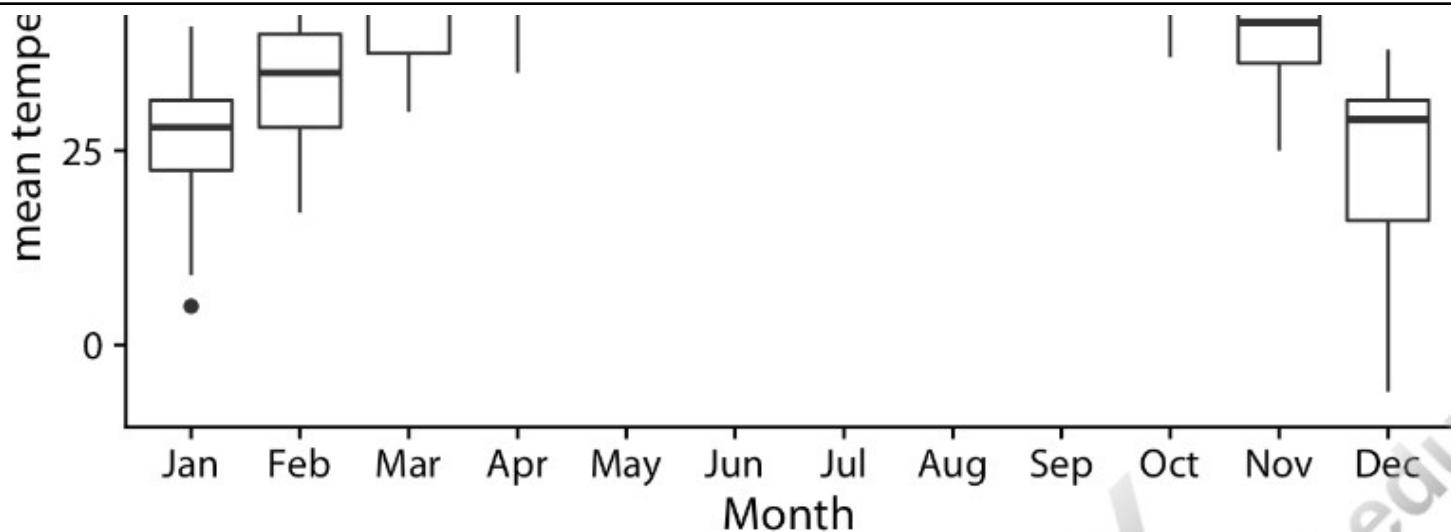


Figure 25-8. Distributions of daily mean temperatures in Lincoln, NE, in 2016. Boxes are drawn in the traditional way, without shading.  
Data source: Weather Underground.

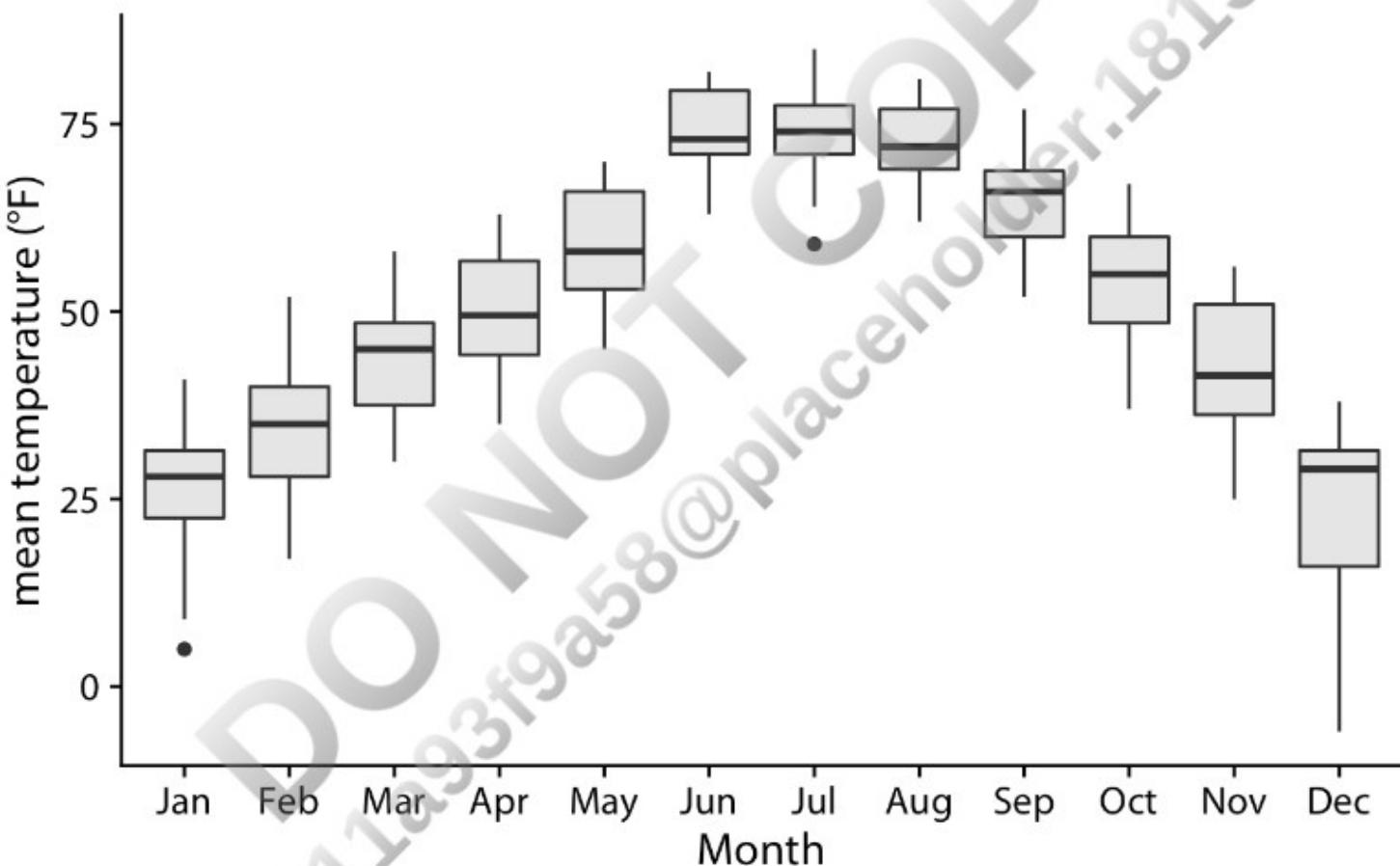


Figure 25-9. Distributions of daily mean temperatures in Lincoln, NE, in 2016. By giving the boxes a light gray shading, we can make them stand out better against the background. Data source: Weather Underground.

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[Marcos and Echave 2015].

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