Gov 50: 3. Data Visualization

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Roadmap

1. Building plots by layers

2. Histograms and boxplots

3. Grouped data

1/ Building plots by layers

Midwest data

```
midwest
```

```
## # A tibble: 437 x 28
##      PID county    state  area poptotal popdensity popwhite
##    <int> <chr>     <chr> <dbl>    <int>      <dbl>    <int>
##  1   561 ADAMS     IL    0.052    66090      1271.    63917
##  2   562 ALEXANDER IL    0.014    10626       759      7054
##  3   563 BOND      IL    0.022    14991       681.    14477
##  4   564 BOONE     IL    0.017    30806      1812.    29344
##  5   565 BROWN     IL    0.018     5836       324.     5264
##  6   566 BUREAU    IL    0.05     35688       714.    35157
##  7   567 CALHOUN   IL    0.017     5322       313.     5298
##  8   568 CARROLL   IL    0.027    16805       622.    16519
##  9   569 CASS      IL    0.024    13437       560.    13384
## 10   570 CHAMPAIGN IL    0.058   173025      2983.   146506
## # i 427 more rows
## # i 21 more variables: popblack <int>, popamerindian <int>,
## #   popasian <int>, popother <int>, percwhite <dbl>,
## #   percblack <dbl>, percamerindan <dbl>, percasian <dbl>,
## #   percother <dbl>, popadults <int>, perchsd <dbl>,
## #   percollege <dbl>, percprof <dbl>,
## #   poppovertyknown <int>, percpovertyknown <dbl>, ...
```

Building up a graph in pieces

Create ggplot object and direct it to the correct data:

```
p <- ggplot(data = midwest)
```

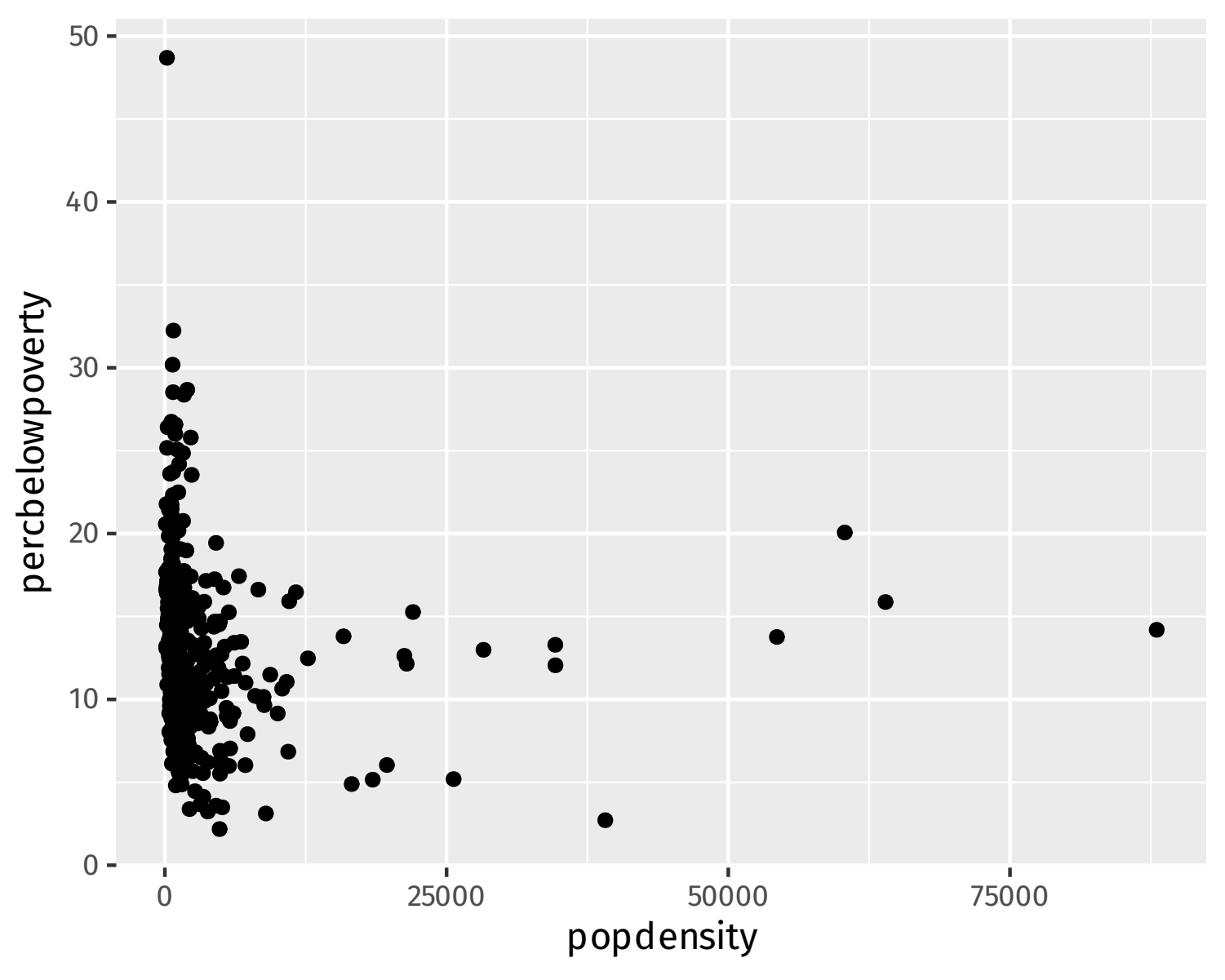
Mapping: tell ggplot what visual aesthetics correspond to which variables

```
p <- ggplot(data = midwest,
            mapping = aes(x = popdensity,
                          y = percbelowpoverty))
```

Other aesthetic mappings: `color`, `shape`, `size`, etc.

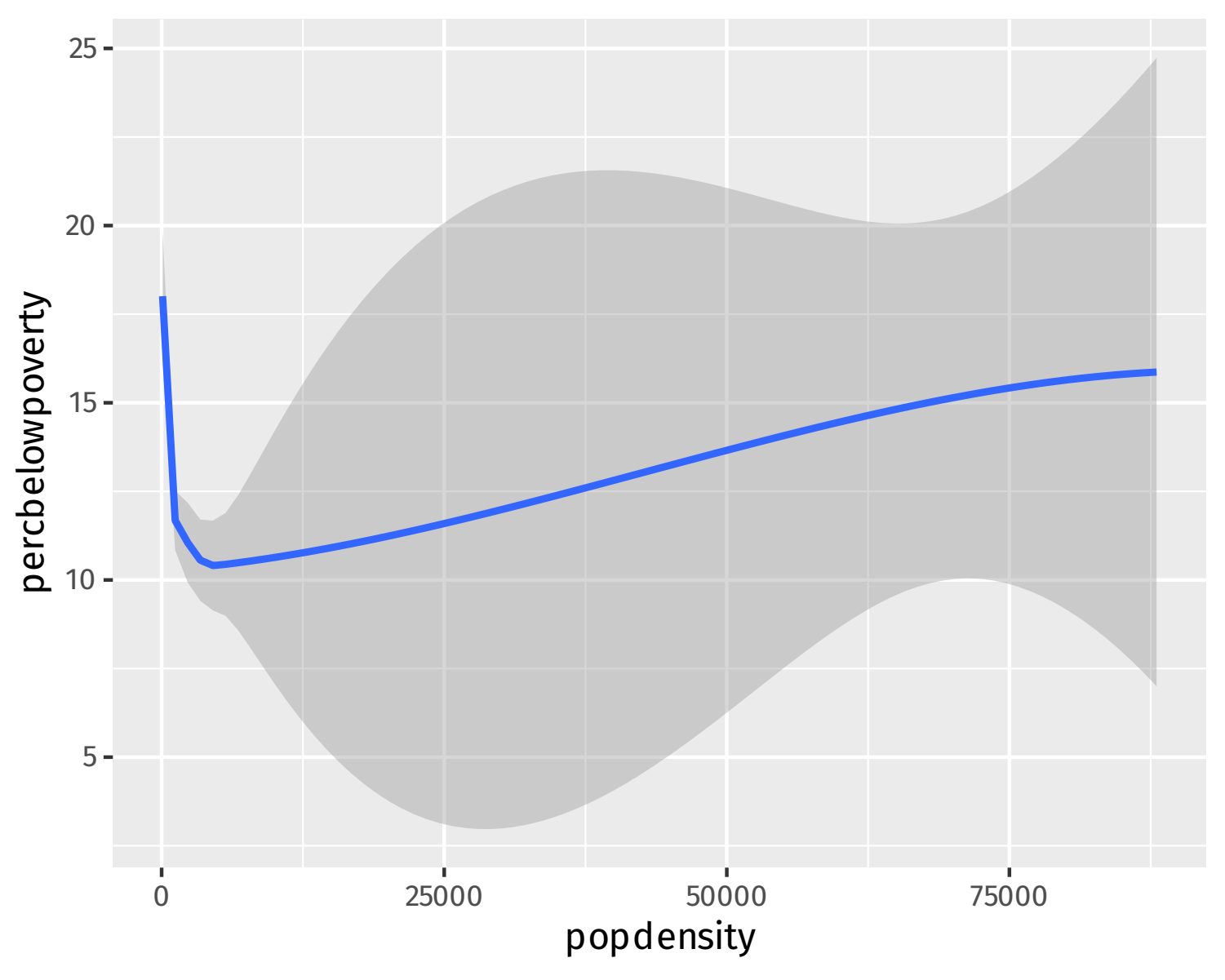
Adding a geom layer

```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty)) +
  geom_point()
```


50
40
30
20
10
0
percbelowpoverty
0
25000
50000
75000
popdensity

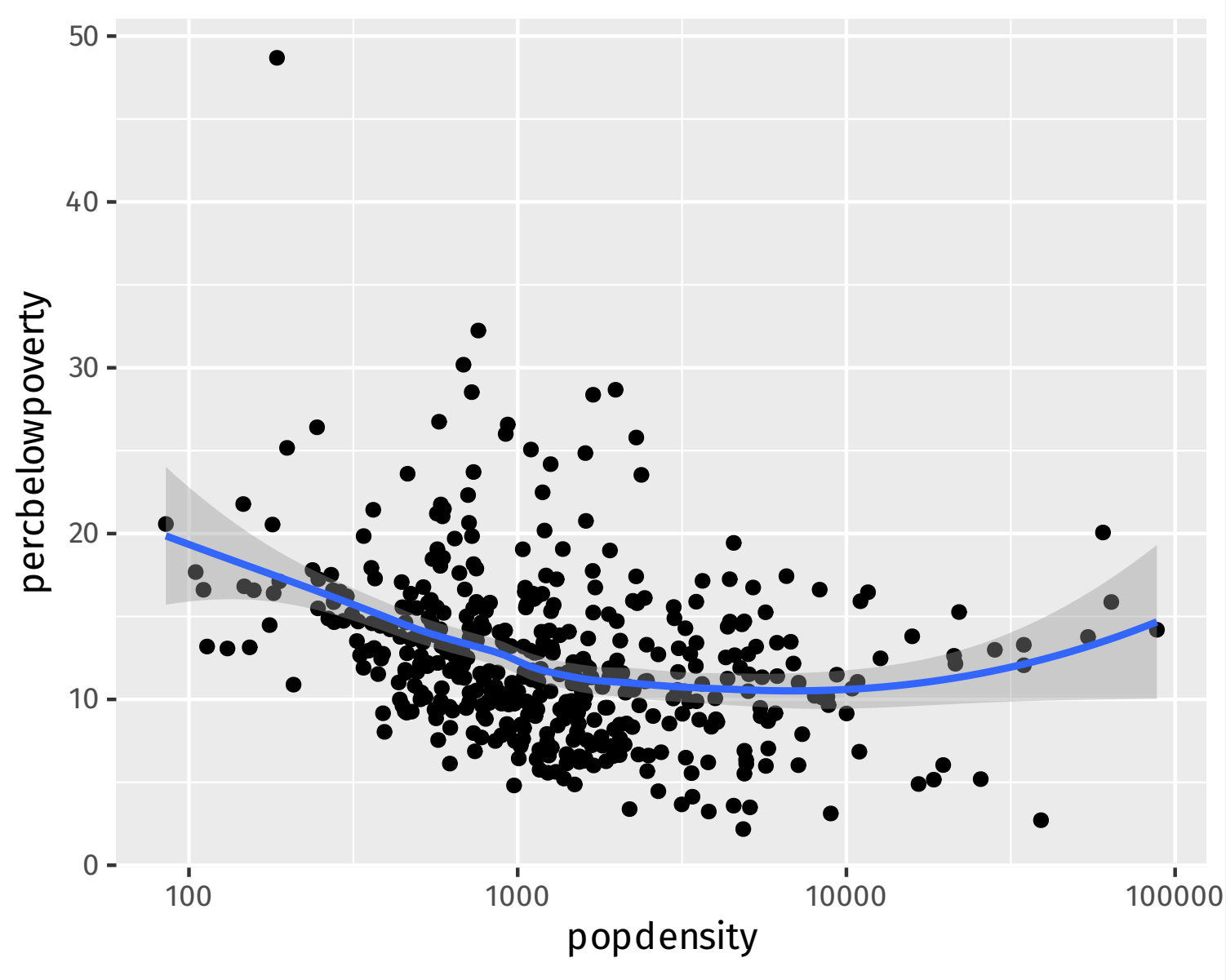
Trying a new geom

```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty)) +
  geom_smooth()
```


25
20
15
10
5
percbelowpoverty
0
25000
50000
75000
popdensity

Layering geoms is additive

```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty)) +
  geom_point() +
  geom_smooth() +
  scale_x_log10()
```

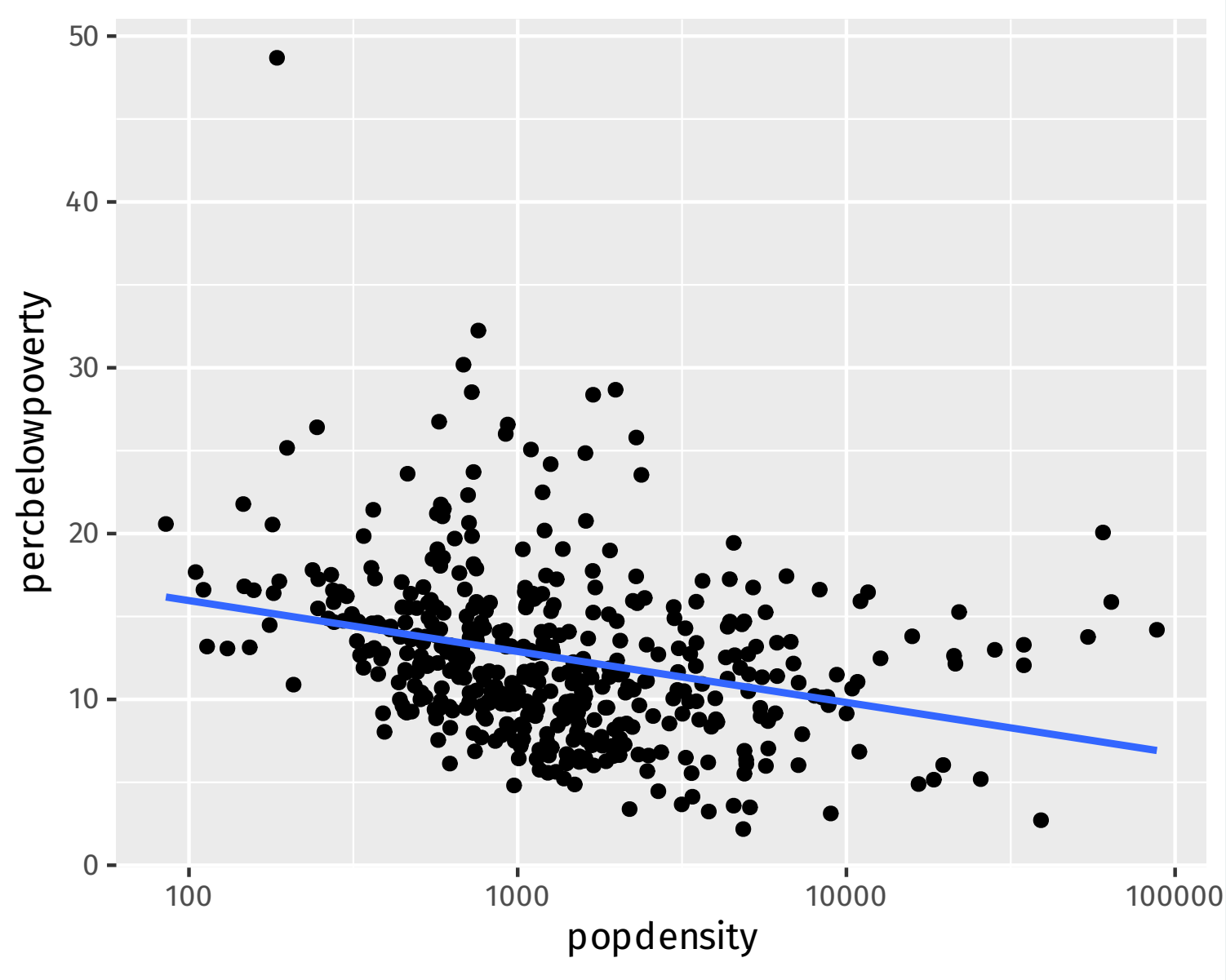

50
40
30
20
10
0
percbelowpoverty
100
1000
10000
100000
popdensity

Geoms are functions

Geoms can take arguments:

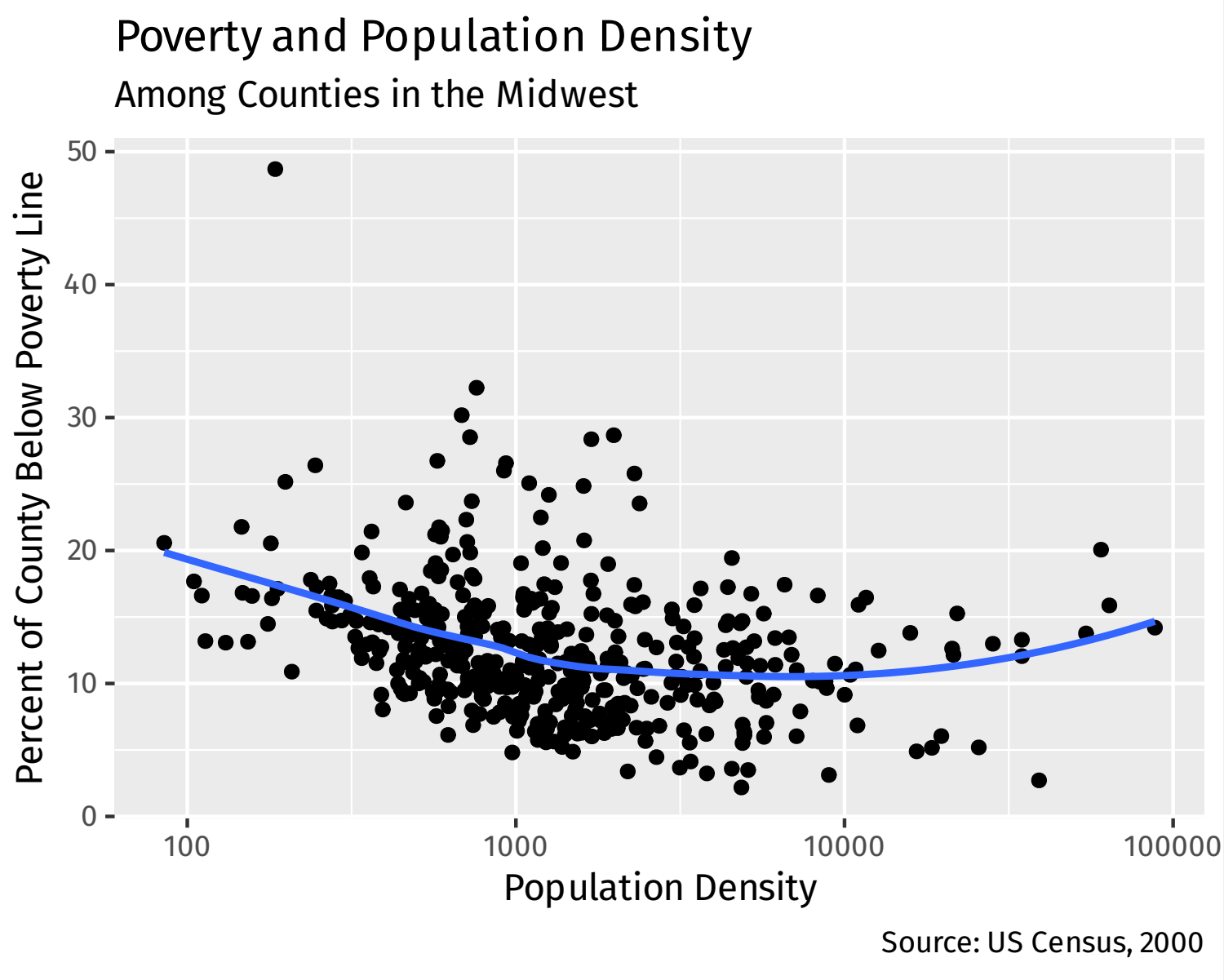
```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty)) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  scale_x_log10()
```

Tells geom_smooth to do a linear fit with no error region


50
40
30
20
10
0
percbelowpoverty
100
1000
10000
100000
popdensity

Adding informative labels

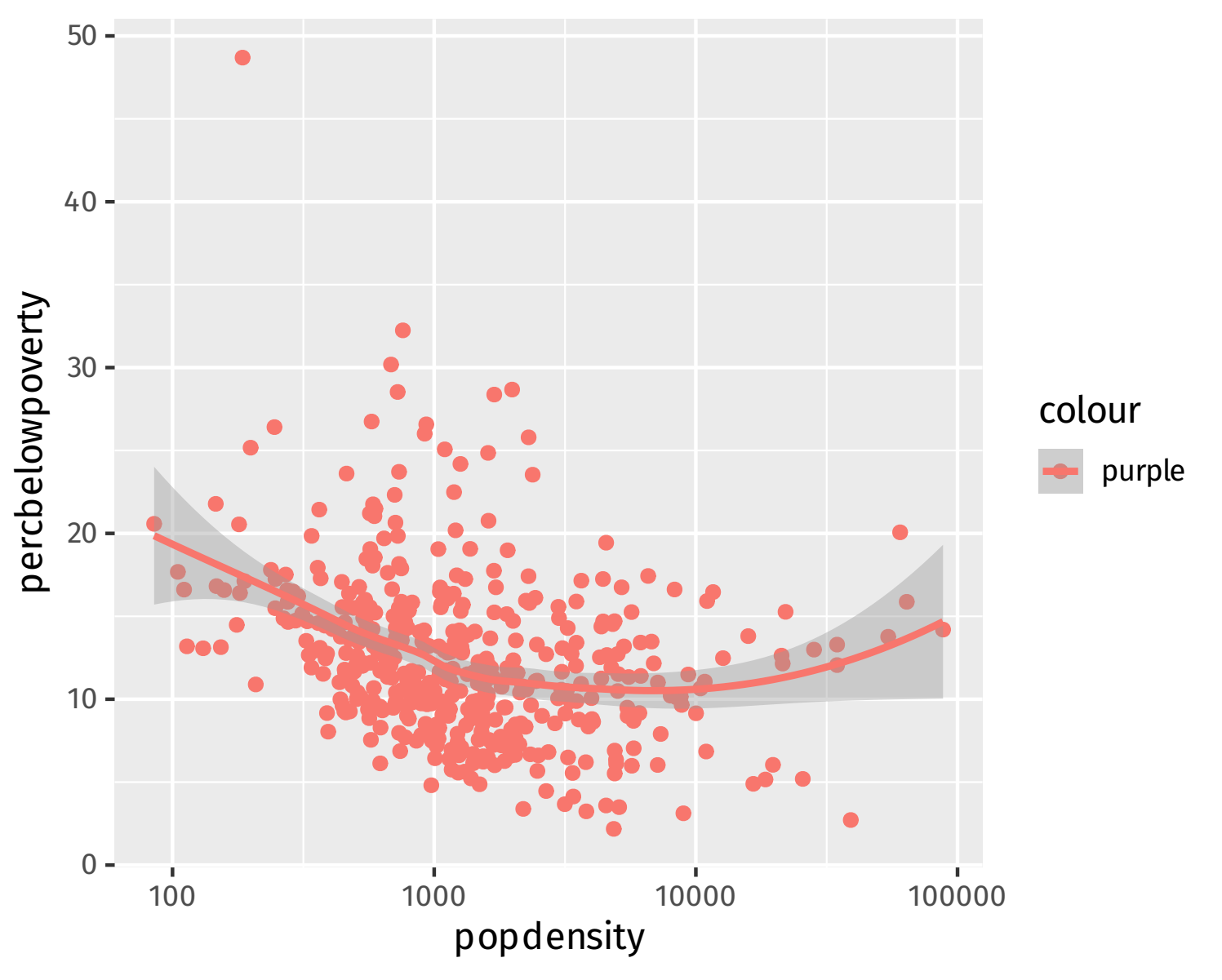
```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty)) +
  geom_point() +
  geom_smooth(method = "loess", se = FALSE) +
  scale_x_log10() +
  labs(x = "Population Density",
       y = "Percent of County Below Poverty Line",
       title = "Poverty and Population Density",
       subtitle = "Among Counties in the Midwest",
       caption = "Source: US Census, 2000")
```


Poverty and Population Density
Among Counties in the Midwest
Percent of County Below Poverty Line
50
40
30
20
10
0
100
1000
10000
100000
Population Density
Source: US Census, 2000

Mapping vs setting aesthetics

```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty,
                     color = "purple")) +
  geom_point() +
  geom_smooth() +
  scale_x_log10()
```

Wait what?


50
40
30
20
10
0
percbelowpoverty
100
1000
10000
100000
popdensity
colour
purple

Mapping always refers to variables

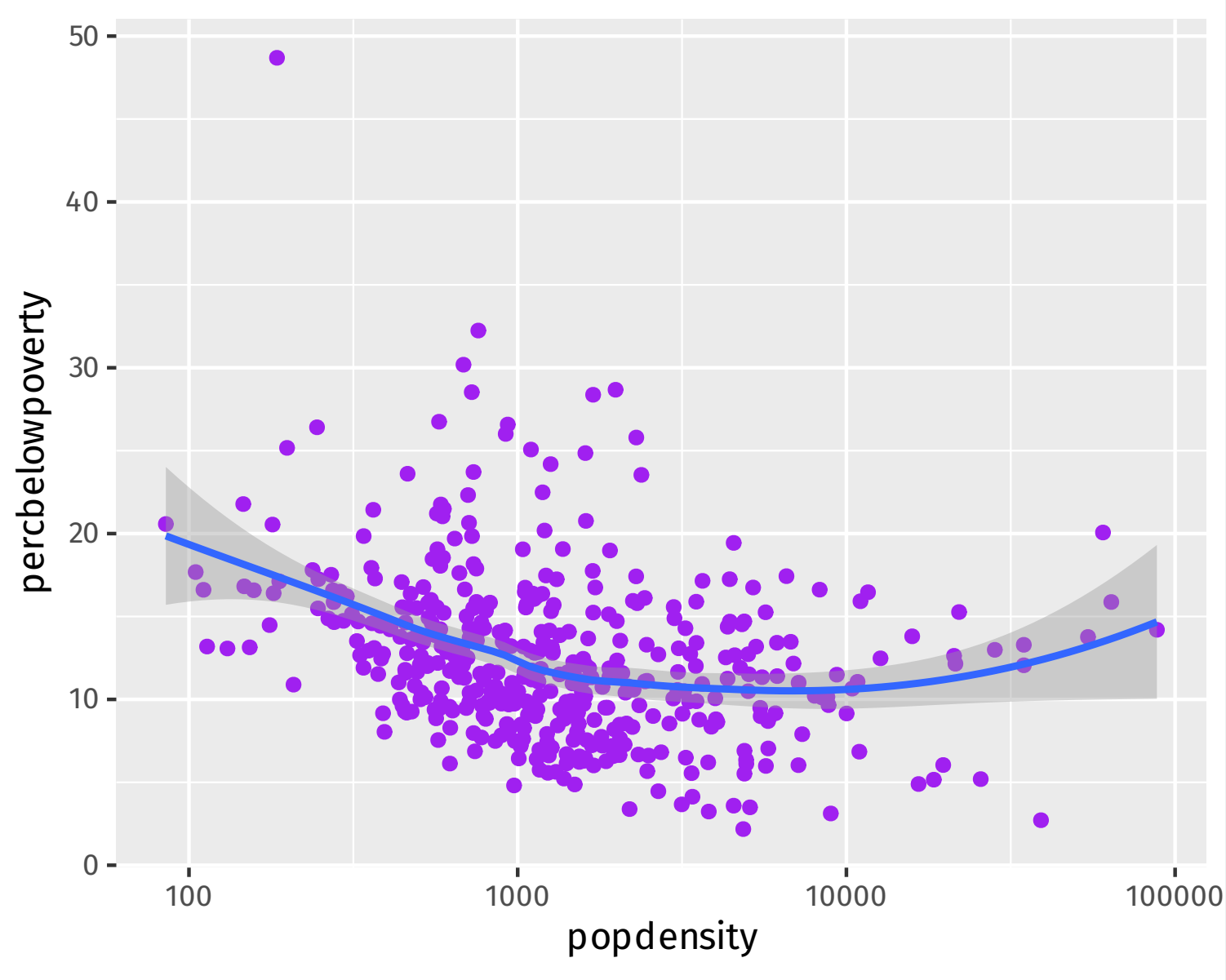
If passed a value other than a variable name, ggplot will implicitly create a variable with that value (in this case `"purple"` that is constant)

```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty,
                     color = "purple")) +
  geom_point() +
  geom_smooth() +
  scale_x_log10()
```

Setting aesthetics

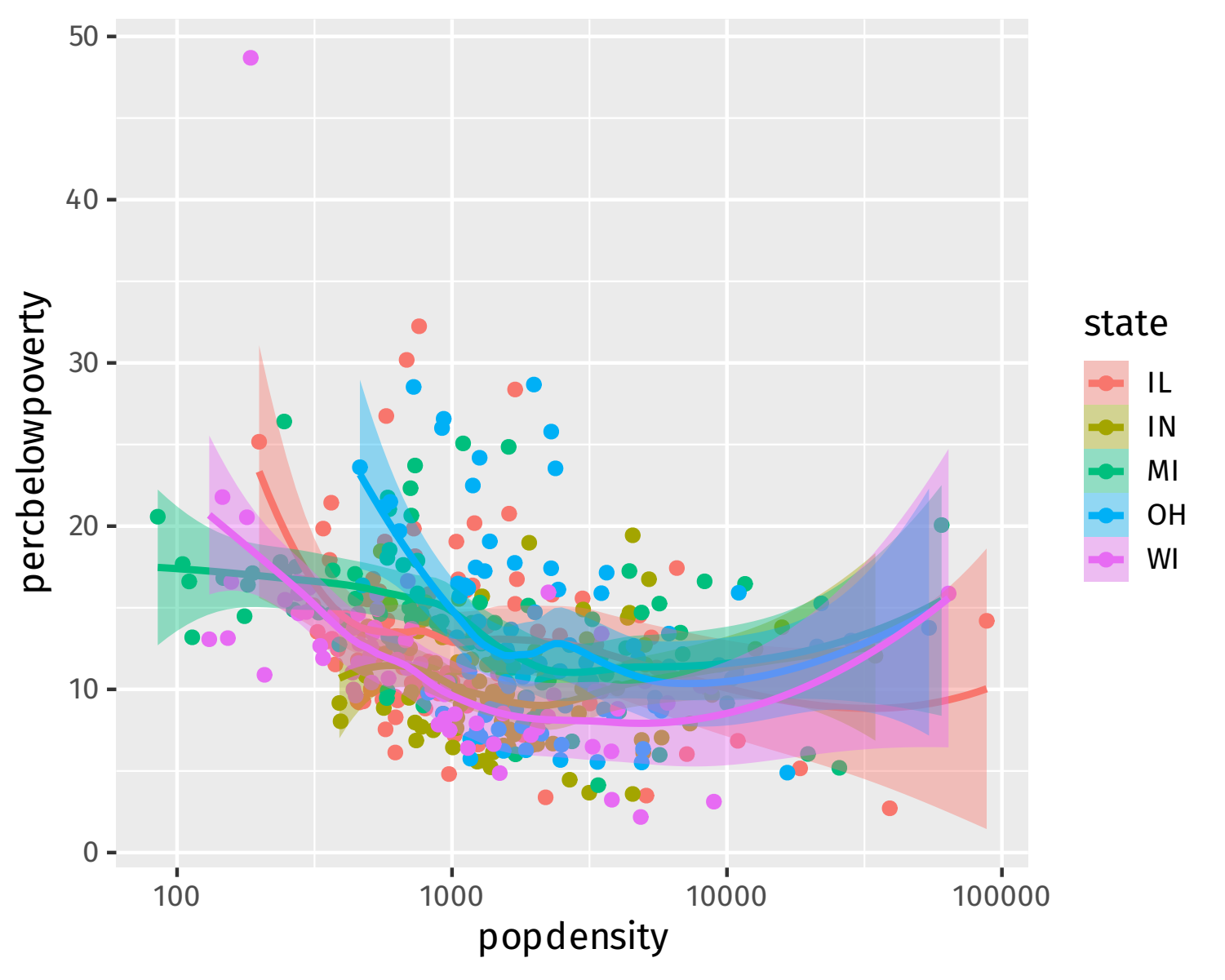
Set the color outside the `mapping = aes()` format.

```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty)) +
  geom_point(color = "purple") +
  geom_smooth() +
  scale_x_log10()
```


50
40
30
20
10
0
percbelowpoverty
100
1000
10000
100000
popdensity

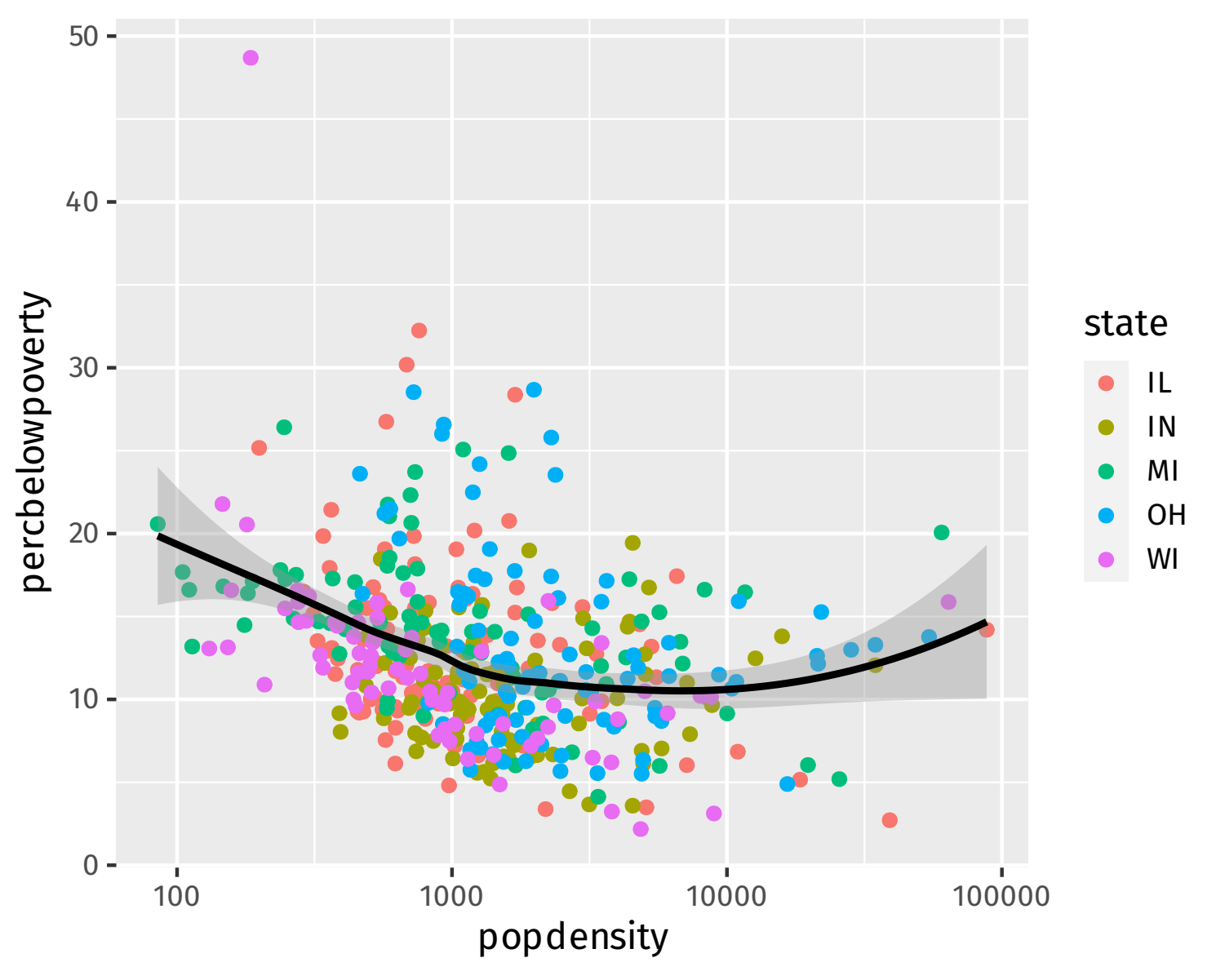
Mapping more aesthetics

```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty,
                     color = state,
                     fill = state)) +
  geom_point() +
  geom_smooth() +
  scale_x_log10()
```


50
40
30
20
10
0
percbelowpoverty
100
1000
10000
100000
popdensity
state
IL
IN
MI
OH
WI

Mappings can be done on a per geom basis

```
ggplot(data = midwest,
       mapping = aes(x = popdensity,
                     y = percbelowpoverty)) +
  geom_point(mapping = aes(color = state)) +
  geom_smooth(color = "black") +
  scale_x_log10()
```


50
40
30
20
10
0
percbelowpoverty
100
1000
10000
100000
popdensity
state
IL
IN
MI
OH
WI

2/ Histograms and boxplots

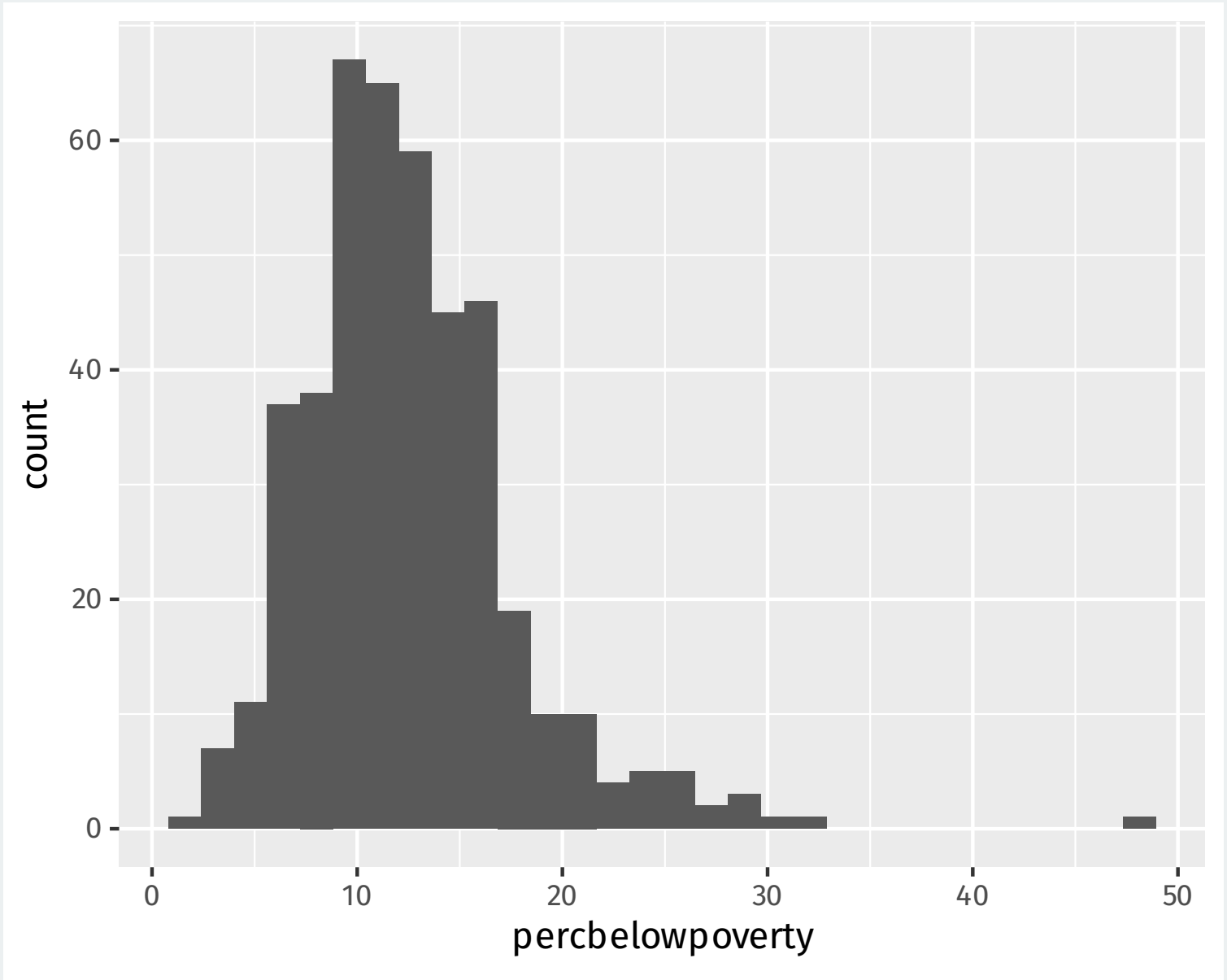
Histograms

Histograms show where there are more or fewer observations of a numeric variable.

```
ggplot(data = midwest,
       mapping = aes(x = percbelowpoverty)) +
  geom_histogram()
```

Split up range of variable into bins, count how many are in each bin.

y aesthetic calculated automatically.

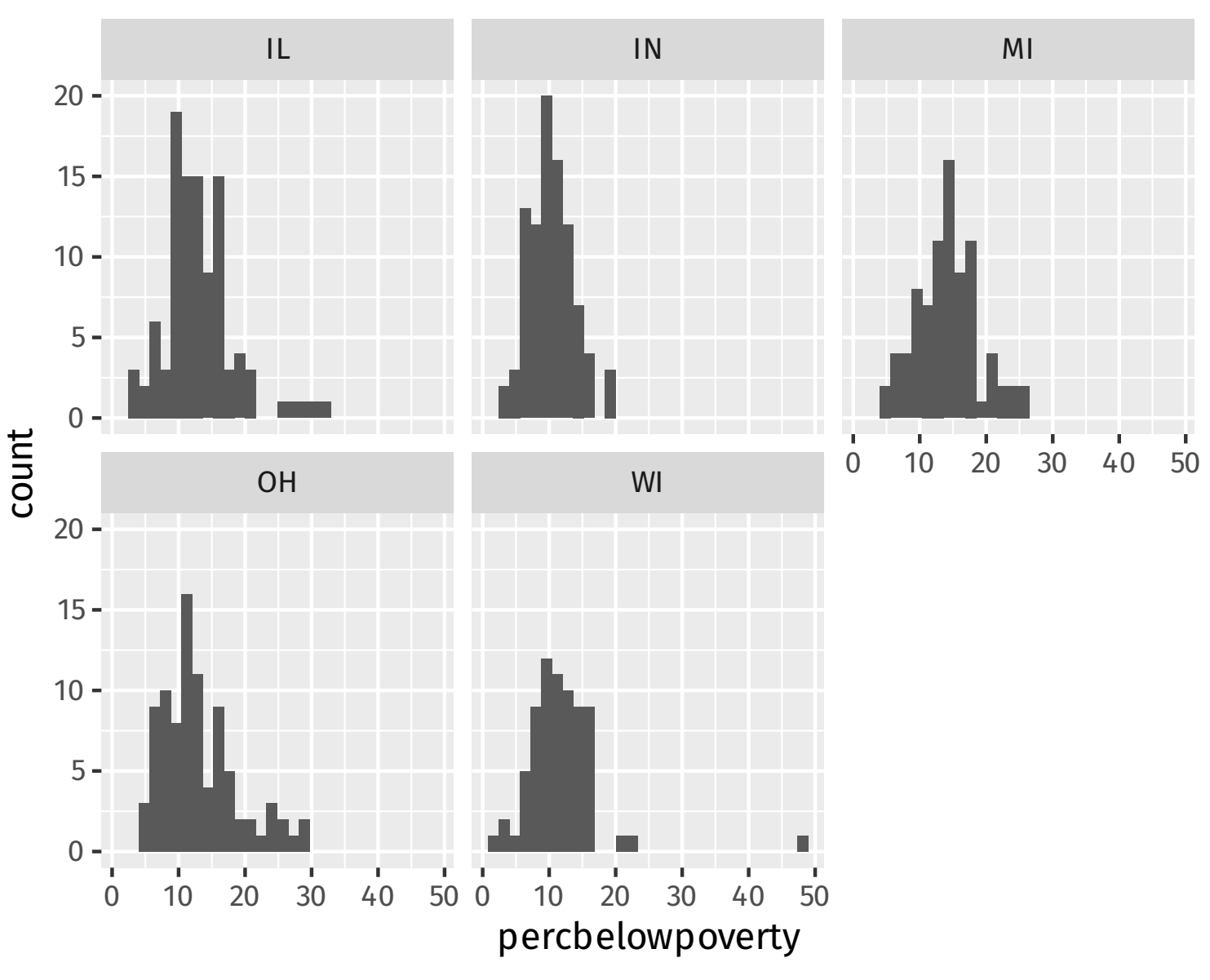

60
40
20
0
count
0
10
20
30
40
50
percbelowpoverty

Creating small multiples with facets

Small multiples: a series of similar graphs with the same scale/axes to help with comparing different partitions of a dataset.

```
ggplot(data = midwest,
       mapping = aes(x = percbelowpoverty)) +
  geom_histogram() +
  facet_wrap(~ state)
```

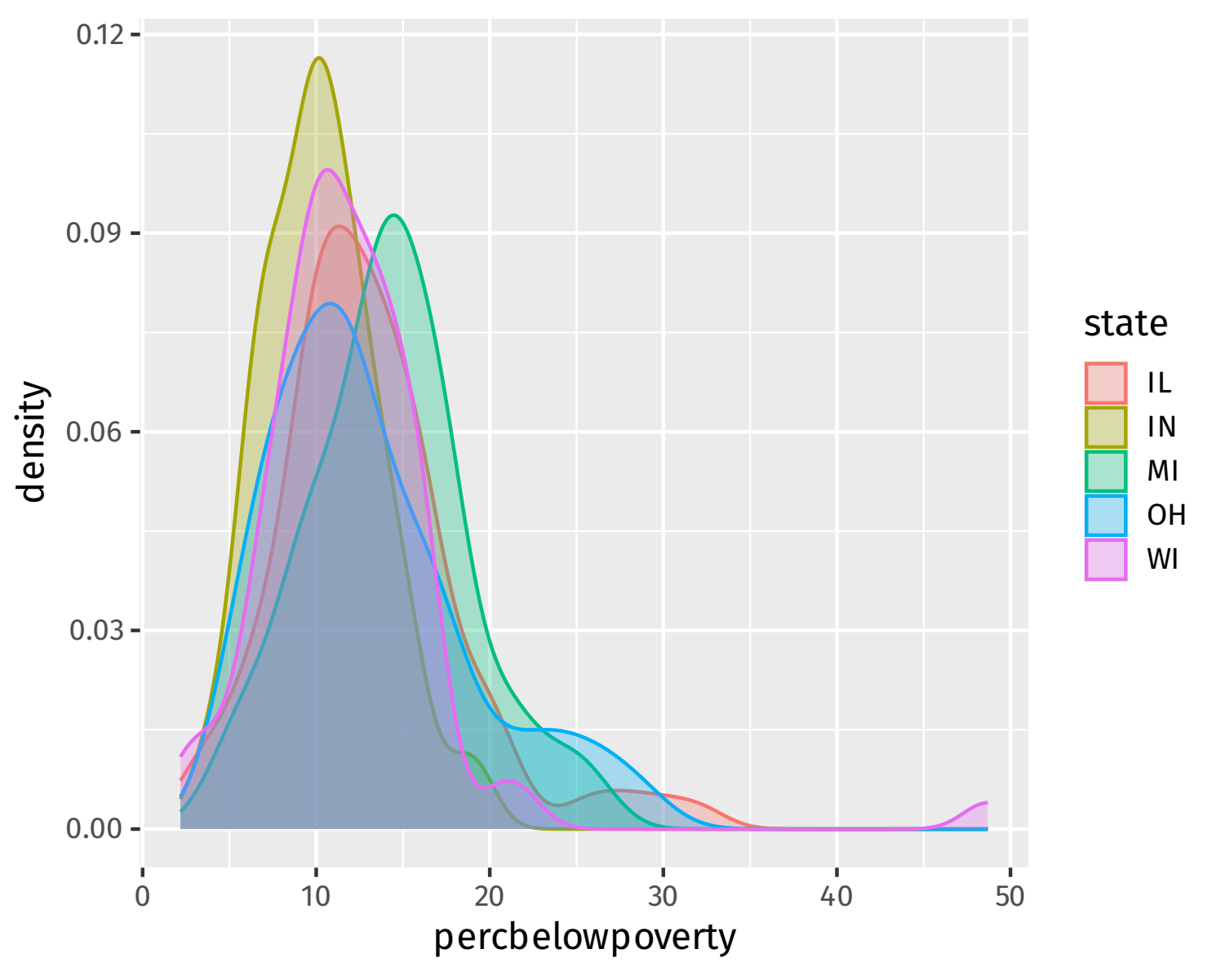
We'll see more of the `~ variable` syntax (called a formula).


IL
IN
MI
OH
WI
count
percbelowpoverty
0
5
10
15
20
0
10
20
30
40
50

Density as alternative to histograms

A **kernel density** plot is a smoothed version of a histogram and slightly easier to overlay.

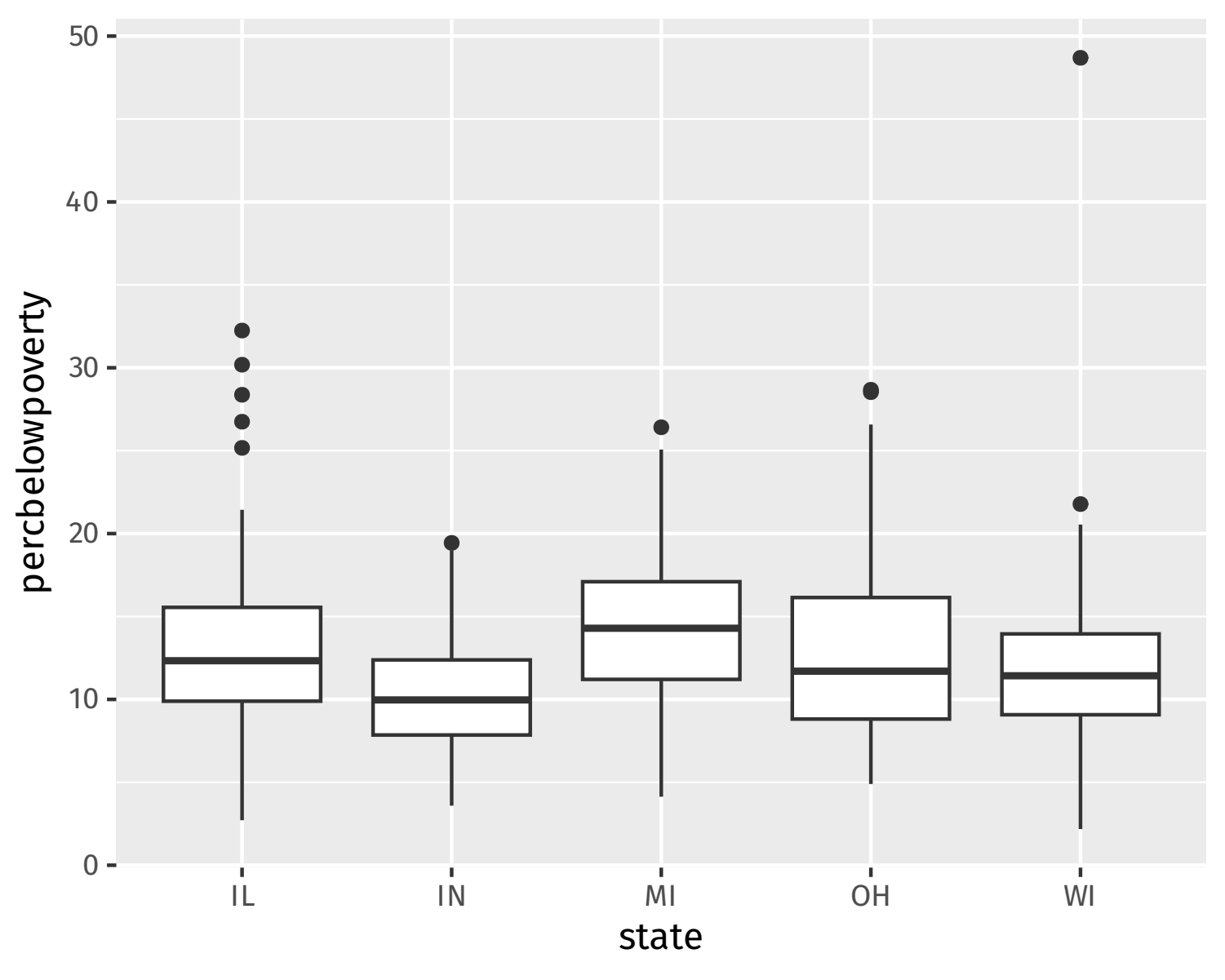
```
ggplot(data = midwest,
       mapping = aes(x = percbelowpoverty,
                     fill = state, color = state)) +
  geom_density(alpha = 0.3)
```


0.12
0.09
0.06
0.03
0.00
density
0
10
20
30
40
50
percbelowpoverty
state
IL
IN
MI
OH
WI

Boxplots

Boxplots are another way to compare distributions across discrete groups.

```
ggplot(data = midwest,
       mapping = aes(x = state,
                     y = percbelowpoverty)) +
  geom_boxplot()
```


50
40
30
20
10
0
percbelowpoverty
IL
IN
MI
OH
WI
state

Boxplots in R

- “Box” represents middle 50% of the data.

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    - 25% of the data above the box, 25% below

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    - Width of the box is called the inter quartile range (IQR)

Boxplots in R

- “Box” represents middle 50% of the data.
    - 25% of the data above the box, 25% below
    - Width of the box is called the inter quartile range (IQR)
- Horizontal line in the box is the median

Boxplots in R

- “Box” represents middle 50% of the data.
    - 25% of the data above the box, 25% below
    - Width of the box is called the inter quartile range (IQR)
- Horizontal line in the box is the median
    - 50% of the data above the median, 50% below

Boxplots in R

- “Box” represents middle 50% of the data.
    - 25% of the data above the box, 25% below
    - Width of the box is called the inter quartile range (IQR)
- Horizontal line in the box is the median
    - 50% of the data above the median, 50% below
- “Whiskers” represents either:

Boxplots in R

- "Box" represents middle 50% of the data.
    - 25% of the data above the box, 25% below
    - Width of the box is called the inter quartile range (IQR)
- Horizontal line in the box is the median
    - 50% of the data above the median, 50% below
- "Whiskers" represents either:
    - 1.5 $\times$ IQR or max/min of the data, whichever is smaller.

Boxplots in R

- "Box" represents middle 50% of the data.
    - 25% of the data above the box, 25% below
    - Width of the box is called the inter quartile range (IQR)
- Horizontal line in the box is the median
    - 50% of the data above the median, 50% below
- "Whiskers" represents either:
    - 1.5 $\times$ IQR or max/min of the data, whichever is smaller.
    - Points beyond whiskers are outliers.

3/ Grouped data

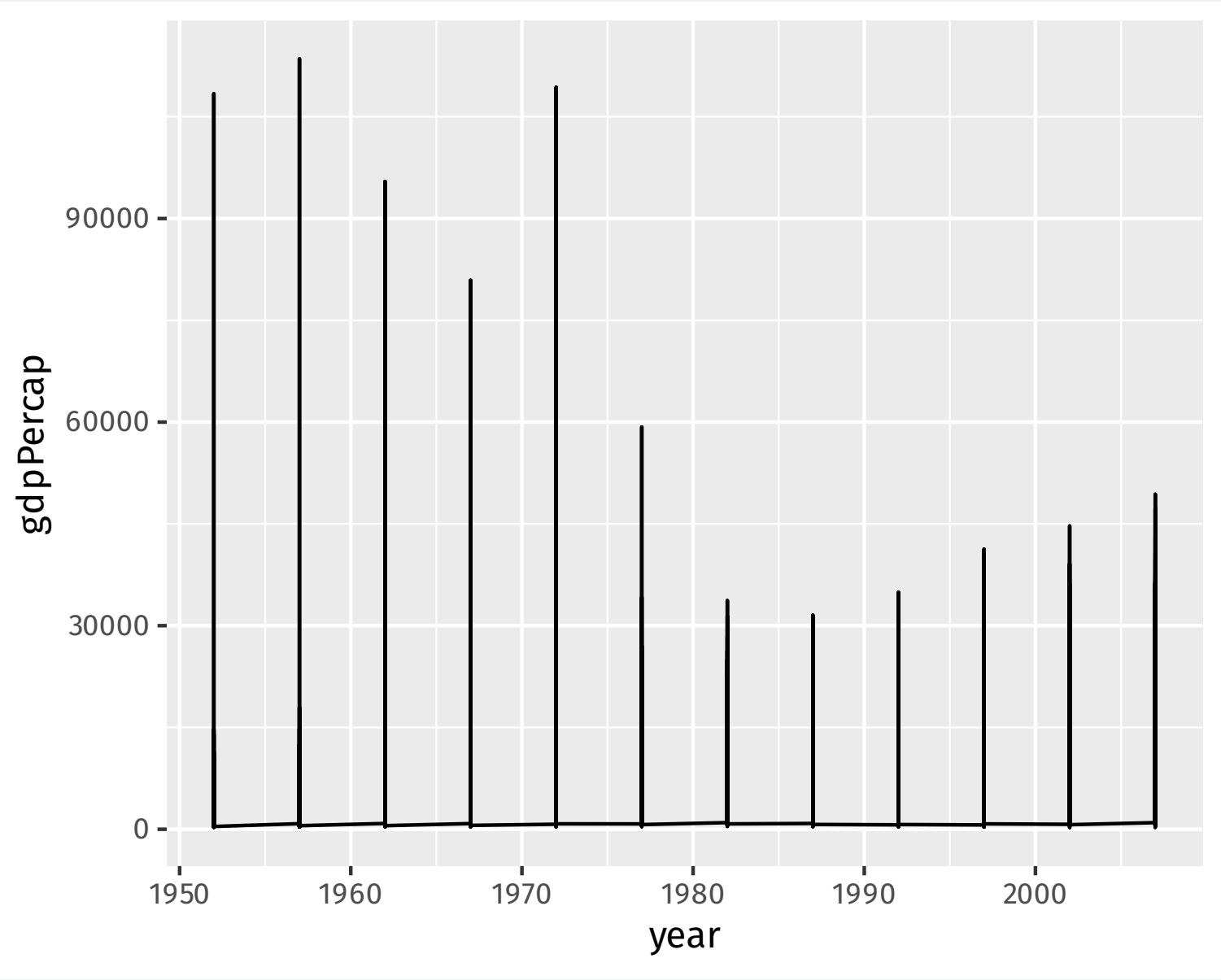
Back to the gapminder data

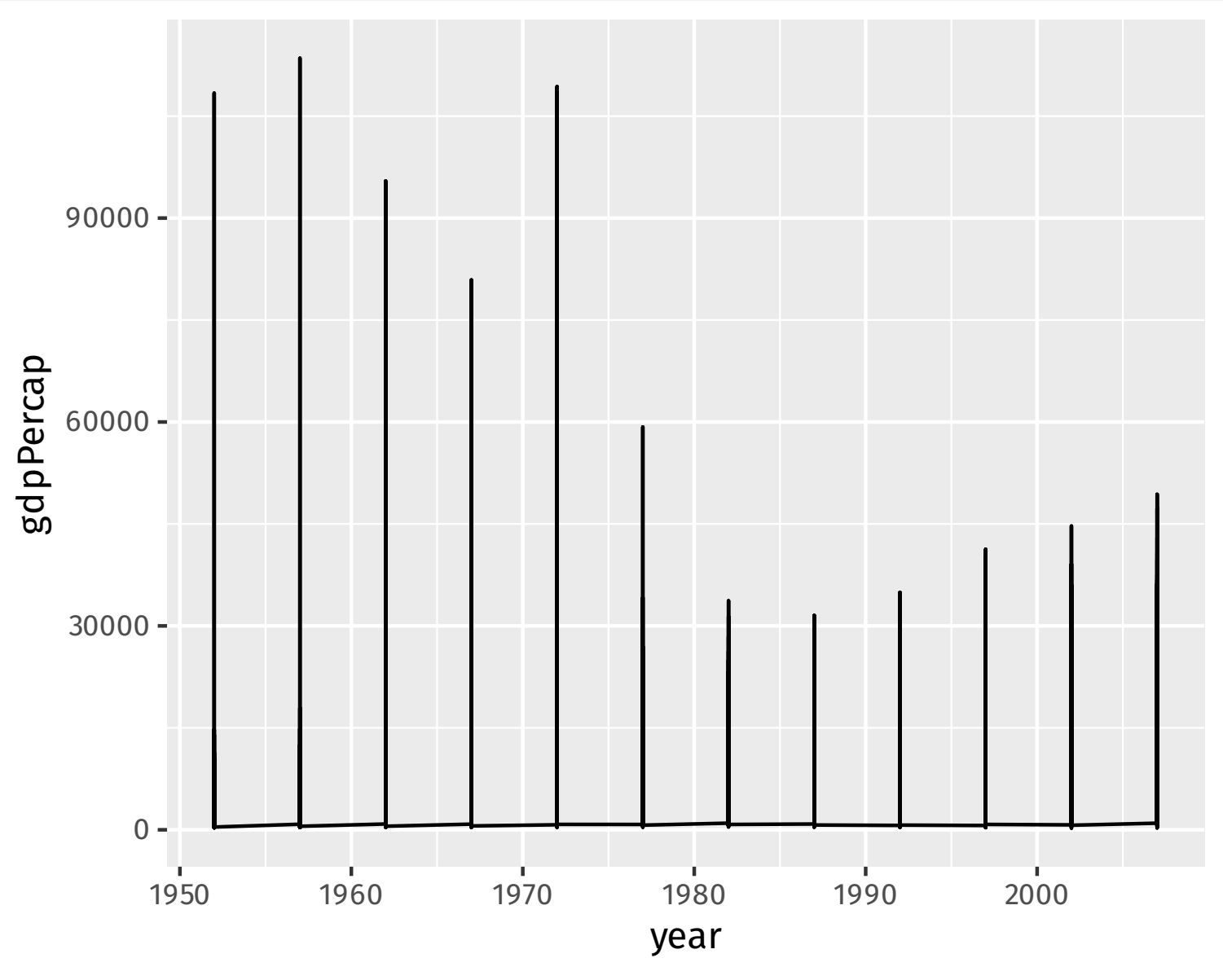
```
glimpse(gapminder)
```

```
## Rows: 1,704
## Columns: 6
## $ country   <fct> "Afghanistan", "Afghanistan", "Afghanist~
## $ continent <fct> Asia, Asia, Asia, Asia, Asia, Asia, Asia~
## $ year      <int> 1952, 1957, 1962, 1967, 1972, 1977, 1982~
## $ lifeExp   <dbl> 28.8, 30.3, 32.0, 34.0, 36.1, 38.4, 39.9~
## $ pop       <int> 8425333, 9240934, 10267083, 11537966, 13~
## $ gdpPercap <dbl> 779, 821, 853, 836, 740, 786, 978, 852, ~
```

Let's plot the trend in income

```
ggplot(data = gapminder,
       mapping = aes(x = year,
                     y = gdpPercap)) +
  geom_line()
```

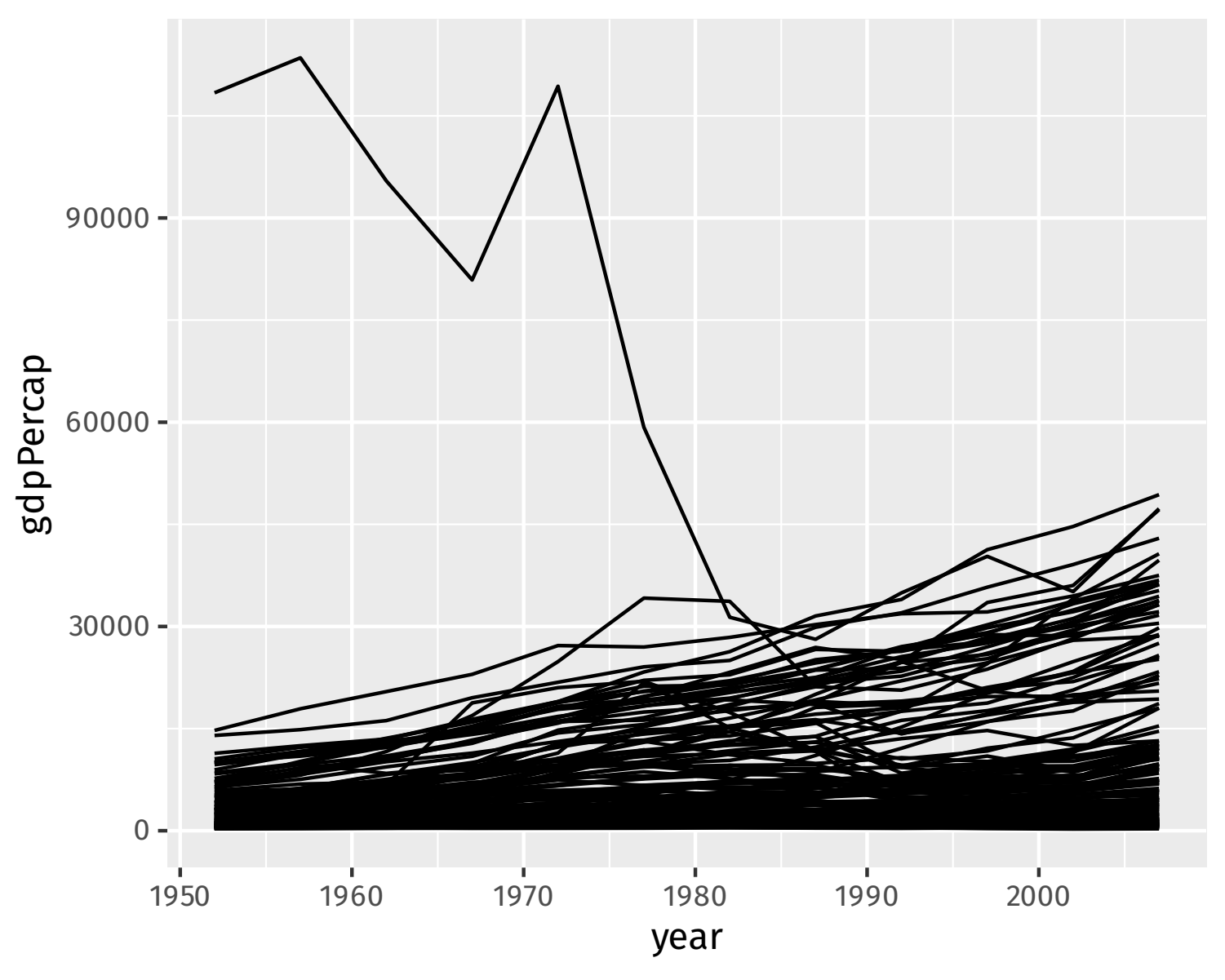

90000
60000
30000
0
gdpPercap
1950
1960
1970
1980
1990
2000
year



`geom_line` connects points from different countries in the same year.

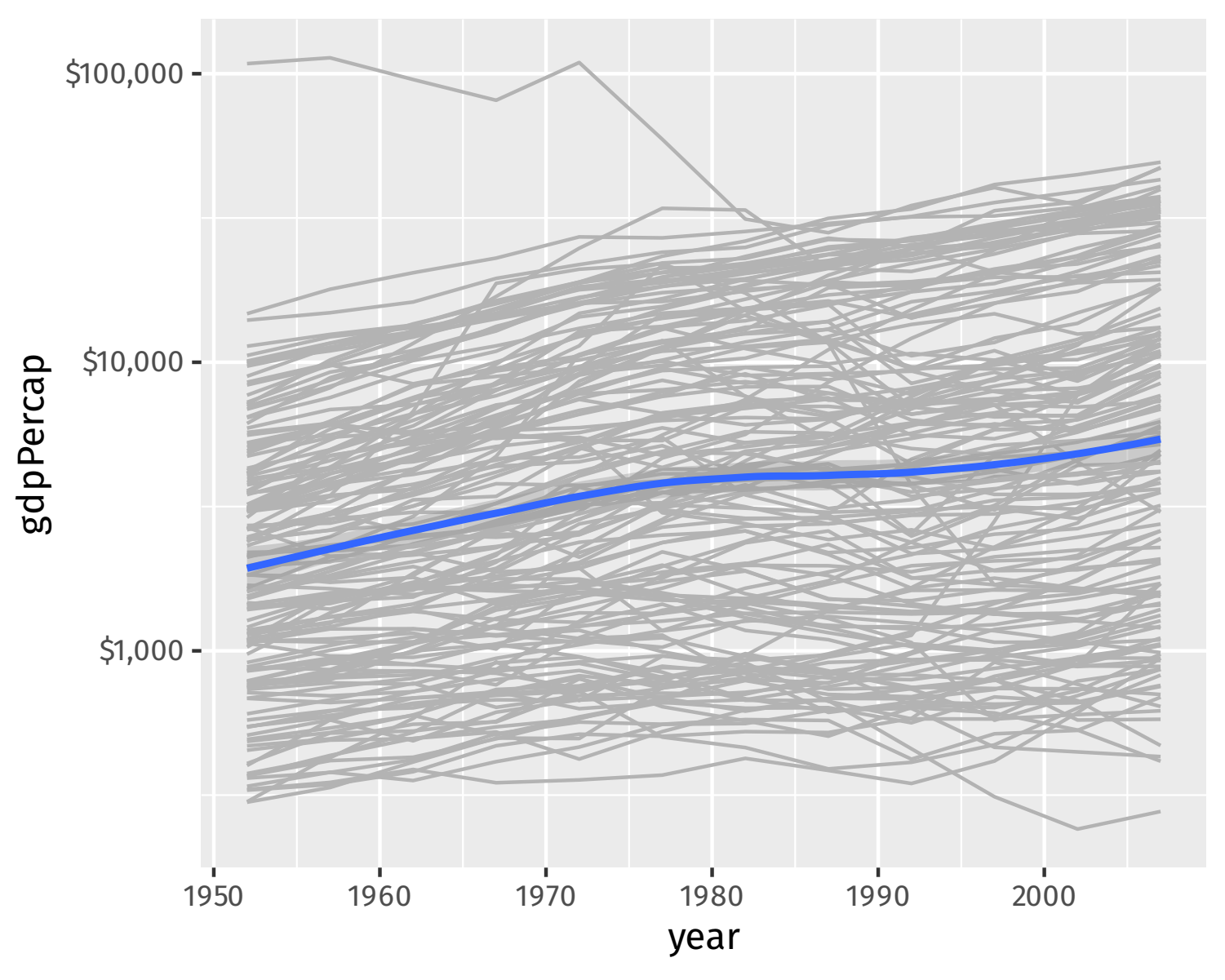
Tell `geom_line` how to group the lines

```
ggplot(data = gapminder,
       mapping = aes(x = year,
                     y = gdpPercap)) +
  geom_line(mapping = aes(group = country))
```


90000
60000
30000
0
gdpPercap
1950
1960
1970
1980
1990
2000
year

Scales

```
ggplot(data = gapminder,
       mapping = aes(x = year,
                     y = gdpPercap)) +
  geom_line(mapping = aes(group = country), color = "grey70") +
  geom_smooth(method = "loess") +
  scale_y_log10(labels = scales::dollar)
```


$100,000
$10,000
$1,000
gdpPercap
1950
1960
1970
1980
1990
2000
year