Problem Set 2, Solution 1

Statistics 506, Fall 2017

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The RESC data can be downloaded from here.

```
# load the libraries
library(tidyverse)
```

```
# load the data
full_data = read_delim("recs2009_public.csv", delim=",", col_names=TRUE)

# remove rooftype -2 (Not applicable)
working_data = full_data %>% filter(ROOFTYPE!=-2) %>%
                             select(REPORTABLE_DOMAIN, ROOFTYPE, NWEIGHT)


# convert REPORTABLE_DOMAIN to factor and label the corresponding state name
working_data$state = as.factor(working_data$REPORTABLE_DOMAIN)
levels(working_data$state) = c("CT, ME, NH, RI, VT", "MA", "NY", "NJ", "PA", "IL",
                               "IN, OH", "MI", "WI", "IA, MN, ND, SD", "KS, NE", "MO",
                               "VA", "DE, DC, MD, WV", "GA", "NC, SC", "FL", "AL, KY, MS",
                               "TN", "AR, LA, OK", "TX", "CO", "ID, MT, UT, WY", "AZ",
                               "NV, NM", "CA", "AK, HI, OR, WA" )

# convert ROOFTYPE to factor and label the corresponding type name
working_data$roof_type = as.factor(working_data$ROOFTYPE)
levels(working_data$roof_type) = c("Ceramic or Clay", "Wood Shingles",
                                   "Metal", "Slate", "Composition", "Asphalt", "Concrete",
                                   "Other")
```

Which state has the highest proportion of wood shingle roofs? Which state(s) the lowest?

The proportion of roof type r in for state s is calculated as:

$$\frac{\text{weighted sum of roof type } r \text{ in state } s}{\text{weighted sum in state } s}$$

We first compute the weighted sum in each state.

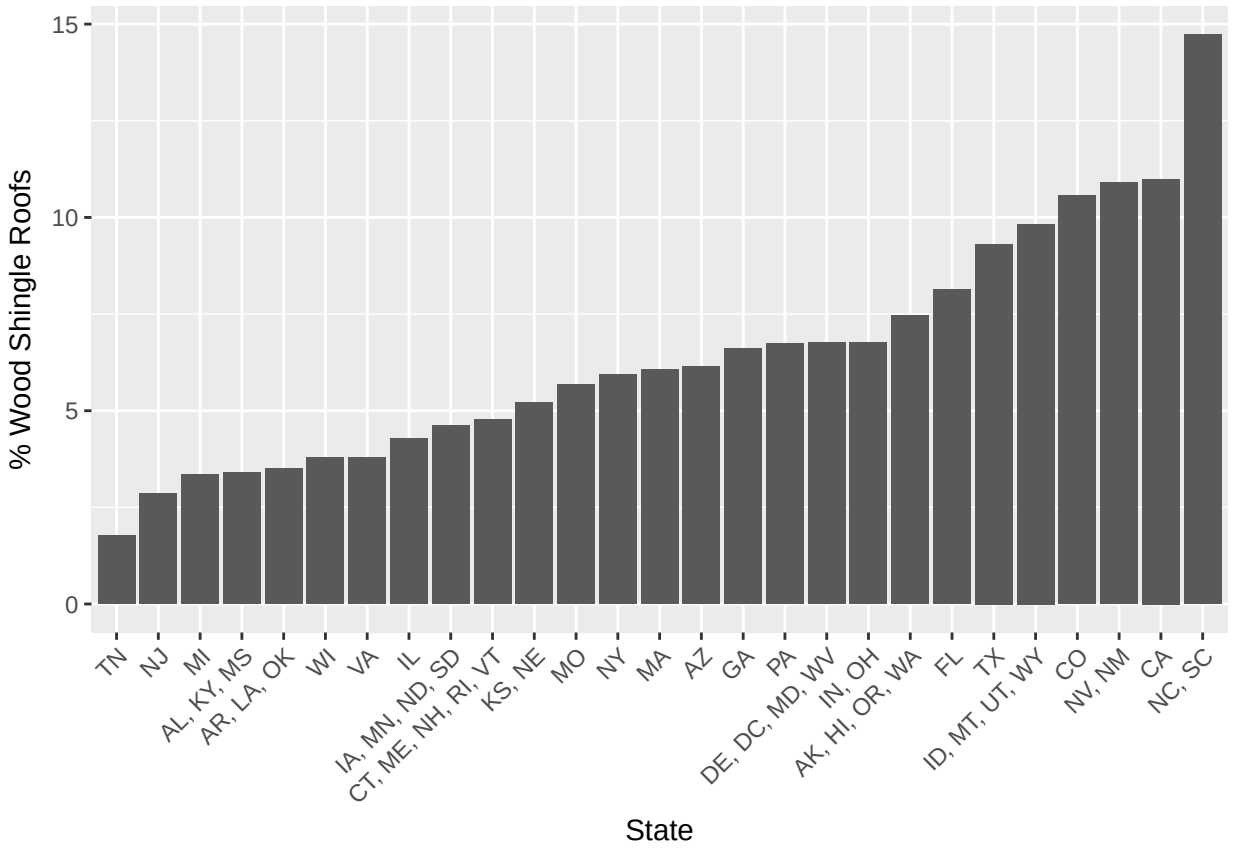
```
# calculate the total weighted counts for each state
state_total = working_data %>% group_by(state) %>% summarise(state_total=sum(NWEIGHT))

# calculate the proportion of each roof type in different state
roof_proportion = working_data %>% group_by(state, roof_type) %>%
                                   summarise(weight_counts=sum(NWEIGHT)) %>%
                                   left_join(state_total, by="state") %>%
                                   mutate(proportion=weight_counts/state_total*100)

# keep the wood shingles roof type and find the min/max proportion
wood_proportion = roof_proportion %>% filter(roof_type=="Wood Shingles") %>%
                                   arrange(desc(proportion)) %>%
```

```
                                select(state, proportion) %>%
                                ungroup
knitr::kable(wood_proportion, digits=1,
             col.names = c('State(s)','% Wood Shingle Roofs'))
```

State(s)	% Wood Shingle Roofs
NC, SC	14.7
CA	11.0
NV, NM	10.9
CO	10.6
ID, MT, UT, WY	9.8
TX	9.3
FL	8.1
AK, HI, OR, WA	7.5
IN, OH	6.8
DE, DC, MD, WV	6.8
PA	6.7
GA	6.6
AZ	6.1
MA	6.1
NY	5.9
MO	5.7
KS, NE	5.2
CT, ME, NH, RI, VT	4.8
IA, MN, ND, SD	4.6
IL	4.3
VA	3.8
WI	3.8
AR, LA, OK	3.5
AL, KY, MS	3.4
MI	3.4
NJ	2.9
TN	1.8

From the results, we see that North/South Carolina has the highest percentage of wood shingle roofs, while Tennessee has the lowest. You can also get this conclusion from the following graph.

```
roof_proportion %>% ungroup() %>%
  filter(roof_type=="Wood Shingles") %>%
  mutate(state = factor(state, state[order(proportion)])) %>%
  ggplot(aes(state, proportion)) +
      geom_bar(stat="identity") +
        theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  xlab('State') + ylab('% Wood Shingle Roofs')
```



Compute the proportion of each roof type for all houses constructed in each decade. Which roof type saw the largest relative rise in use between 1950 and 2000?

Similarly, the proportion of roof type r in decade d is calculated as:

$$\frac{\text{weighted sum of roof type } r \text{ in decade } d}{\text{weighted sum in decade } d}$$

```
# keep the needed columns
working_data = full_data %>% filter(ROOFTYPE!=-2) %>%
                             select(ROOFTYPE, YEARMADERANGE, NWEIGHT)

# convert ROOFTYPE to factor and label the corresponding type name
working_data$roof_type = as.factor(working_data$ROOFTYPE)
levels(working_data$roof_type) = c("Ceramic or Clay", "Wood Shingles", "Metal", "Slate",
                                   "Composition", "Asphalt", "Concrete", "Other")

# convert YEARMAGERANGE to factor and label the corresponding year name
# remember to combine year 2000-2004 (7) and year 2005 - 2009 (8)
working_data$decade = as.factor(working_data$YEARMADERANGE)
levels(working_data$decade) = c("pre1950", "1950s", "1960s", "1970s", "1980s", "1990s",
                                "2000s", "2000s")

# compute the weighted sum in each decade
decade_total = working_data %>% group_by(decade) %>% summarise(decade_total=sum(NWEIGHT))
```

```
# proportion of different roof types in each decade
decade_proportion = working_data %>% group_by(roof_type, decade) %>%
                                summarise(weight_counts=sum(NWEIGHT)) %>%
                                left_join(decade_total, by="decade") %>%
                                mutate(proportion=weight_counts/decade_total*100) %>%
                                select(decade, roof_type, proportion) %>%
                                spread(decade, proportion)

# relative change
relative_change = decade_proportion$`2000s` / decade_proportion$`1950s`
max_relative_change = which.max(relative_change)
answer = sprintf("The roof type with the largest relative rise is %s,
                  with relative change %3.1f.",
            levels(working_data$roof_type)[max_relative_change],
            max(relative_change)
            )

# table formatting
tab = decade_proportion %>%
  ungroup() %>%
  rename('Roof Type'=roof_type) %>%
  mutate('Relative Change'=relative_change) %>%
  arrange(desc(`Relative Change`))

knitr::kable(tab,
             digits=1, caption="Propotion of roof types by decades")
```

Table 2: Propotion of roof types by decades

Roof Type	pre1950	1950s	1960s	1970s	1980s	1990s	2000s	Relative Change
Ceramic or Clay	1.2	1.1	2.0	3.2	5.0	6.6	5.7	5.5
Concrete	0.4	0.8	0.7	1.3	1.4	1.9	3.0	3.5
Composition	54.0	61.2	58.9	56.0	52.1	55.9	64.1	1.0
Metal	6.9	4.5	6.3	13.1	13.8	11.6	4.5	1.0
Wood Shingles	5.8	8.0	8.2	6.3	8.4	6.1	6.4	0.8
Asphalt	26.7	21.4	21.2	17.7	17.4	16.3	15.5	0.7
Slate	2.7	1.6	1.3	0.8	1.2	1.0	0.4	0.3
Other	2.4	1.4	1.3	1.7	0.7	0.6	0.4	0.3

The roof type with the largest relative rise is Ceramic or Clay, with relative change 5.5. A graphical illustration is shown below:

```
rel_order = levels(decade_proportion$roof_type[order(relative_change)])
figure_data = working_data %>%
  group_by(roof_type, decade) %>%
  summarise(weight_counts=sum(NWEIGHT)) %>%
  left_join(decade_total, by="decade") %>%
  mutate(proportion=weight_counts/decade_total*100) %>%
  filter(decade=="1950s" | decade=="2000s" ) %>%
  ungroup() %>% rename(Decade=decade) %>%
  mutate(roof_type = factor(roof_type,rel_order))

ggplot(figure_data, aes(roof_type, proportion)) +
```

```
  geom_bar(aes(fill=Decade), stat="identity", position="dodge") +
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  xlab('Relative Change, 1950s to 2000s') +
  ylab('% roofs')
```