National Basketball Association (NBA) and 3-pointers

Final Project, DECS-922: *Data Exploration*, Winter 2019

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## Warning: package 'reticulate' was built under R version 3.5.3
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1 Introduction

In the 2018-2019 NBA season, we saw many new 3 pointers records. For example, Klay Thompson from Golden State Warriors, made 14 3-pointers in Chicago last October. (link) James Harden, Houston's top 3-point shooter, recorded 2nd longest 30-point games streak, 32 games, in last Feb., which is the first record change after 1962. (link) Also, Klay Thompson succeeded 10 consecutive 3-pointers in last Jan. (link) Thus, we would like to answer questions on the historical development, correlation with other factors such as team's standing, player's age, other shoots, and others.

1.1 Methodology

To acquire detailed historical data, we used nbastatR package. (link) This is a well-made open-source package that has several functions to get the NBA data. We found that not all the functions are working and some of them are duplicates. However, it was successful to find the fundamental data to research on 3-pointers.

For additional data such as histrical standings and salary information, that are not included in nbastatR package, we downloaded CSV files from Basketball-Reference.com (link)

The data from nbastatR (`dataGameLogsPlayer` & `dataGameLogsTeam`) contain all the variables available so we trimmed the data by selecting relevant variables for analysis of each question.

1.2 Questions

1.2.1 It seems that players are getting better at making 3-pointers than 10 or 20 years ago (both on average and also top 3-pointer shooters vs. top 3-pointer shooters) Is it true?

1.2.2 Teams with more 3-pointers tend to be the better performing teams?

1.2.3 Are there any relationship between players' ages and 3-pointers?

1.2.4 Players who are good at 3-pointers are also good at 2-pointers or free throws?

1.2.5 Players with high salaries are good at 3-pointers?

1.2.6 We want to analyze whether players can drastically improve their three point shooting skills over time or the skill is rather something people are born with.

1.2.7 Show the 3-pointer statistics geographically based on players' hometowns. Maybe this help illustrates the different basketball playing style across different regions, both domestic and international.

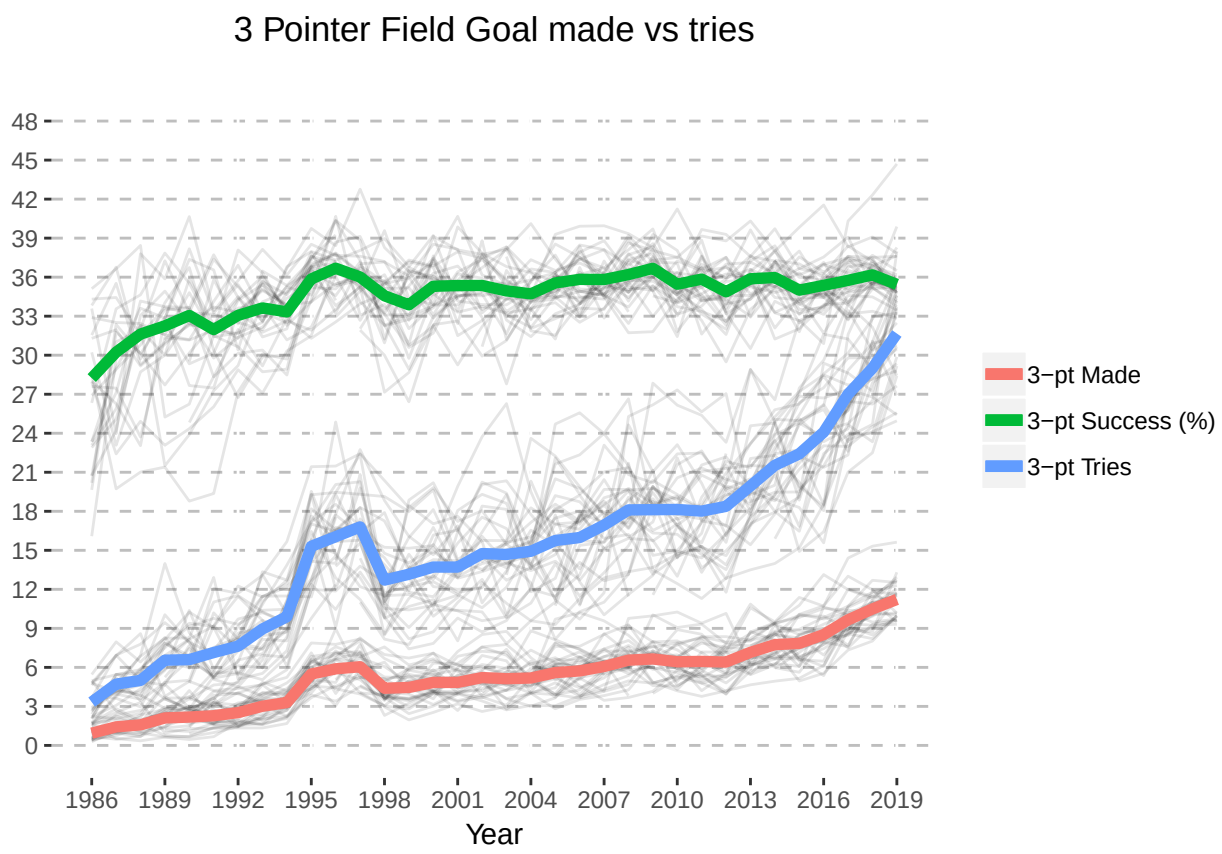
1.2.8 We would like to explore the importance of three point shooters in a given team by measuring the share of the team's total salary over time.

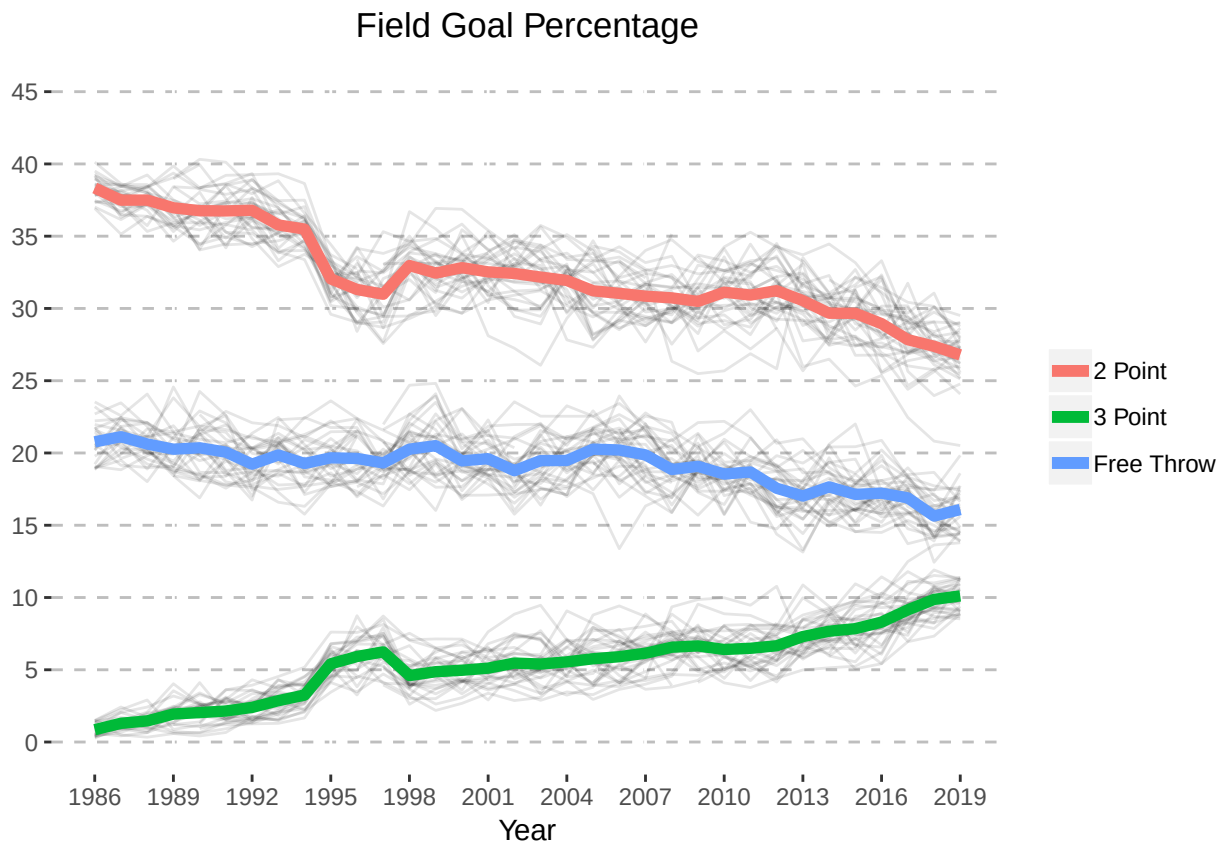
1.2.9 What are the expected average points of 3-pointers and 2-pointers?

1.2.10 If the expected average point from 3-pointers is getting higher than that of 2-pointers, how should each team's strategy chang?

2 Team level questions

- **Q1. It seems that players are getting better at making 3-pointers than 20 years ago (both on average and also top 3-pointer shooters vs. top 3-pointer shooters) Is it true?**

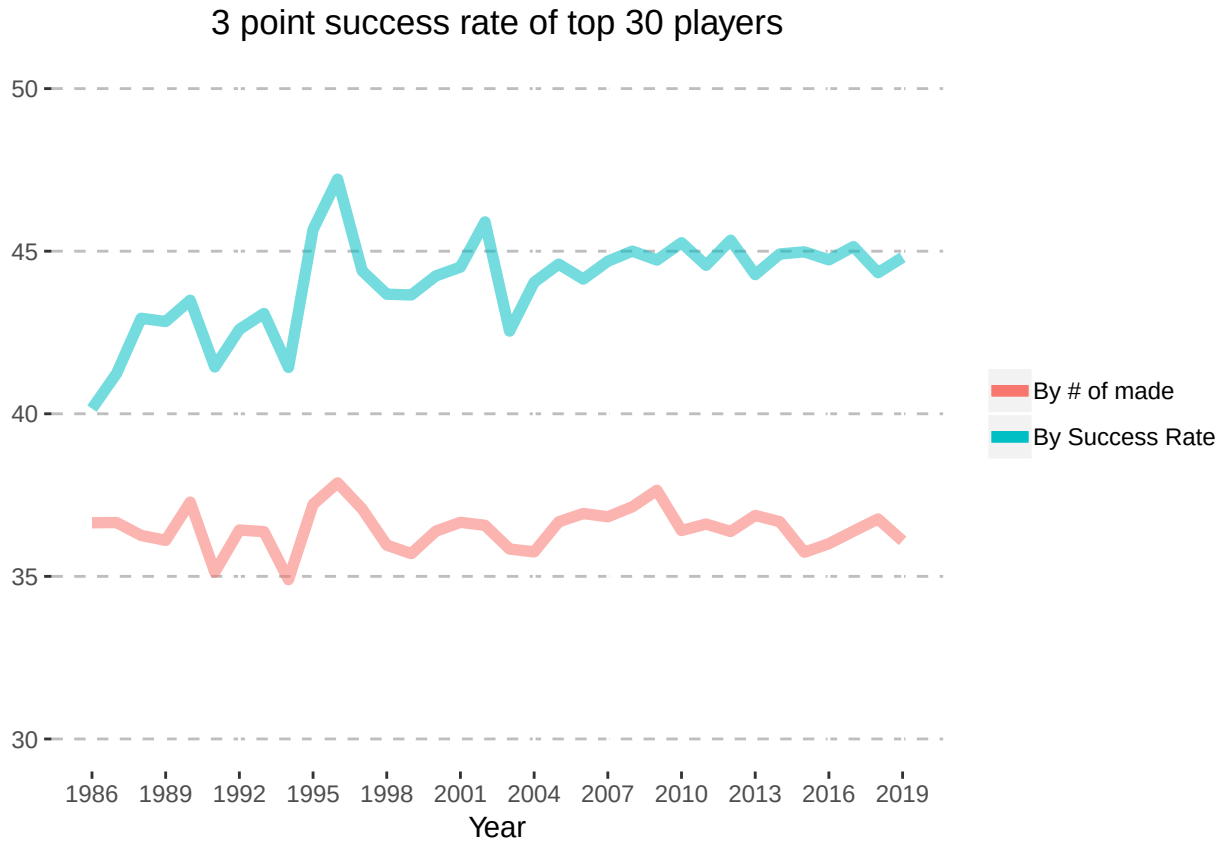




Statistics of top 10 3-point shooters each year

```
      Year         Player               fgm             fga
 Min.   :1986   Length:14714       Min.   :   0   Min.   :   0
 1st Qu.:1995   Class :character   1st Qu.:  49   1st Qu.: 115
 Median :2004   Mode  :character   Median : 154   Median : 345
 Mean   :2004                      Mean   : 200   Mean   : 437
 3rd Qu.:2012                      3rd Qu.: 308   3rd Qu.: 670
 Max.   :2019                      Max.   :1098   Max.   :2279
                                                  NA's   :9
      fg3m          fg3a            ftm             fta          pctfg3
 Min.   :  0   Min.   :  0.0   Min.   :  0   Min.   :  0   Min.   :  0.0
 1st Qu.:  0   1st Qu.:  2.0   1st Qu.: 20   1st Qu.: 29   1st Qu.: 16.0
 Median :  5   Median : 21.0   Median : 64   Median : 88   Median : 30.9
 Mean   : 29   Mean   : 82.2   Mean   :101   Mean   :134   Mean   : 26.3
 3rd Qu.: 44   3rd Qu.:128.0   3rd Qu.:145   3rd Qu.:194   3rd Qu.: 36.8
 Max.   :402   Max.   :886.0   Max.   :833   Max.   :972   Max.   :100.0
 NA's   :15    NA's   :16                    NA's   :9     NA's   :2300
     pctfg2          pctft
 Min.   :  0.0   Min.   :  0.0
 1st Qu.: 40.3   1st Qu.: 66.6
 Median : 44.3   Median : 75.0
 Mean   : 44.0   Mean   : 72.4
 3rd Qu.: 48.5   3rd Qu.: 81.4
 Max.   :100.0   Max.   :100.0
 NA's   :63      NA's   :470
# A tibble: 340 x 12
# Groups:   Year [34]
    Year Player   fgm   fga  fg3m  fg3a   ftm   fta pctfg3 pctfg2 pctft
   <int> <chr>  <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>  <dbl>  <dbl> <dbl>
 1  1986 Craig~   284   568    73   161    75    86   45.3   50    87.2
 2  1986 Trent~   349   739    41    91    79   100   45.1   47.2  79
 3  1986 Larry~   796  1606    82   194   441   492   42.3   49.6  89.6
```

```
 4  1986 World~   652  1428    71   169   379   486   42.0   45.7  78.0
 5  1986 Kyle ~   286   592    58   140    73    90   41.4   48.3  81.1
 6  1986 Micha~   274   606    63   163   147   170   38.7   45.2  86.5
 7  1986 Leon ~   184   463    41   112   123   155   36.6   39.7  79.4
 8  1986 Dale ~   193   470    63   174    59    82   36.2   41.1  72.0
 9  1986 Mike ~   252   544    41   114    42    64   36.0   46.3  65.6
10  1986 Brad ~   267   502    32    89   198   228   36.0   53.2  86.8
# ... with 330 more rows, and 1 more variable: Rank <int>
# A tibble: 4,651 x 12
# Groups:   Year [34]
    Year Player   fgm   fga  fg3m  fg3a   ftm   fta pctfg3 pctfg2 pctft
   <int> <chr>  <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>  <dbl>  <dbl> <dbl>
 1  1986 Larry~   796  1606    82   194   441   492   42.3   49.6  89.6
 2  1986 Craig~   284   568    73   161    75    86   45.3   50    87.2
 3  1986 World~   652  1428    71   169   379   486   42.0   45.7  78.0
 4  1986 Dale ~   193   470    63   174    59    82   36.2   41.1  72.0
 5  1986 Micha~   274   606    63   163   147   170   38.7   45.2  86.5
 6  1986 Kyle ~   286   592    58   140    73    90   41.4   48.3  81.1
 7  1986 John ~   365   818    45   146   231   297   30.8   44.6  77.8
 8  1986 Norm ~   403   921    42   121   131   162   34.7   43.8  80.9
 9  1986 Leon ~   184   463    41   112   123   155   36.6   39.7  79.4
10  1986 Mike ~   252   544    41   114    42    64   36.0   46.3  65.6
# ... with 4,641 more rows, and 1 more variable: Rank <int>
```



Yes, the success rate of 3-point field goal has been increased by about 9% since 1986.

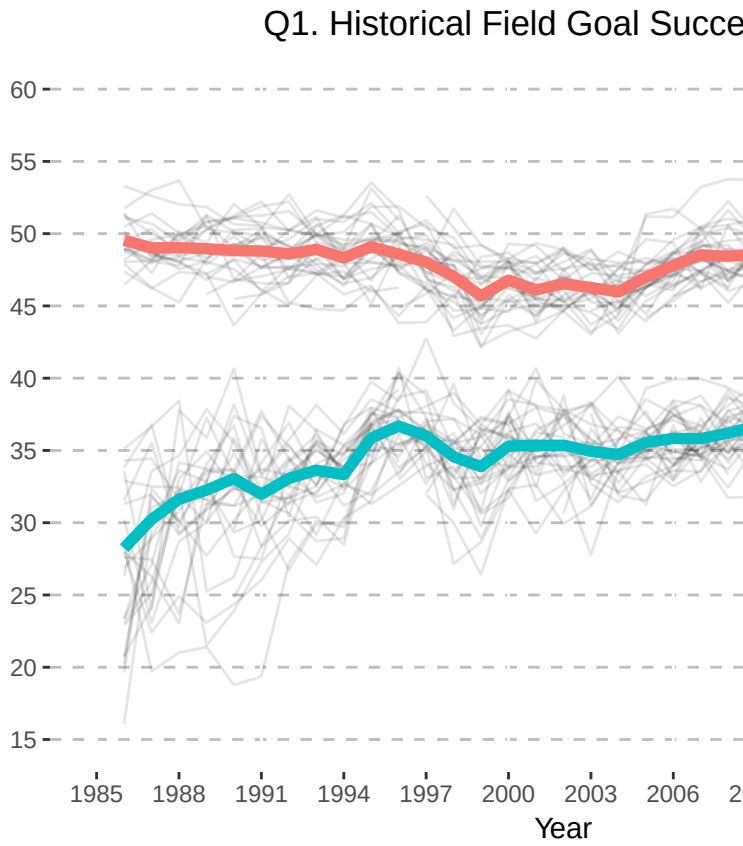
- **Q2. If true, what could be the reasons for that?**
  - What are the expected average points of 3-pointers and 2-pointers? Show the historical data.
  - If the expected average point from 3-pointers is getting higher than that of 2-pointers, how should each team's strategy changes

https://www.nytimes.com/2016/01/21/sports/basketball/how-the-nba-3-point-shot-went-from-gimmick-to-game-changer.html

Its debut, in the 1979-80 season, was inauspicious.

There are many reasons for the rise of the 3-point shot, but one may simply be math. It took a while, but coaches finally stopped listening to the traditionalist naysayers and realized that a shot that is worth 50 percent more pays off, even if that shot is a little harder to make.

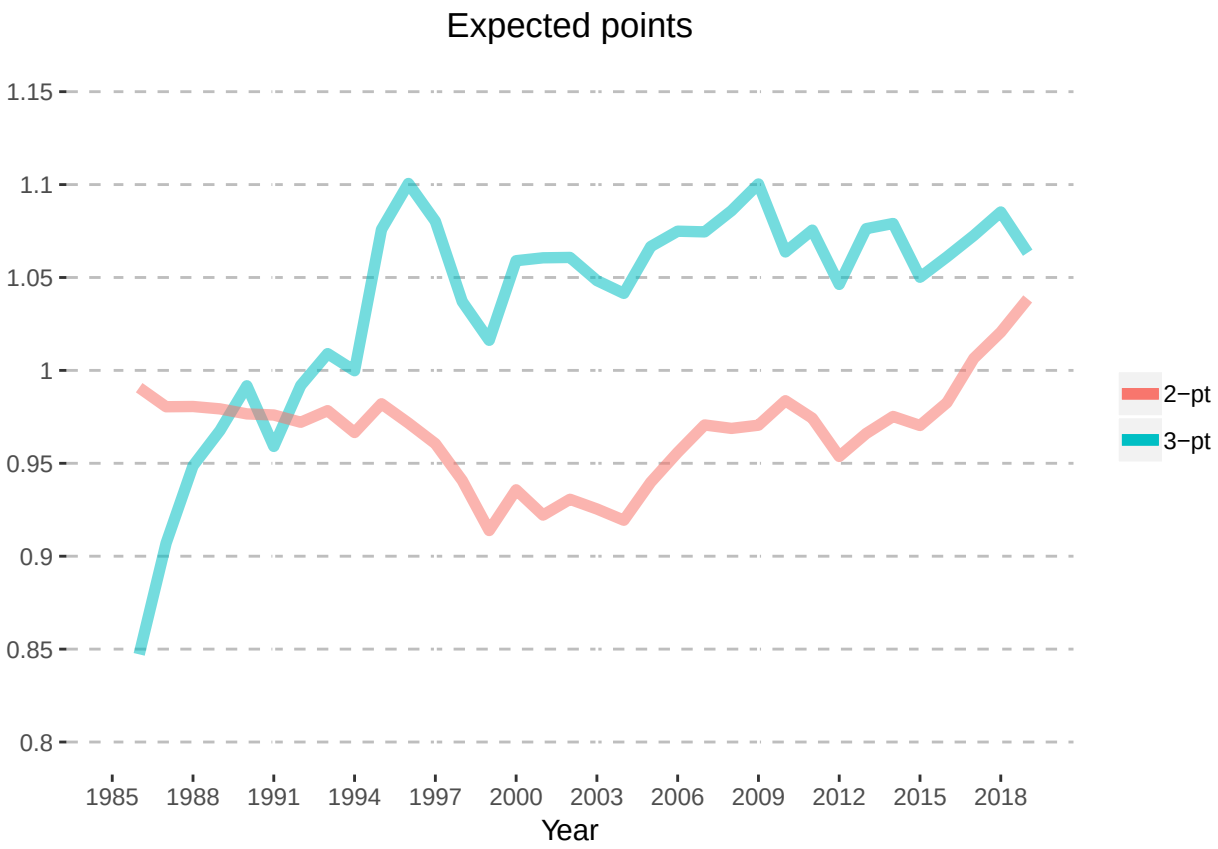
"Teams have all caught on to the whole points-per-possession argument," Lawrence Frank, the Nets' coach at the time, said in 2009 as the 3 rate began to rapidly increase.



The expected points of 2-point shots in 1986 was 'r fgyear$pctfg2[1986-1985]/100'*2 =' rfgyear$pctfg2[1986-1985]/100*2' *The expected points of 3-point shots in 1986 was 'r fgyearpctfg3*[1986 − 1985]/100′ ∗ 3 =′ *rfgyearpctfg3[1986-1985]/1003*'

The expected points of 2-point shots in 2019 was 'r fgyear$pctfg2[2019-1985]/100'*2 =' rfgyear$pctfg2[2019-1985]/100*2' *The expected points of 3-point shots in 2019 was 'r fgyearpctfg3*[2019 − 1985]/100′ ∗ 3 =′ *rfgyearpctfg3[2019-1985]/1003*'

Teams started to focus on 3-point shots after its first introduction in 1979, because the expected points of 3-point shots are higher than that of 2-point shots since early 90's.


Expected points
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
2015
2018
Year
2−pt
3−pt

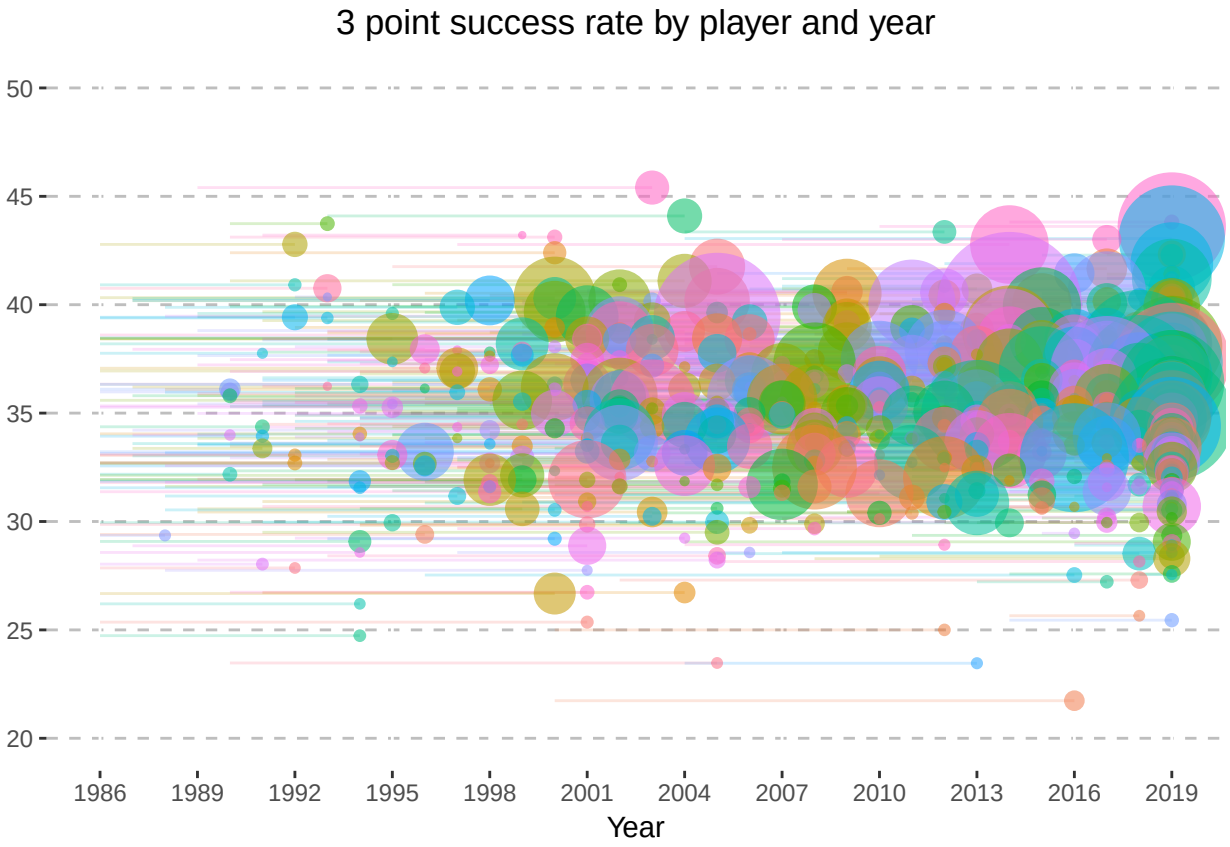
- **Q3. Teams with more 3-pointers tend to be the better performing teams?**
  - **Any insights between standings and 3-pointers?**

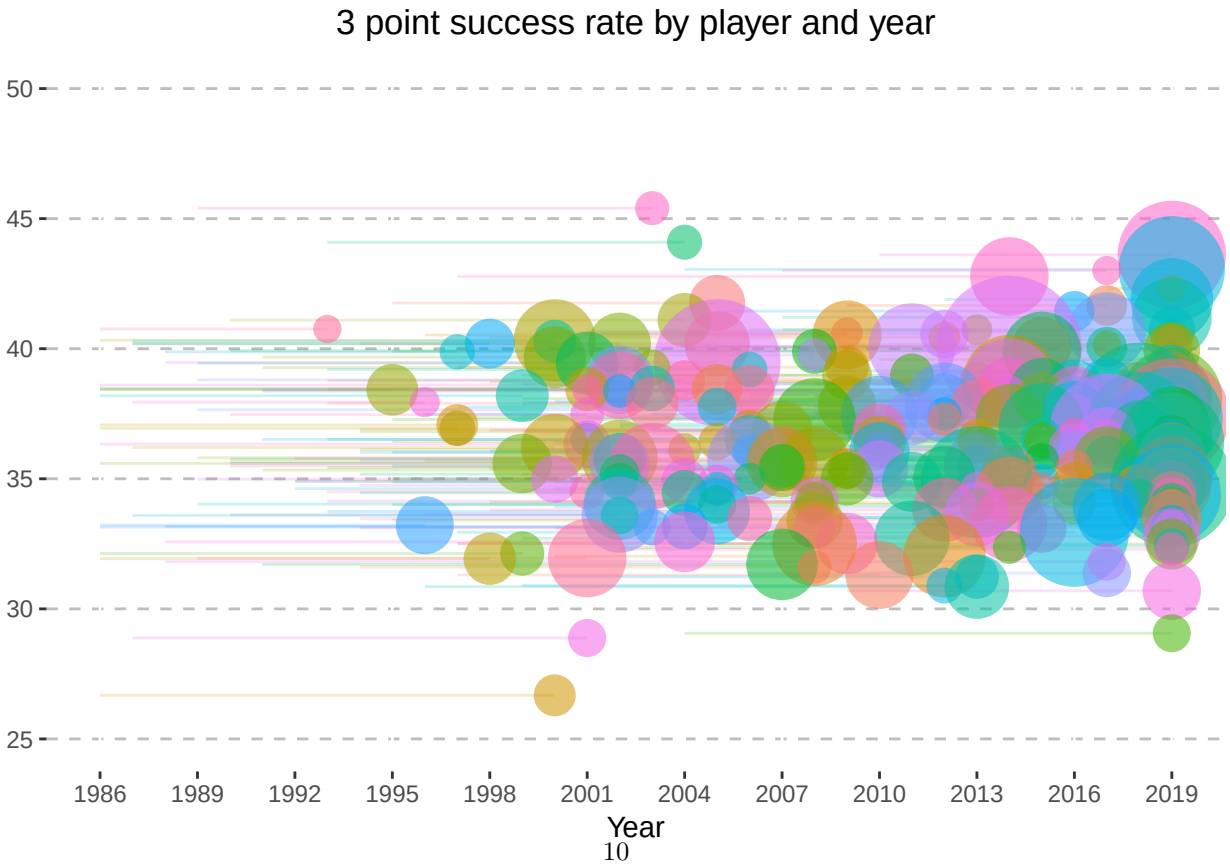
```
# A tibble: 2 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)   32.6      2.72       12.0  5.33e-31
2 pctfg3        -0.518    0.0787     -6.58 7.74e-11
# A tibble: 2 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)   107.       4.97       21.6 2.14e-84
2 pctfg2         -1.91     0.103     -18.6 3.69e-66
# A tibble: 3 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)  114.       5.15       22.1  9.52e-88
2 pctfg3        -0.305    0.0694     -4.40 1.23e- 5
3 pctfg2        -1.83     0.103     -17.7  4.80e-61
# A tibble: 2 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)   22.0      2.29        9.60 6.40e-21
2 pctfg2         0.257    0.0472      5.45 6.57e- 8
```

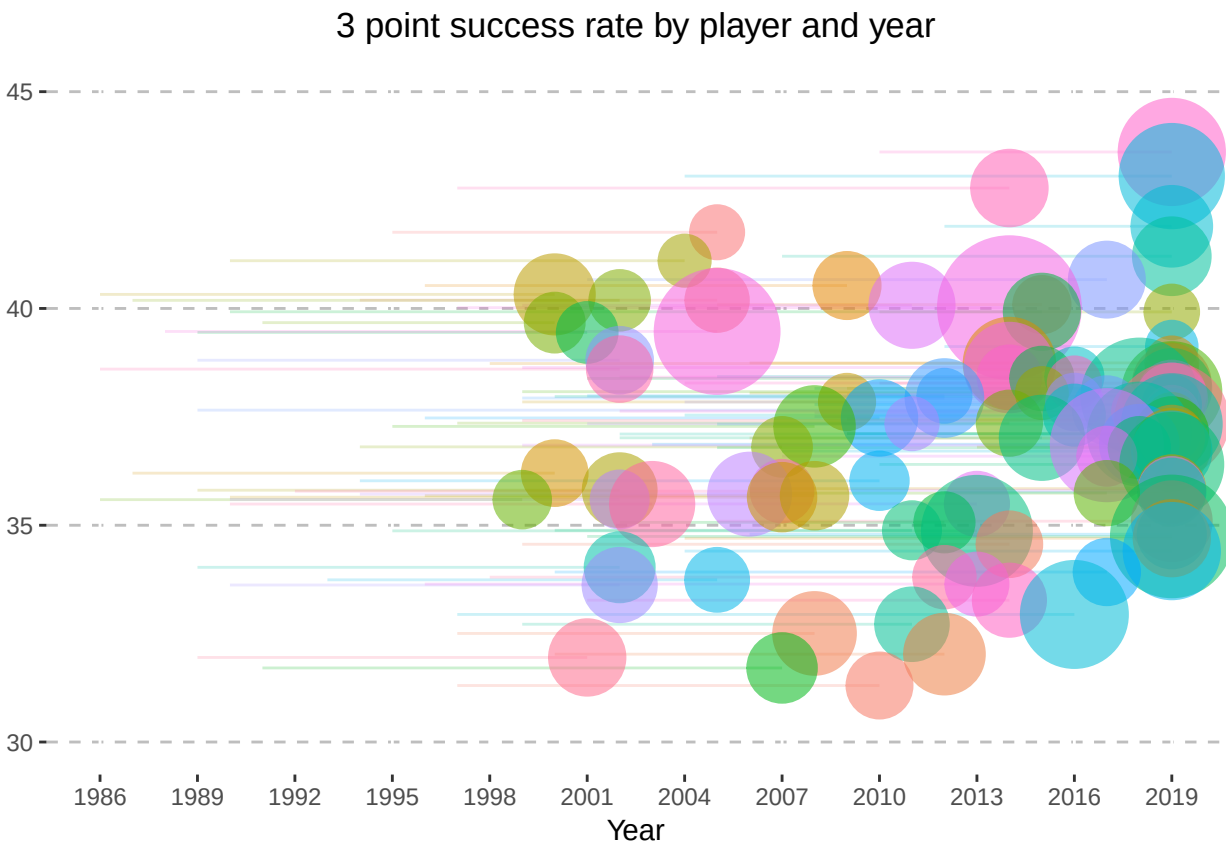
Yes. However, pctfg2 is more relevant than pctfg3

- Focus on three point shooting is a strategy that started fairly recently, we can create a map to show where this strategy initially emerged and how fast it spreaded across the entire country.

3 Player level questions







Above graph shows more players are trying 3 point shots than before. even though the average success rate is similar.

- **Q4. Players who are good at 3-pointers are also good at 2-pointers or free throws?**

By regression.

Players who are good at free throws tend to be good at 3-pointers. However, 2-point field goal success rate is not related with 3-point field goal success rate!!! Why?

```
# A tibble: 2 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)  33.7       1.75      19.2   2.81e-67
2 pctfg2        0.0330    0.0400     0.823 4.11e- 1
# A tibble: 2 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)  184.     19.6          9.41 6.19e-20
2 fgm            0.143   0.00618     23.1  2.24e-89
# A tibble: 2 x 5
  term        estimate std.error statistic   p.value
  <chr>          <dbl>     <dbl>     <dbl>     <dbl>
1 (Intercept)  404.     48.0          8.42 1.98e- 16
2 fga            0.197   0.00687     28.6  3.67e-122
# A tibble: 3 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)  276.      47.4         5.82 8.67e- 9
2 fga            0.347    0.0172     20.2  7.38e-73
3 fta           -0.455    0.0481     -9.47 3.52e-20
# A tibble: 2 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)   18.2      1.42        12.8 3.40e-34
2 pctft          0.216    0.0181      11.9 4.54e-30
# A tibble: 2 x 5
  term        estimate std.error statistic   p.value
  <chr>          <dbl>     <dbl>     <dbl>     <dbl>
1 (Intercept)  41.9       1.42       29.6  4.07e-128
2 pctft         0.0219    0.0180      1.21 2.25e-  1
# A tibble: 3 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)  17.7       2.10       8.42  1.86e-16
2 pctfg2        0.0136    0.0368     0.370 7.12e- 1
3 pctft         0.216     0.0182    11.9   6.51e-30
```

When we look at all the players, 2-pointers and 3-pointers are reverse-related. Maybe because of dunk shots?

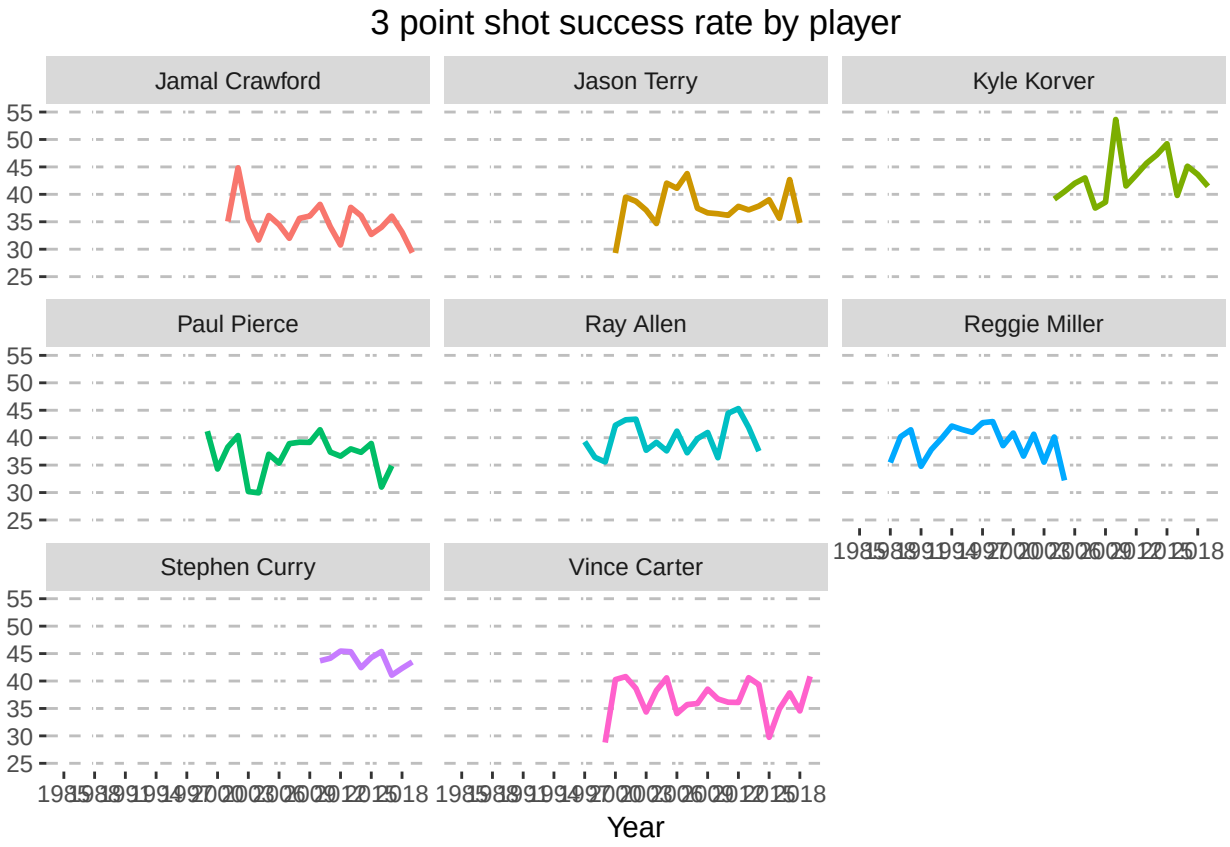
```
# A tibble: 3 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)   3.65      2.52        1.45 1.48e- 1
2 pctfg2       -0.0441    0.0415     -1.06 2.88e- 1
3 pctft         0.329     0.0237     13.9  3.19e-42
```

Best players (more than 1,000 career 3-point field goals) are good at 2-pointers as well!!!

```
# A tibble: 3 x 5
  term        estimate std.error statistic       p.value
  <chr>          <dbl>     <dbl>     <dbl>         <dbl>
1 (Intercept)    3.76     4.06       0.926 0.356
2 pctfg2         0.345    0.0843     4.09  0.0000841
```

```
3 pctft          0.226    0.0344     6.58  0.00000000197
# A tibble: 3 x 5
  term        estimate std.error statistic p.value
  <chr>          <dbl>     <dbl>     <dbl>   <dbl>
1 (Intercept)  -21.5      20.1       -1.07   0.334
2 pctfg2         0.799     0.442      1.81   0.131
3 pctft          0.290     0.231      1.26   0.264
```

-. Are there any relationship between players' ages and 3-pointers? Both total and average.



Let's regress.

```
# A tibble: 2 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)  39.6       0.720      55.0  1.01e-95
2 career       -0.0994    0.0656     -1.51 1.32e- 1
# A tibble: 2 x 5
  term        estimate std.error statistic p.value
  <chr>          <dbl>     <dbl>     <dbl>   <dbl>
1 (Intercept)  35.4       0.281     126.    0
2 career        0.0730    0.0306      2.38  0.0173
# A tibble: 2 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)   31.7      0.208     153.    0.
```

```
2 career         0.186    0.0280      6.63 3.63e-11
# A tibble: 2 x 5
  term        estimate std.error statistic  p.value
  <chr>          <dbl>     <dbl>     <dbl>    <dbl>
1 (Intercept)   24.1      0.252      95.5 0.
2 career         0.414    0.0378     11.0 7.90e-28
```

Really good players are not related with ages/career. Average players' success rate is increased by 0.4% in one year. Not bad. . . ?

- Players with high salaries are good at 3-pointers?

2018-2019 season data only

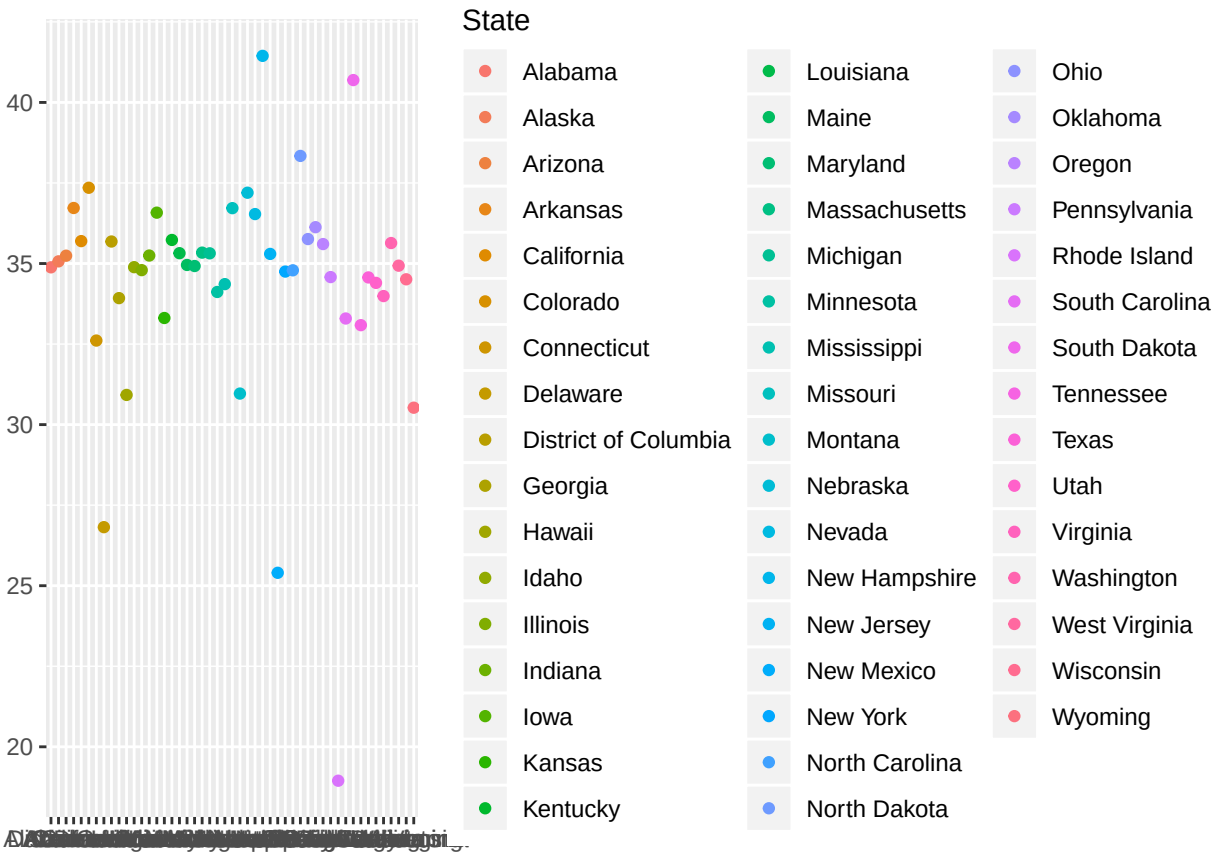
```
# A tibble: 2 x 5
  term        estimate std.error statistic p.value
  <chr>          <dbl>     <dbl>     <dbl>   <dbl>
1 (Intercept)    1.10     25.9      0.0426   0.966
2 pctfg3         0.580     0.690    0.841    0.403
# A tibble: 2 x 5
  term        estimate std.error statistic p.value
  <chr>          <dbl>     <dbl>     <dbl>   <dbl>
1 (Intercept) 16.1       5.69         2.83 0.00587
2 fg3m         0.00460   0.00374      1.23 0.223
```

When the salary increases by a million dollar, career success rate of 3-point shots increases by 0.09% only. It's difficult to say that 3-pointer success rate is the most important factor for one's salary.

- We would like to explore the importance of three point shooters in a given team by measuring the share of the team's total salary over time.
- We want to analyze whether players can drastically improve their three point shooting skills over time or the skill is rather something people are borned with.

There is no dramatic increase in 3-pointer success rate. Maybe if we can check the players' data from NCAA or high school league, there might be different insight. However, based on NBA data, no big changes.

- Show the 3-pointer statistics geographically based on players' hometowns. Maybe this help illustrates the different basketball playing style across different regions, both domestic and international.


40
35
30
25
20
State
Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Delaware
District of Columbia
Georgia
Hawaii
Idaho
Illinois
Indiana
Iowa
Kansas
Kentucky
Louisiana
Maine
Maryland
Massachusetts
Michigan
Minnesota
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
New Jersey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
Pennsylvania
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Utah
Virginia
Washington
West Virginia
Wisconsin
Wyoming