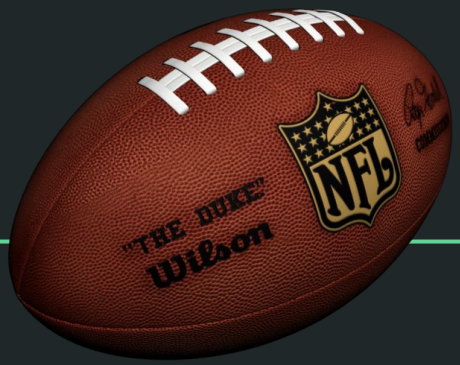
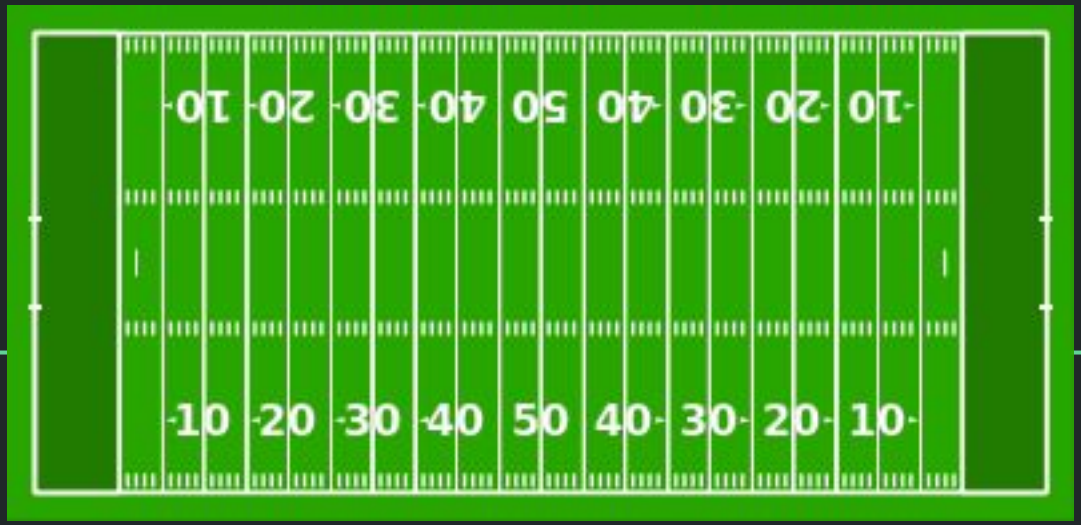
Optimal Run/Pass Ratio in the NFL





Bryce Grove, Ben Thorpe and Jack Lichtenstein
Duke University

Summary of data

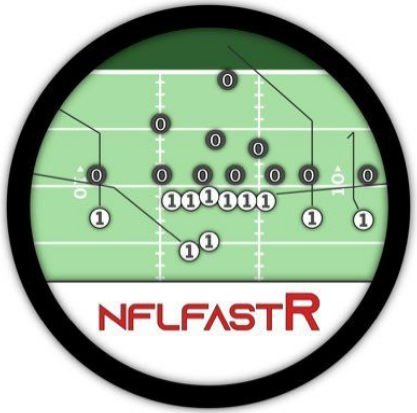
Pro Football Focus play-by-play data from 2014-2020 NFL seasons

Pro Football Focus team season grades data from 2014-2020 NFL seasons

➔ Join in play-by-play data from **nflfastR**
- Time outs remaining

nflfastR data allows us to:

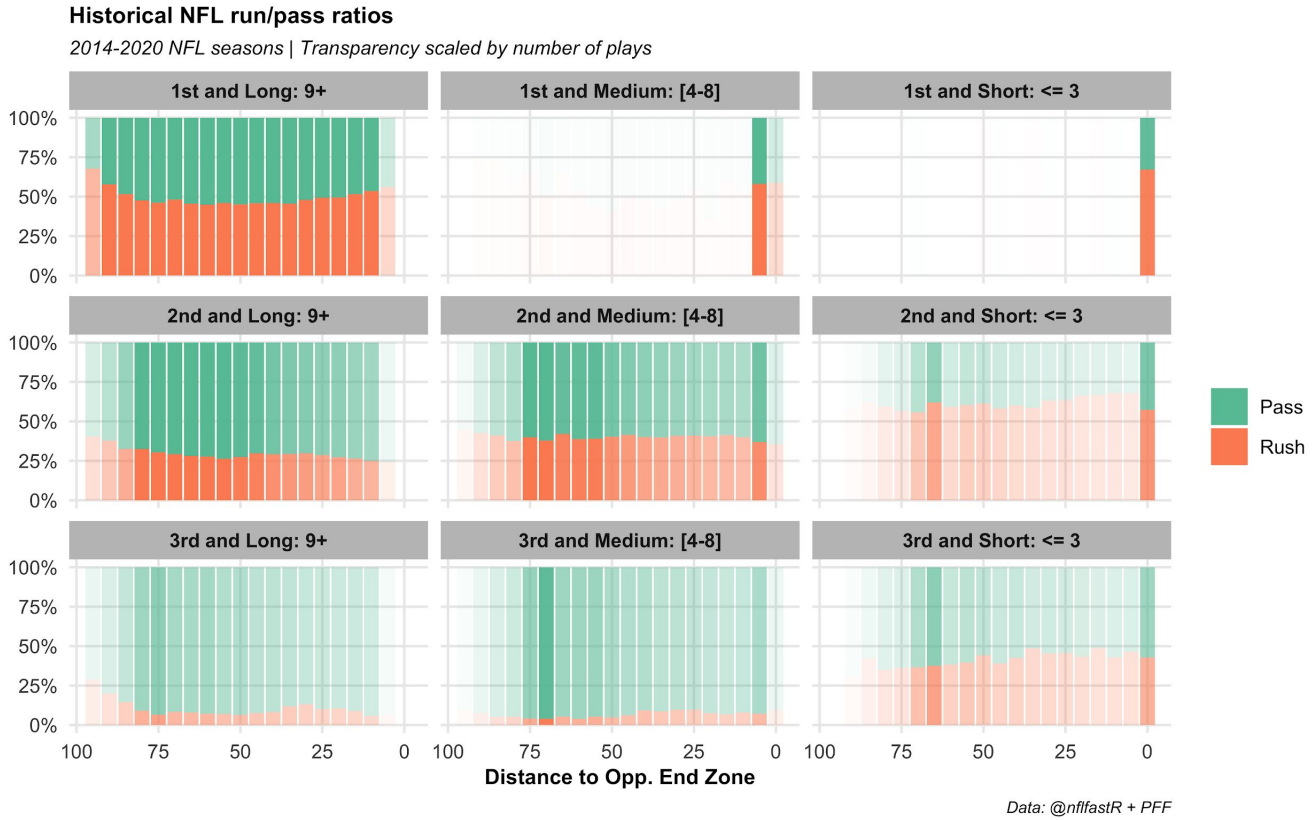
➔ Calculate **win probability**
➔ Calculate **expected pass percentage** given situation



Exploring historical run/pass ratios

NFL teams are historically **most run-heavy** on:

- ➔ 1st & 10
- ➔ 2nd & short
- ➔ 3rd & short

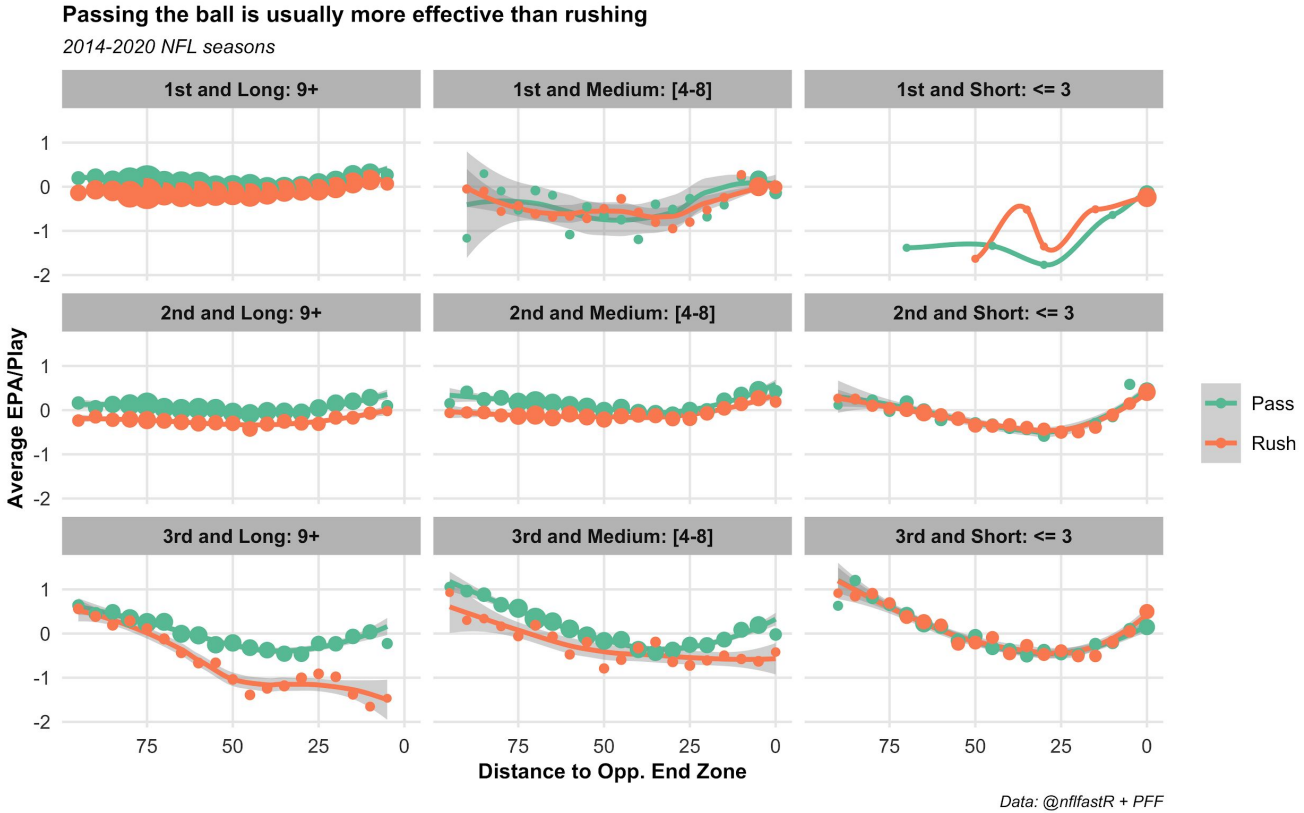


What play types are most effective and where?

Rushing the ball is only **efficient in short yardage** situations

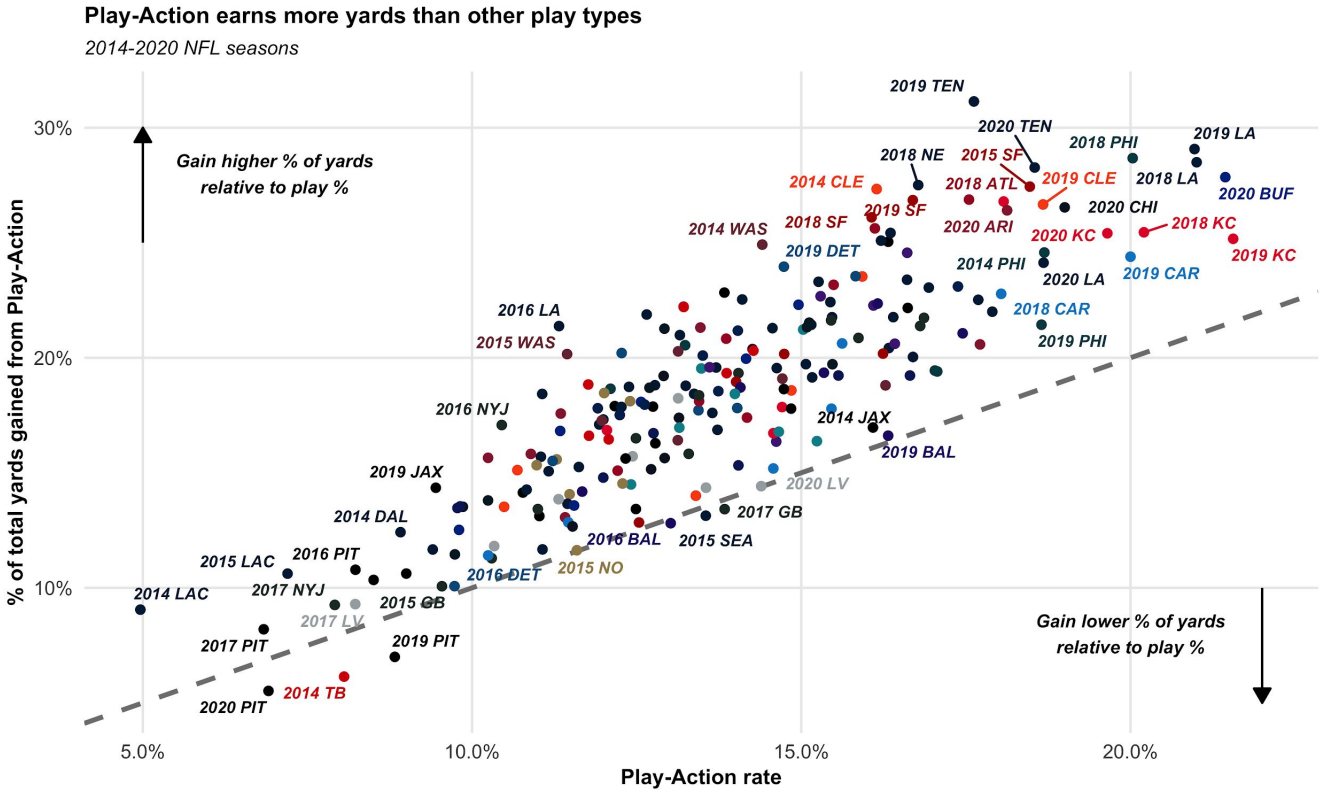
➔ 2nd & short

➔ 3rd & short



Play-action gains more yards than other plays

NFL teams gain **more yards on play-action** relative to how often they call it

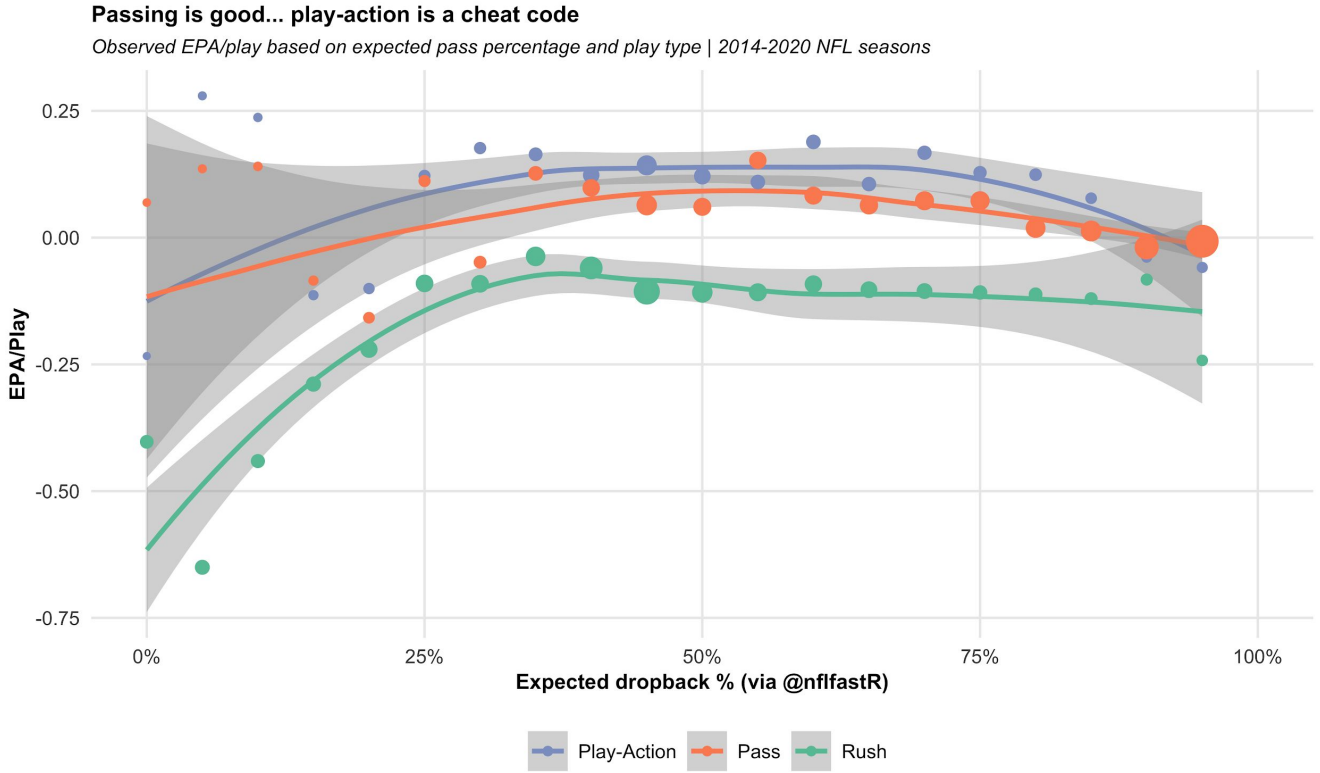


Data: @nflfastR + PFF

Play-action is good almost regardless of situation

Only when teams are **sure** an offense must pass is play-action inefficient

Running is **least** efficient when it is **expected**

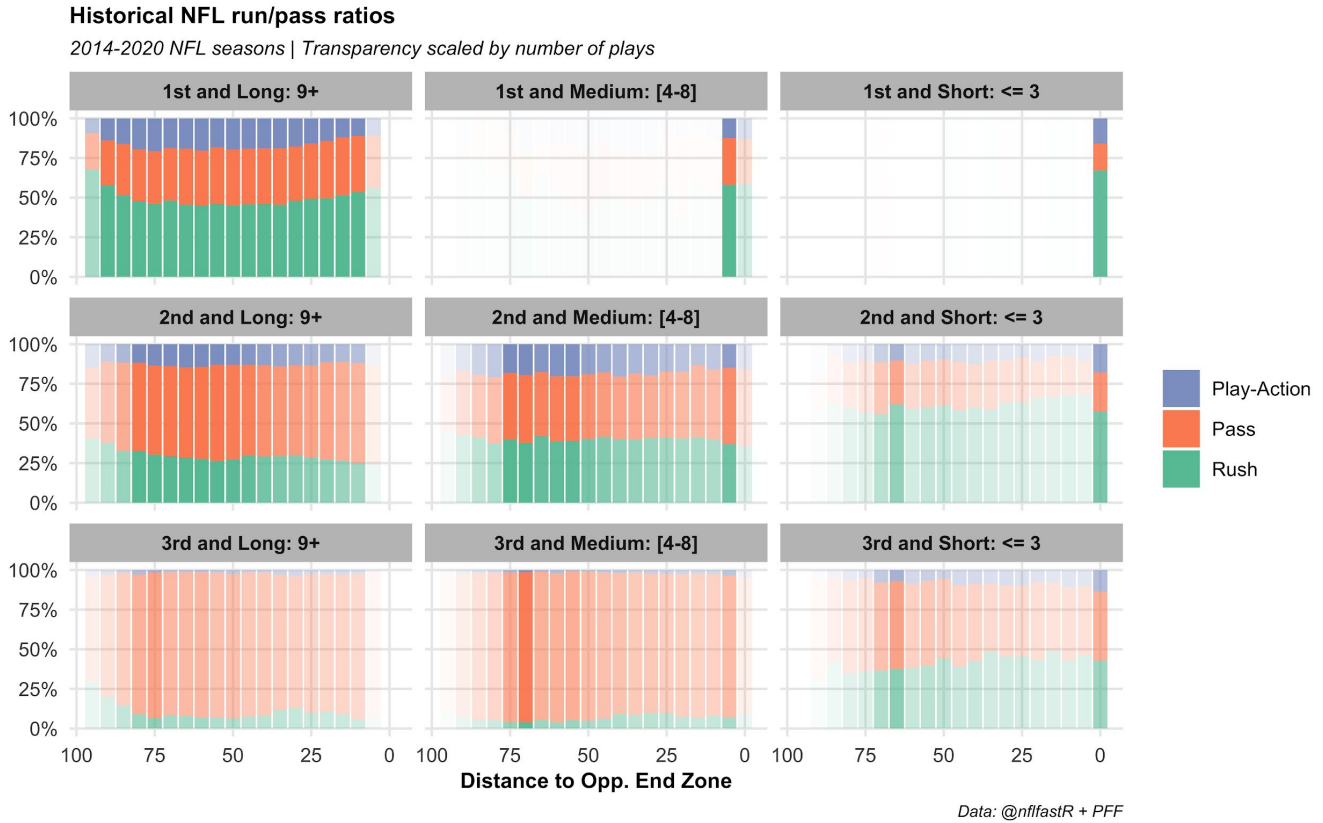


Data: @nflfastR + PFF

Exploring historical run/pass ratios with play-action

Teams run **play-action** on only **about 15%** of plays, despite its effectiveness

➔ Teams **rarely** run play-action on **3rd down**



Determining Optimal Run/Pass Ratios in the NFL

Methodology:

Train a model to **predict EPA/play** based on a number of features:

- ➔ PFF season grades for the offense and defense
- ➔ Game situation
  - ◆ Down
  - ◆ Yards to go for 1st down
  - ◆ Yardline
  - ◆ Game seconds remaining
  - ◆ Whether possession team is home
  - ◆ Whether the play is a run, pass or play-action pass
  - ◆ Expected dropback percentage
  - ◆ Win probability

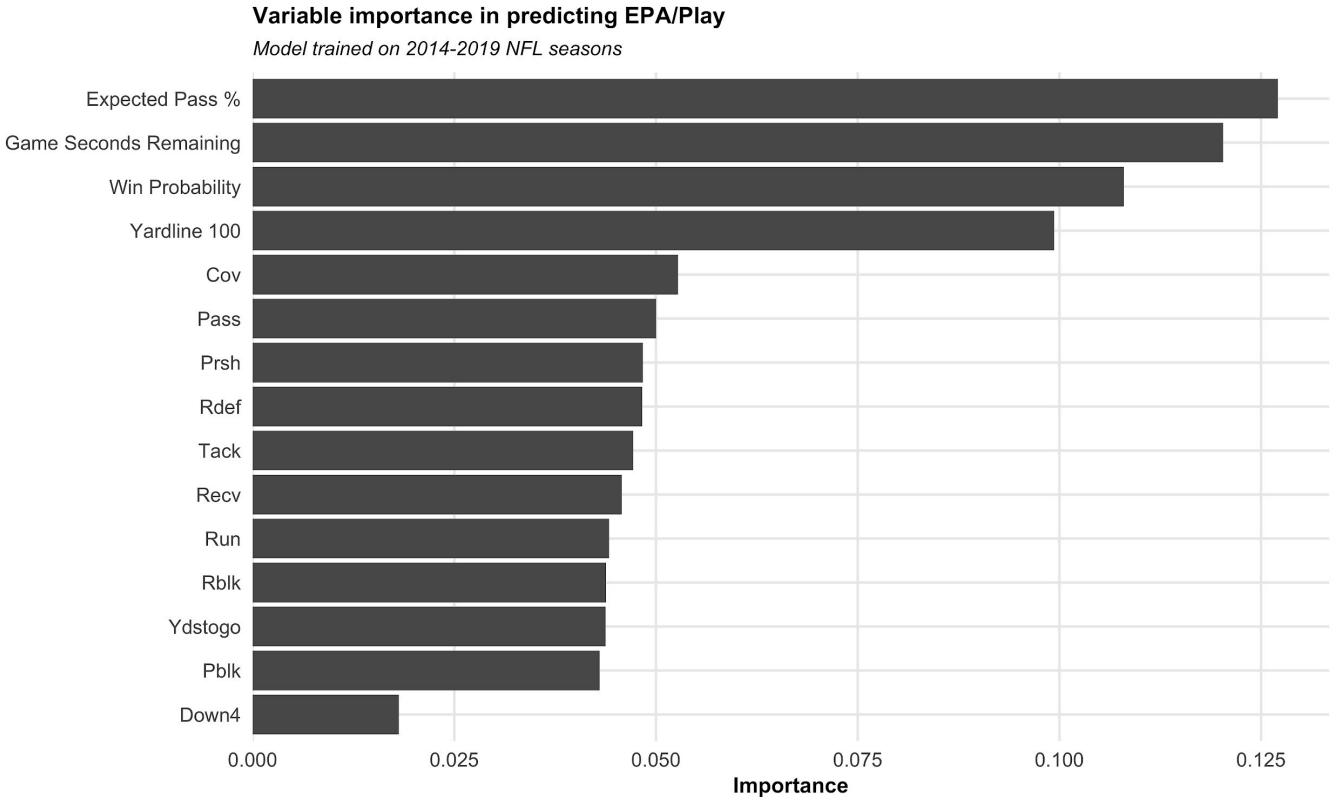
Simulate all combinations of game situations to determine optimal play types

Model variable importance

The **best predictors** of EPA/play have to do with the current **game situation**

➔ **PFF season grades** help explain EPA/play

Demonstrates the importance of **passing offense and defense**



Optimal NFL Run/Pass Ratios

Model trained on 2014-2019 NFL play-by-play data

DIST FROM ENDZONE		% OF PLAYS	RUN %	PASS %	% OF PASSES PA
Goal Line	0-9	6.2%	25.2%	74.8%	99.8%
Red Zone	10-19	7.2%	2.4%	97.6%	94.2%
Field Goal range	20-39	17.9%	11.5%	88.5%	98.9%
No man's land	40-75	56.1%	4.8%	95.2%	93.1%
Deep in own territory	>75	12.6%	1.1%	98.9%	76.6%

Data: @nflfastR + PFF

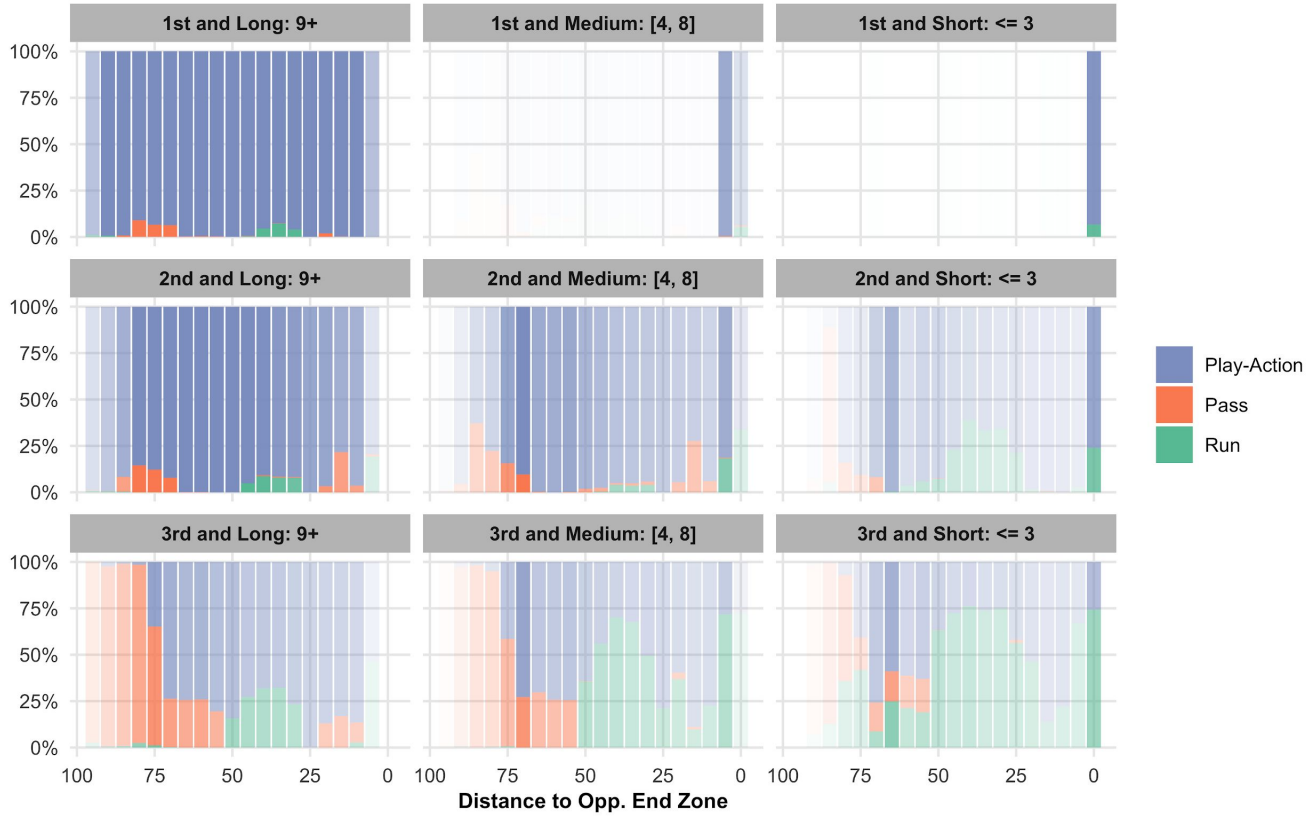
Simulation results

Rush the ball in **short yardage** situations

➔ 2nd & short
➔ 3rd & short

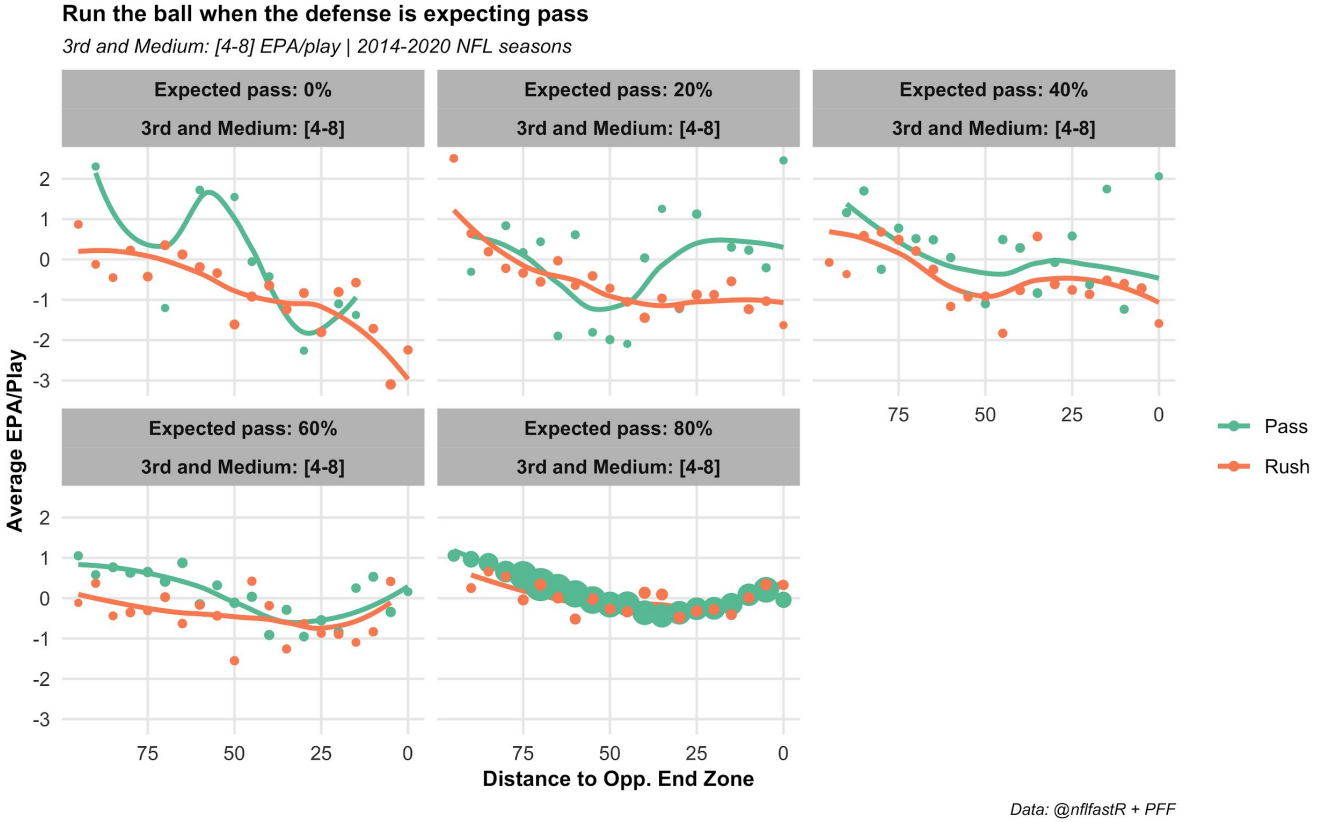
Play-action otherwise!

Surprise Finding:
Running is preferred on **3rd and medium and closer** while in **deep field goal range**



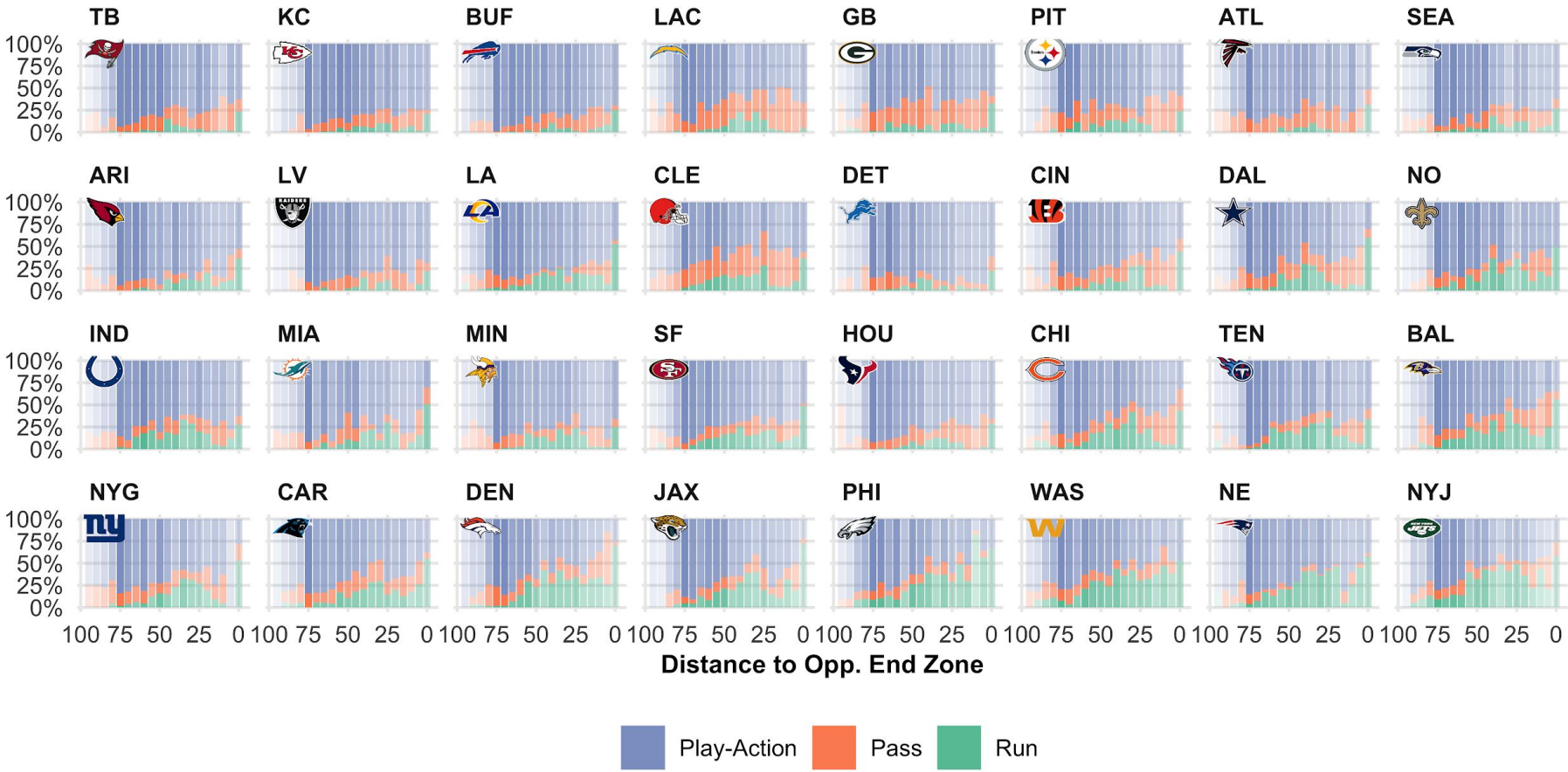
Looking at those 3rd and mediums...

Teams have had **success rushing** the ball in field goal range when a **defense is expecting pass**



Optimal run/pass ratios for each NFL team in 2020

Based on predicting EPA/play for run or pass | Transparency scaled by number of plays



Case study:

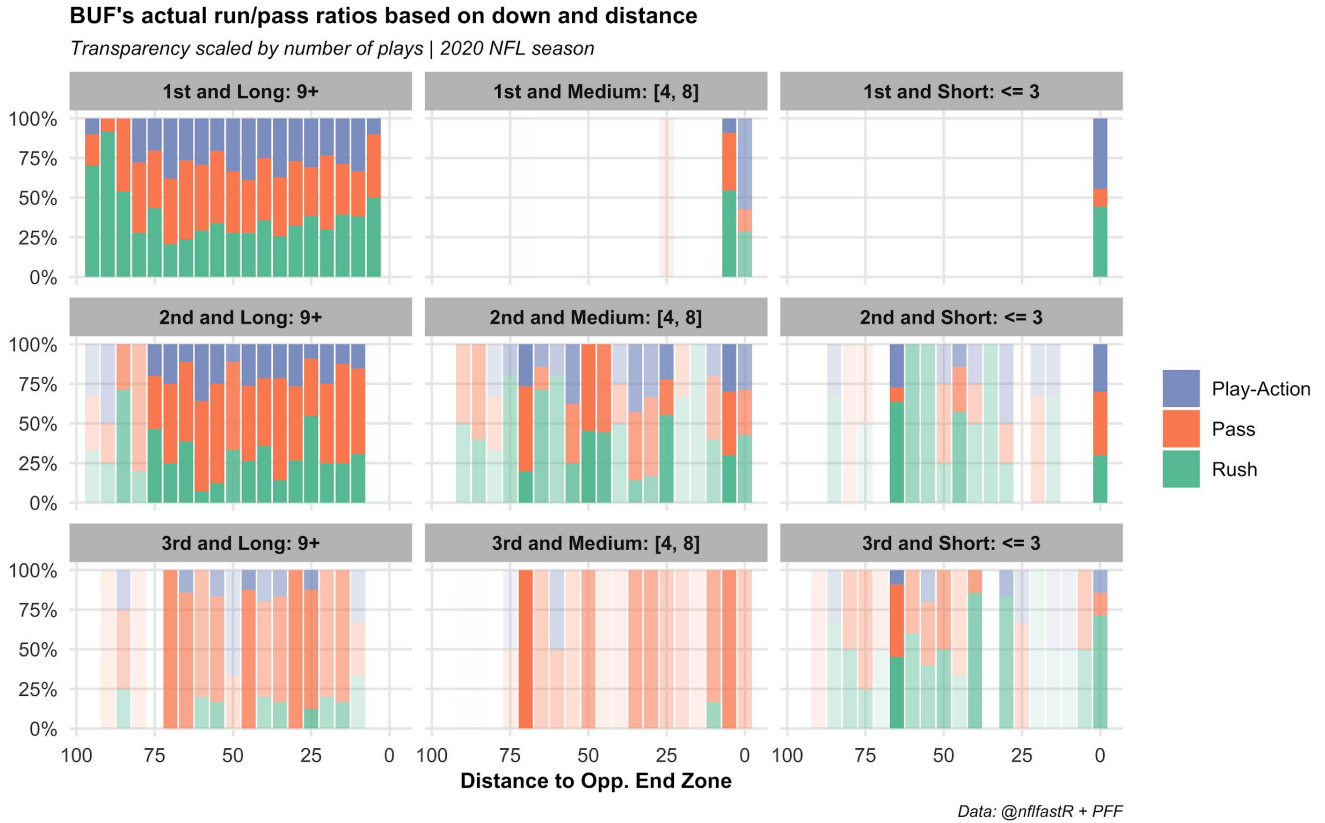
Buffalo Bills

Buffalo Bills actual run/pass ratio

Finished **13-3 and won** the AFC East

Ranked **5th in EPA/play** on offense according to PFF

Ranked **5th in PFF offensive grade** on the season

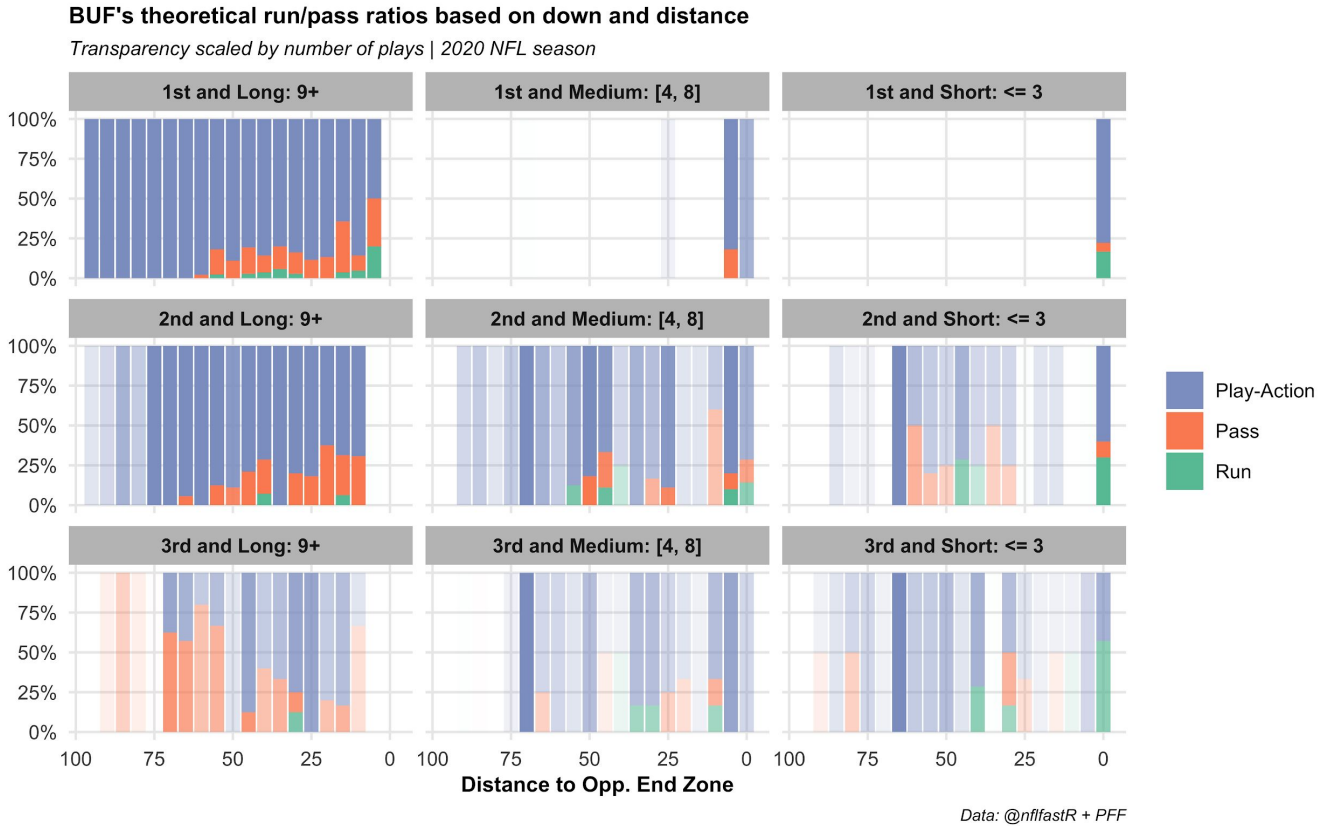


Buffalo Bills optimal run/pass ratio

Bills should have been the **3rd pass heaviest** team according to our model

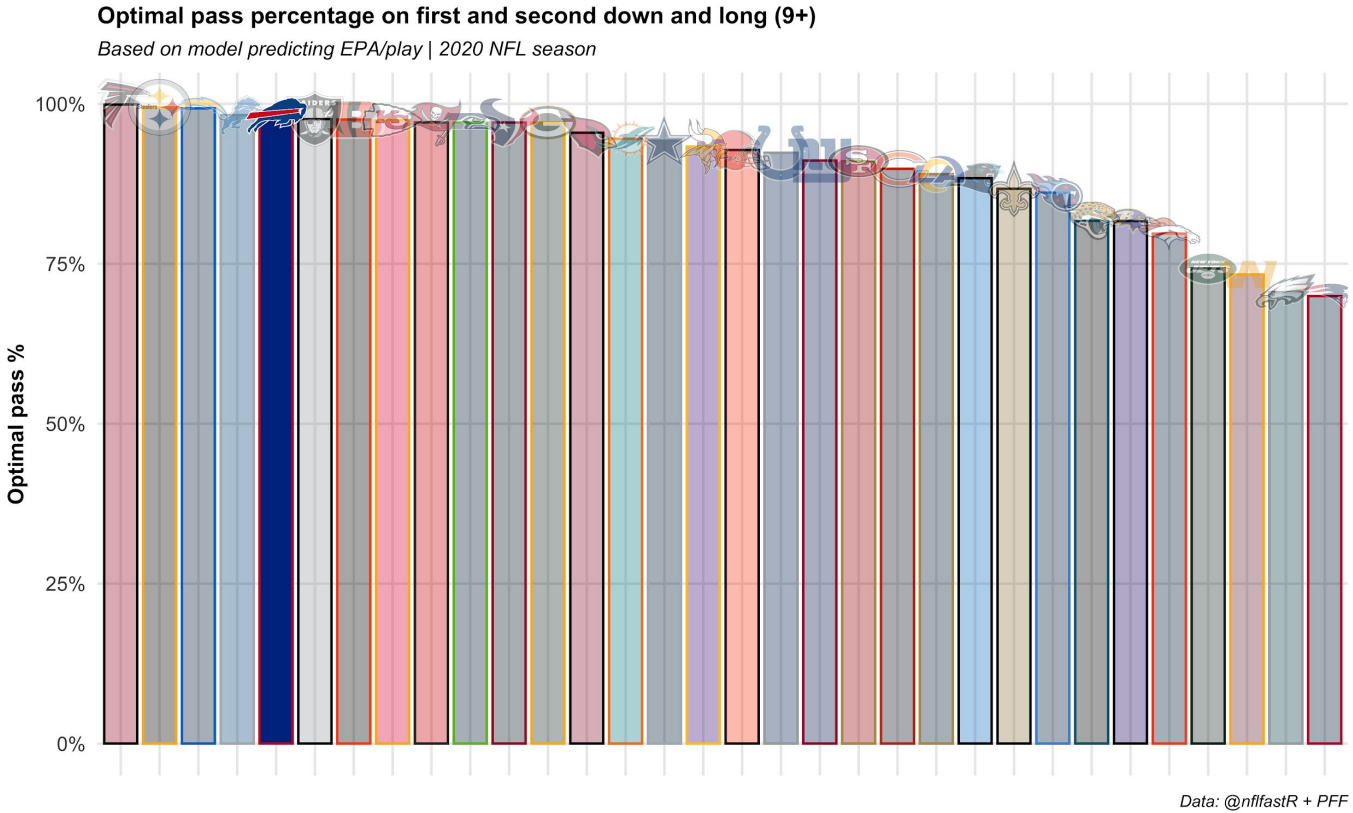
Ranked **6th** in PFF **passing** grade

Ranked **3rd** in PFF **receiving** grade



The Bills should have passed a lot

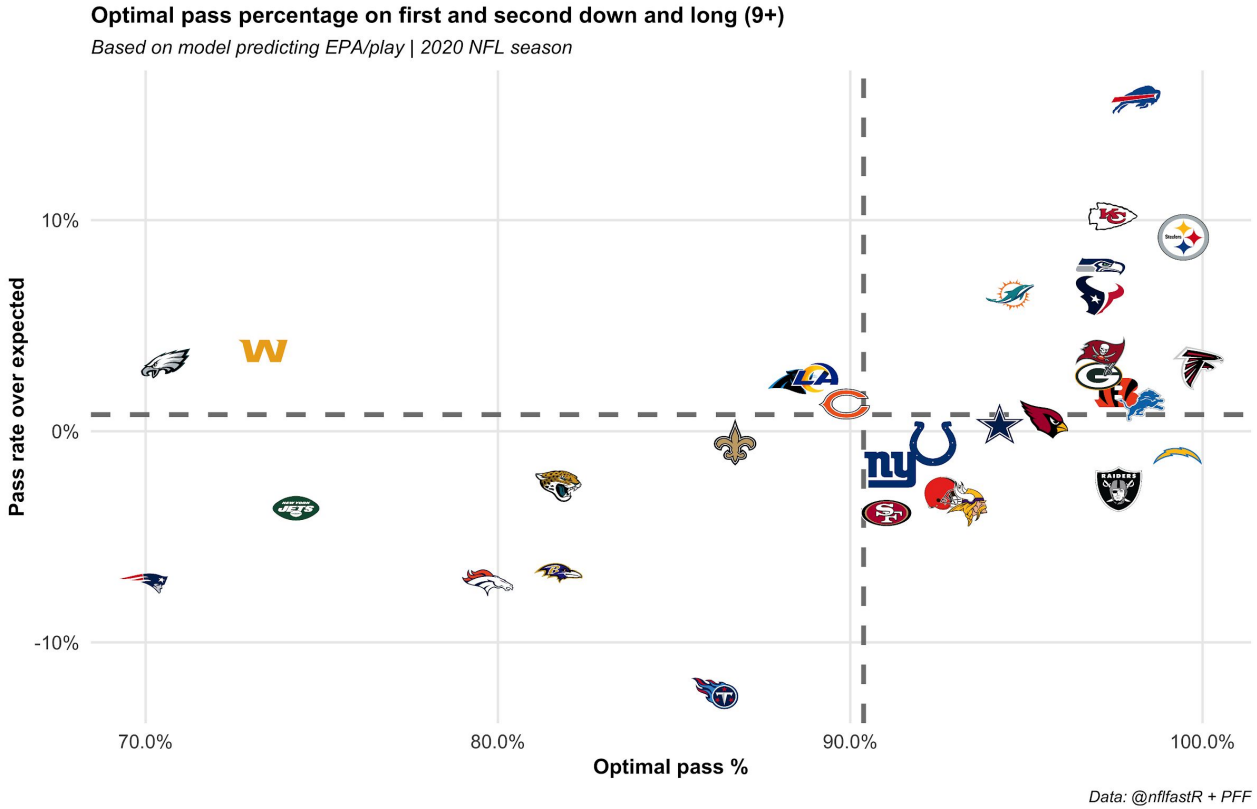
Our model suggests they should have been the **4th most pass heavy** of any team on early downs and 9+ yards to go



The Bills took advantage of their strong passing game

The Bills ranked **1st in pass rate over expectation** on **long early downs** according to @nflfastR

➔ Ranked **5th in EPA/play** in these situations

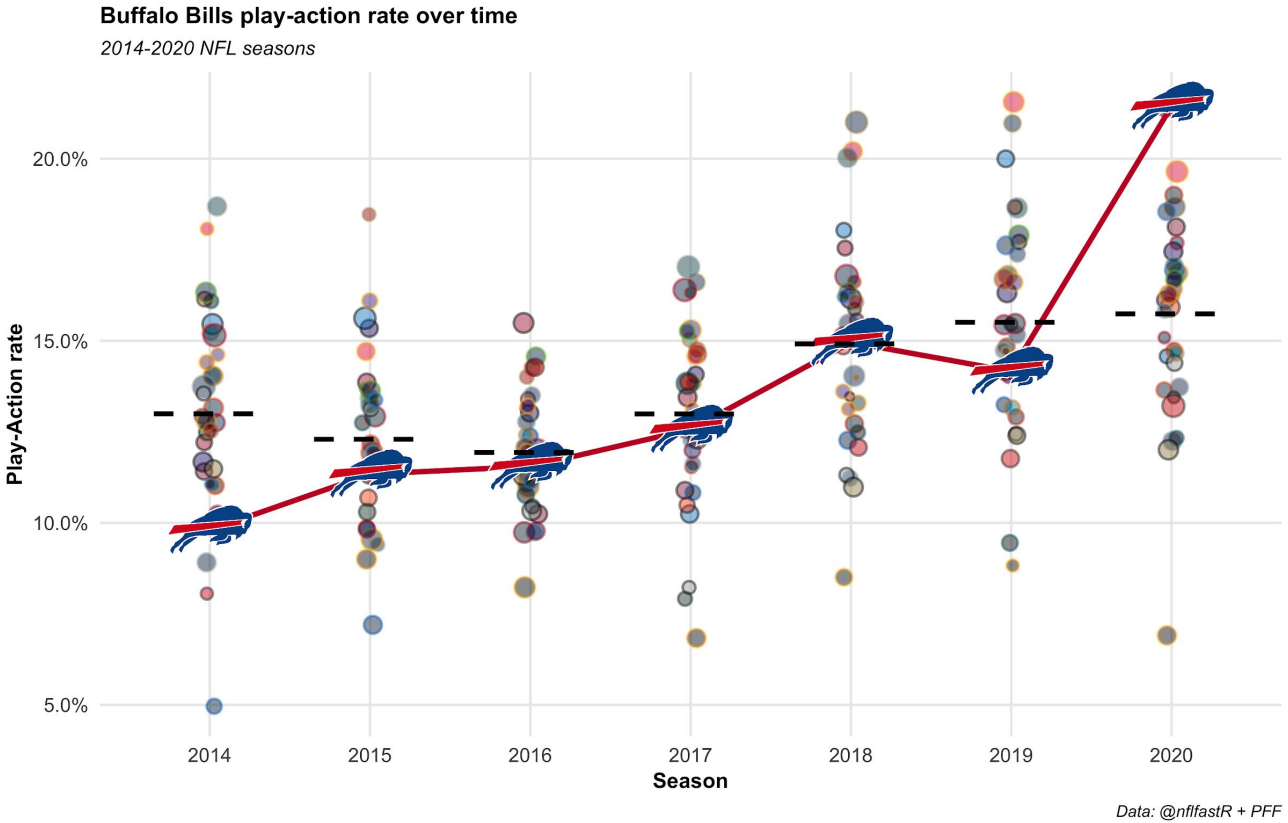


The Bills play-action rate spiked in 2020

Bills ranked **1st in play-action rate** according to PFF

➔ Ranked **22nd** in play-action rate in **2019**

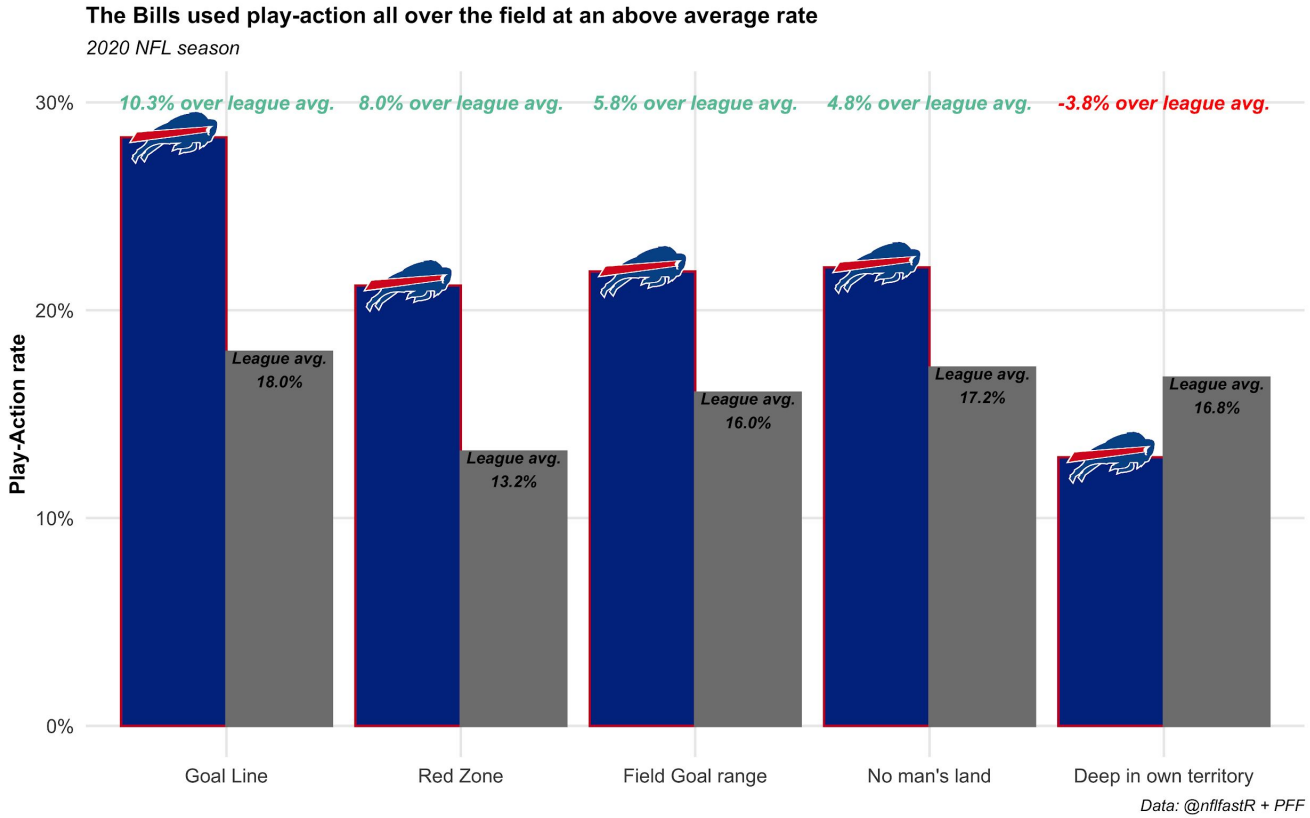
Jumped in EPA/play from 22nd in 2019 to 5th in 2020



The Bills understand that play-action works

Bills used **play-action** on all parts of the field

Ranked 1st in passing over expectation, yet still ranked **8th in EPA/play on play-action**



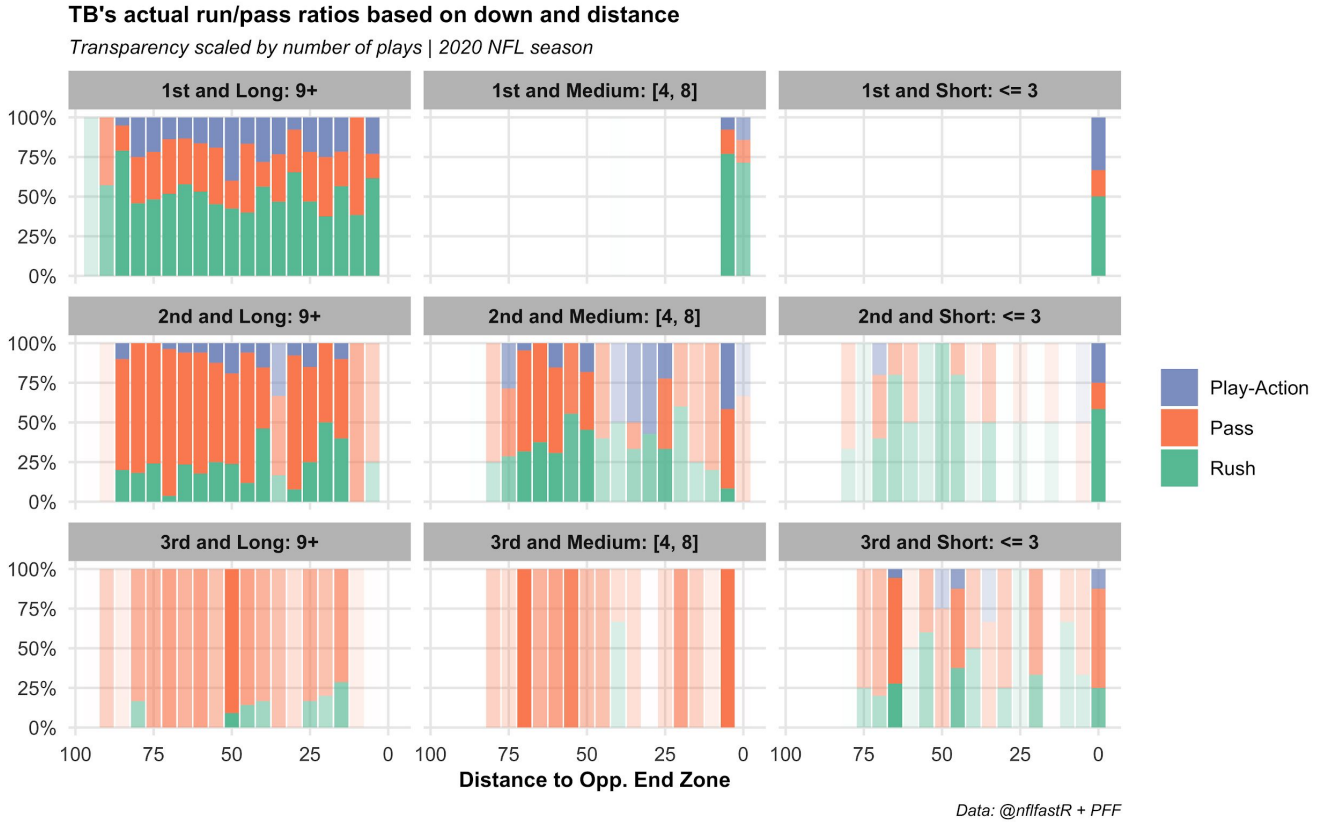
Case study:

Tampa Bay Buccaneers

Tampa Bay Buccaneers actual run/pass ratio

Finished **11-5 and won** the Super Bowl

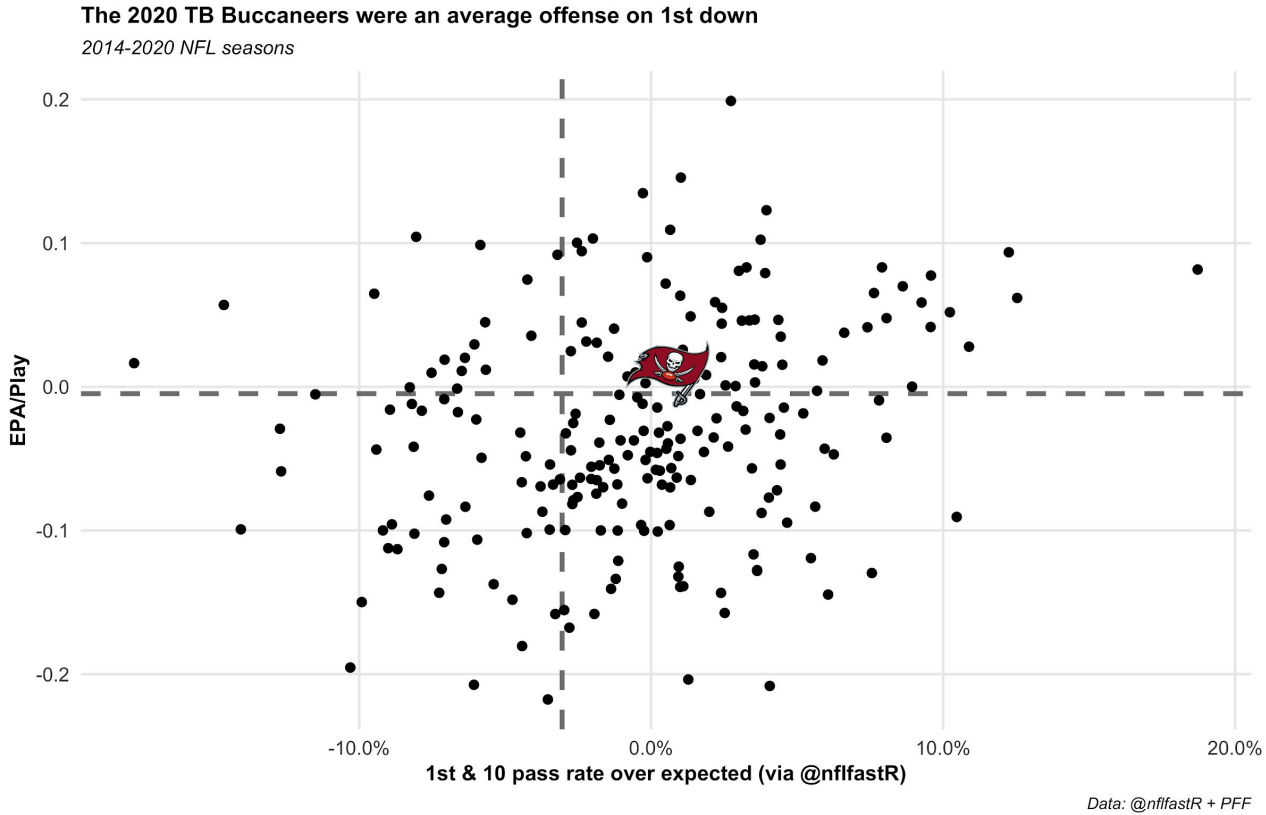
The Bucs **ran** the ball **a lot on 1st & 10** given their QB and receiving options



The Bucs hindered themselves by running on 1st down

The Bucs **ranked 4th** in overall PFF **EPA/play**

➔ They ranked just **13th** in EPA/play on **first downs**

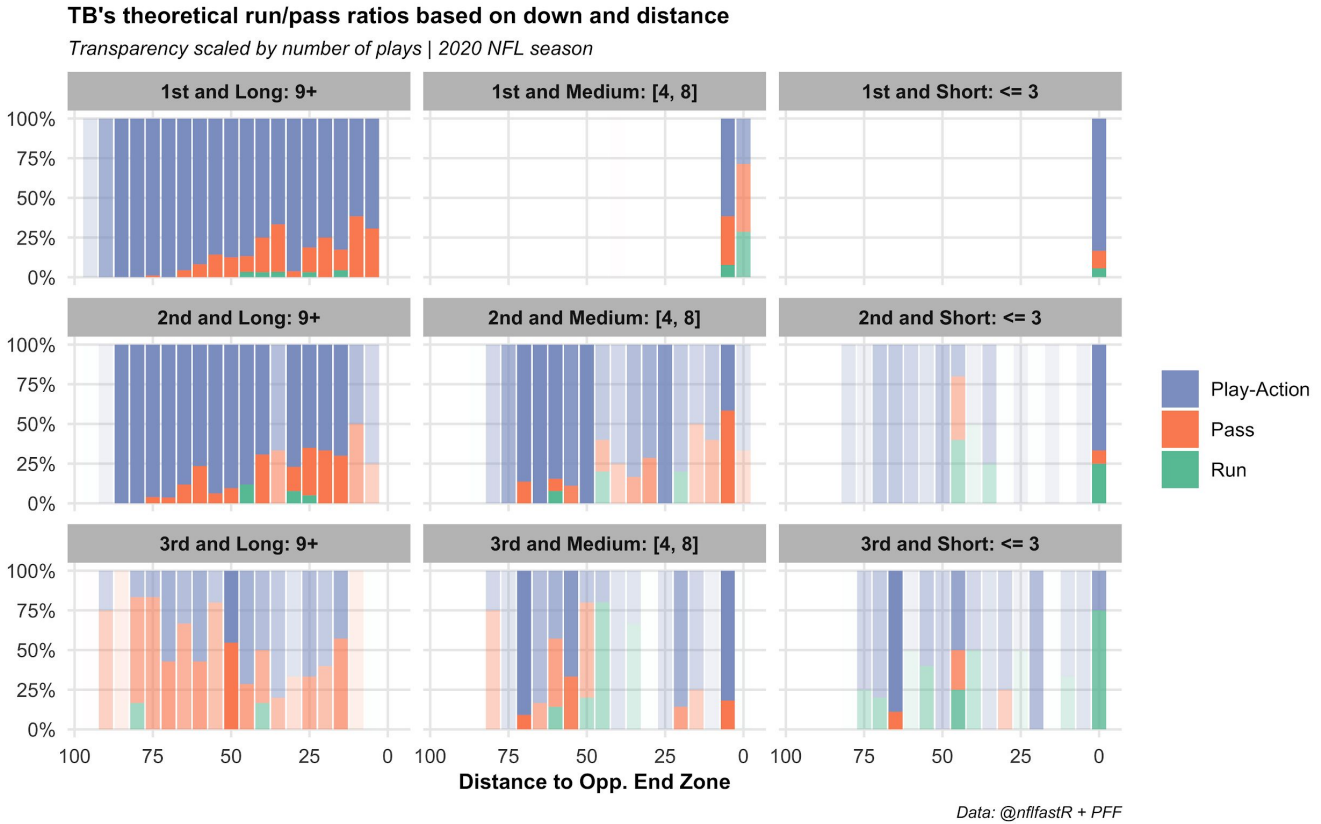


Tampa Bay Buccaneers optimal run/pass ratio

Our model suggests the Bucs should have been the **most pass heavy** of any team

Ranked **2nd** in PFF **passing** grade

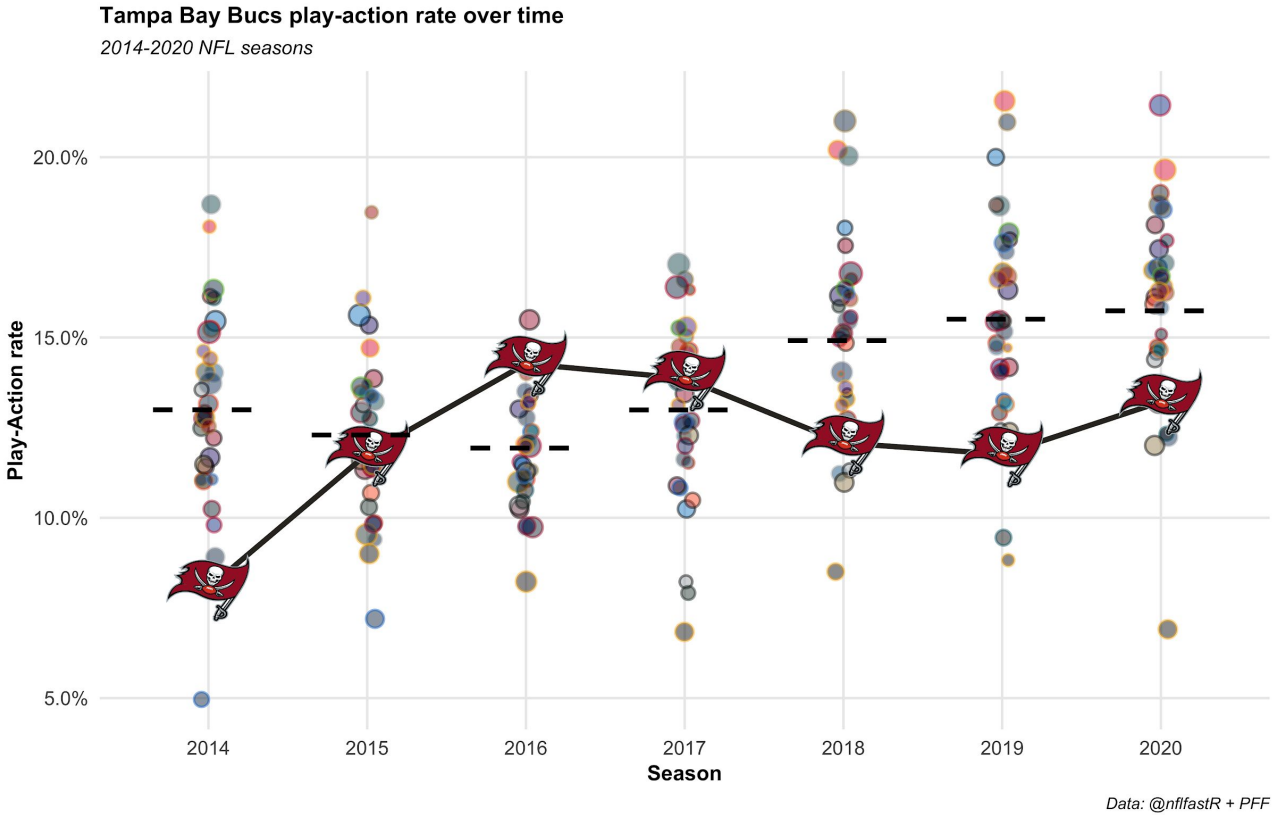
Ranked **7th** in PFF **receiving** grade



The Bucs do not run play-action enough

The Bucs had a **bottom 5 play-action rate** this season

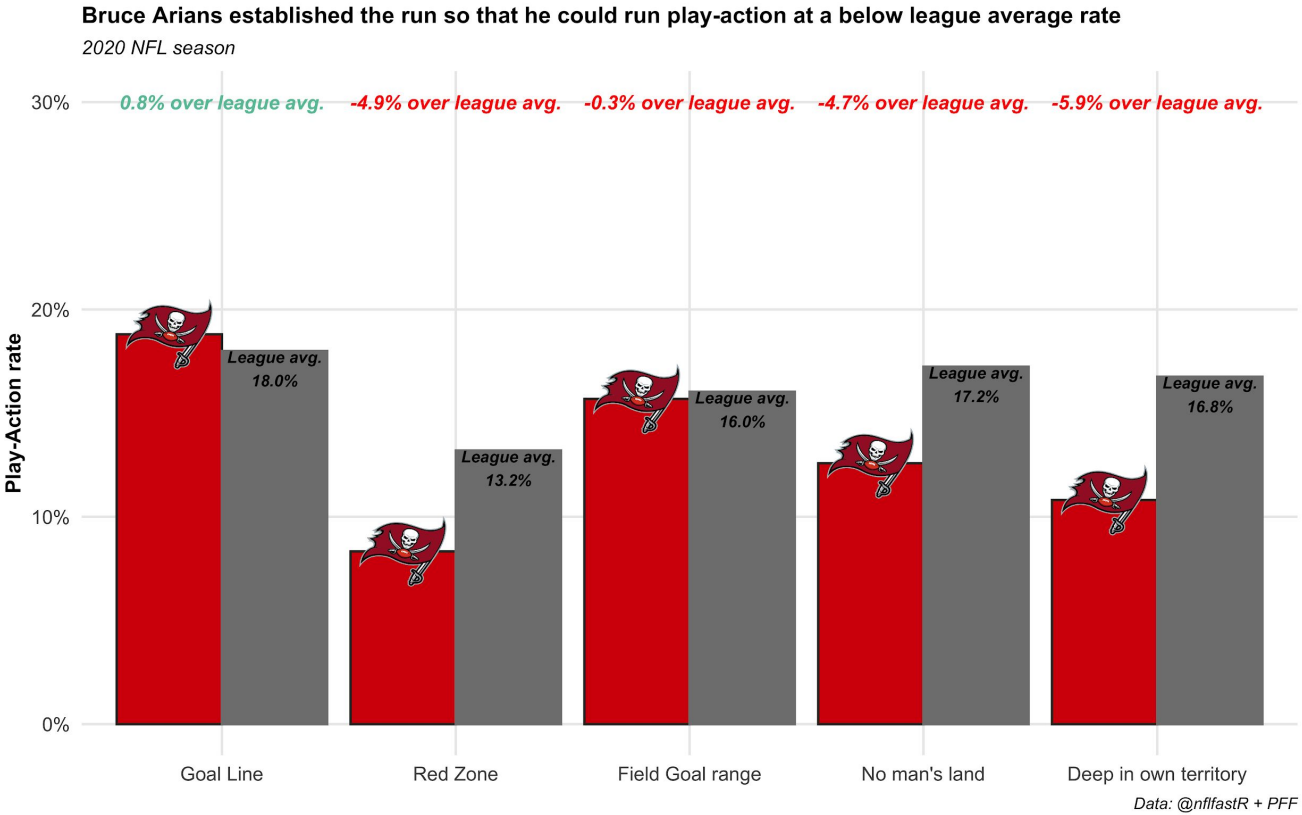
➔ Although they ranked 5th in EPA/Play, their offense could have been even better



The Bucs established the run for nothing

The Bucs used **play-action at below league average rate** at most areas of the field

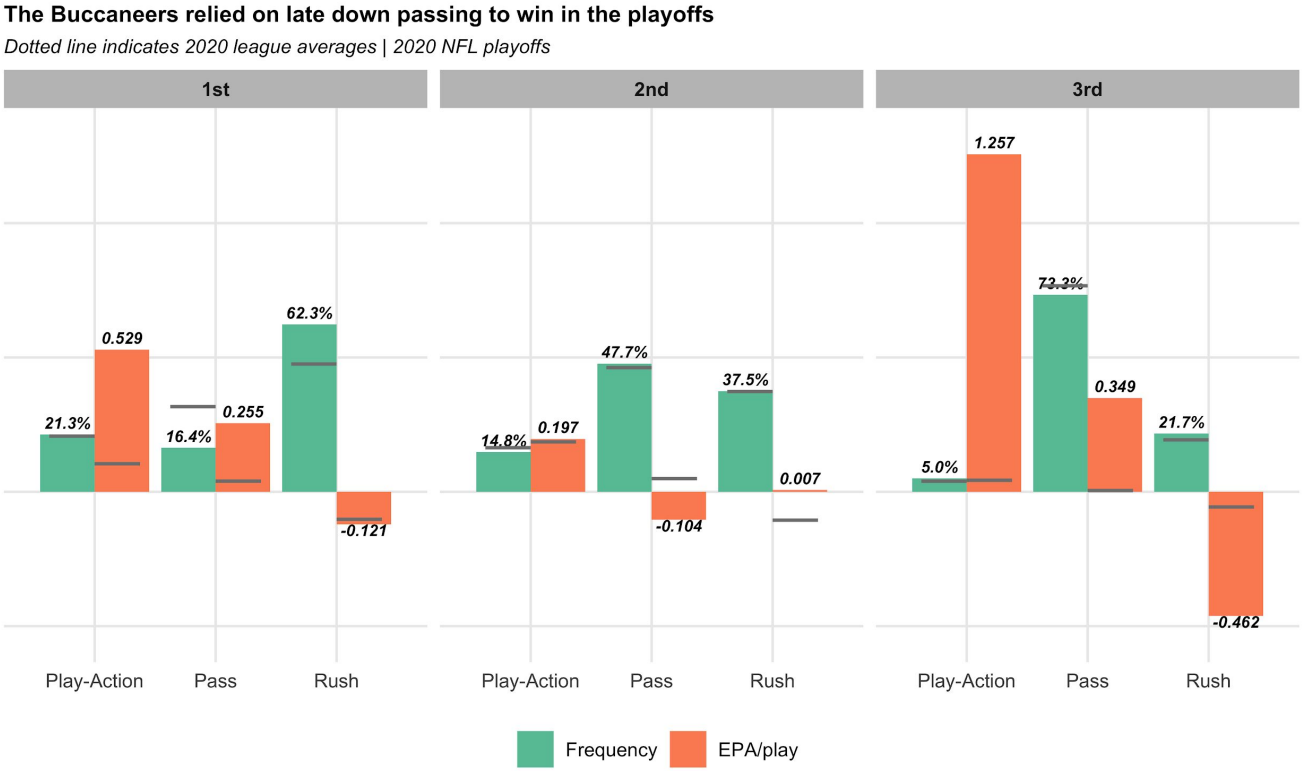
➔ Ranked **2nd in EPA/play** on play-action



What about the playoffs?

Despite success throwing, the **Bucs continued to run** on early downs at an **above average rate**

➔ The Bucs relied on **late down Tom Brady** heroics



Data: @nflfastR + PFF

So... should teams just pass almost every play?

No. Teams should not just pass every play

Just like basketball team's cannot simply shoot only layups and threes

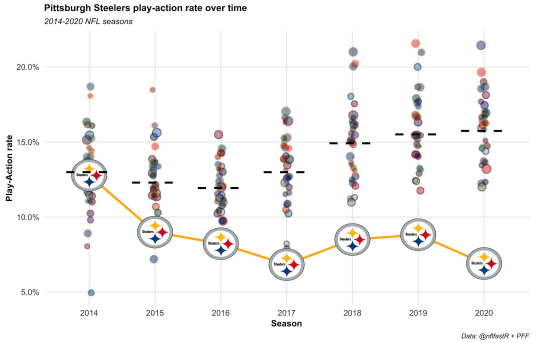
➔ Defenses can adjust by putting fewer men in the box
➔ Dropbacks may increase a QB's chance of injury more than handing the ball off

The **optimal** run/pass ratio is **likely quite far away** from **current run/pass ratios**

Teams will reach a point of diminishing returns with passing, but it is clear teams are not yet at that point

What about play-action?

- ➔ It is possible that certain QB's **really dislike** play-action
  - ◆ Play-action is mostly run from under center
  - ◆ Requires a QB to turn their back to the defense



- ➔ Model is **extrapolating** play-action efficacy to incredibly high play action frequency
  - ◆ Unclear how effective play-action would be if used at the rates the model recommends

However, **play-action should be incorporated far more** into gameplans across the league

Limitations to our approach

Should teams be optimizing **EPA** or **win probability**?

➔ Metrics are aligned until end of game situations

Trained using **season** grades, so **injuries** affect the model's ability to correctly determine optimal play types in individual games, especially QB injuries

Missing potential model features:

➔ Defenders in the box
➔ QB run
➔ Outside/inside run
➔ Offensive personnel
➔ Shotgun/under center

Model is maximizing the **expectation** of EPA

Thank you, we appreciate your time!