

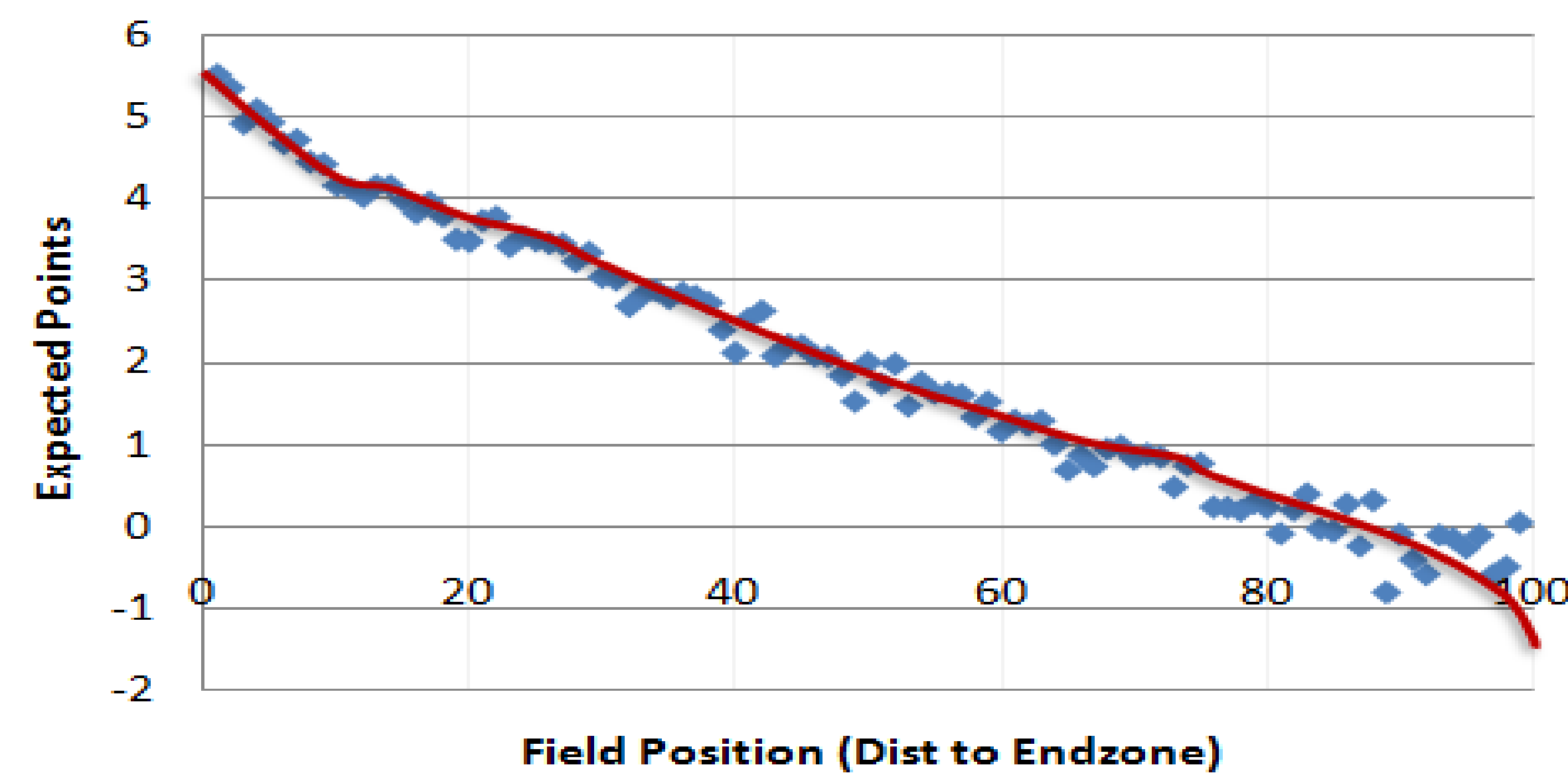
Introduction

The NFL is a multi-billion dollar industry. Although a lot of a team's success can be attributed to the players, some of the success is dependent on the coaching decisions. A better understanding of the probability associated with various critical in-game coaching decisions could give coaches and their teams an advantage over their opponent. All data was collected from the 2000-2015 NFL seasons. We combined our data with data collected by Brian Burke of Advanced Football Analytics from the 2000-2008 NFL seasons. Burke's research created the idea of Expected Points, which are the average potential points a team has at a certain yard line. We used Burke's idea of Expected Points in combination with more recent data to form a blueprint for NFL coaches on fourth downs. We also used data from 2001-2015 to create a guide for coaches potentially tying the game with a touchdown late in the fourth quarter.

Methods and Results

Burke's research created the idea of Expected Points, which are the average potential points a team has at a certain yard line. Expected Points are the average of all next score values at any given yard line. It's not necessarily the average points scored on the current possession because possession could be exchanged several times before the next score. Expected Points are positive when the offense will usually score next, and negative if the defense will usually score next.

Graph 1: Expected Points by First Down Field Position

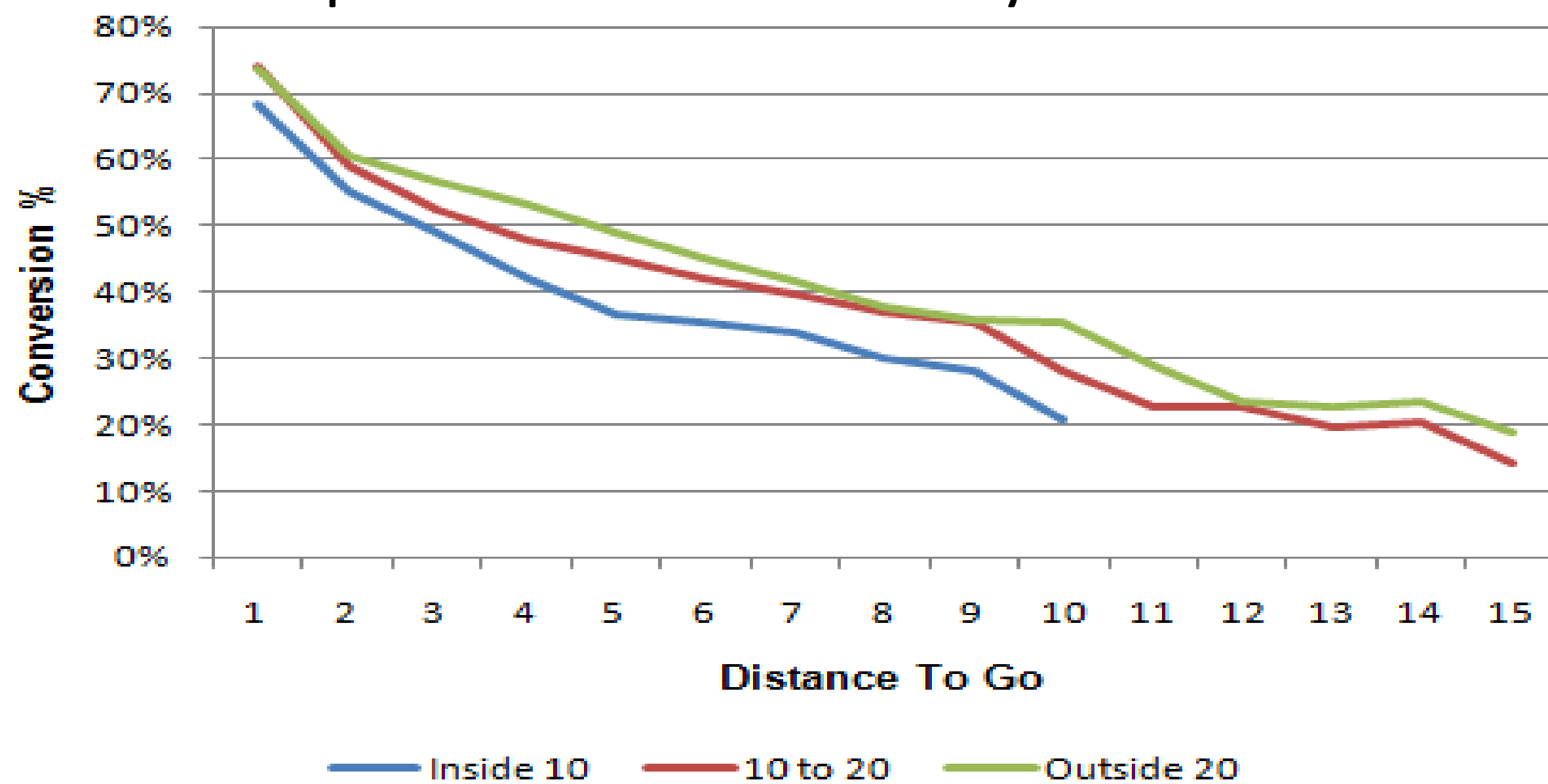


We analyzed every fourth down attempt from the 2015-2016 NFL season. We excluded all of the attempts that occurred while a team was losing in the fourth quarter and attempts with no intention of succeeding (ex. taking a knee to have time run off of the clock). The fourth quarter attempts were excluded from our data because teams were desperate to attempt those conversions in order to have any chance of winning. Including these results would have included desperate long fourth down attempts which are very unlikely to be converted and would skew the results of real fourth down conversion rates. These adjusted fourth down conversion rates were then broken down into pass and run plays as shown.

Table 1: 4th Down Conversion Rates

Type of 4 th Down	Conversions	Attempts	%
League Average (Unadjusted)	233	476	48.9%
League Average (Adjusted)	126	214	58.9%
Total Runs	76	111	68.5%
Total Passes	50	103	48.5%
Types of Attempts	Percent of Conversions	Percent of Attempts	
Run Plays	60.3%	51.9%	
Pass Plays	39.7%	48.1%	

Graph 2: 4th Down Conversion Rate by Distance To Go

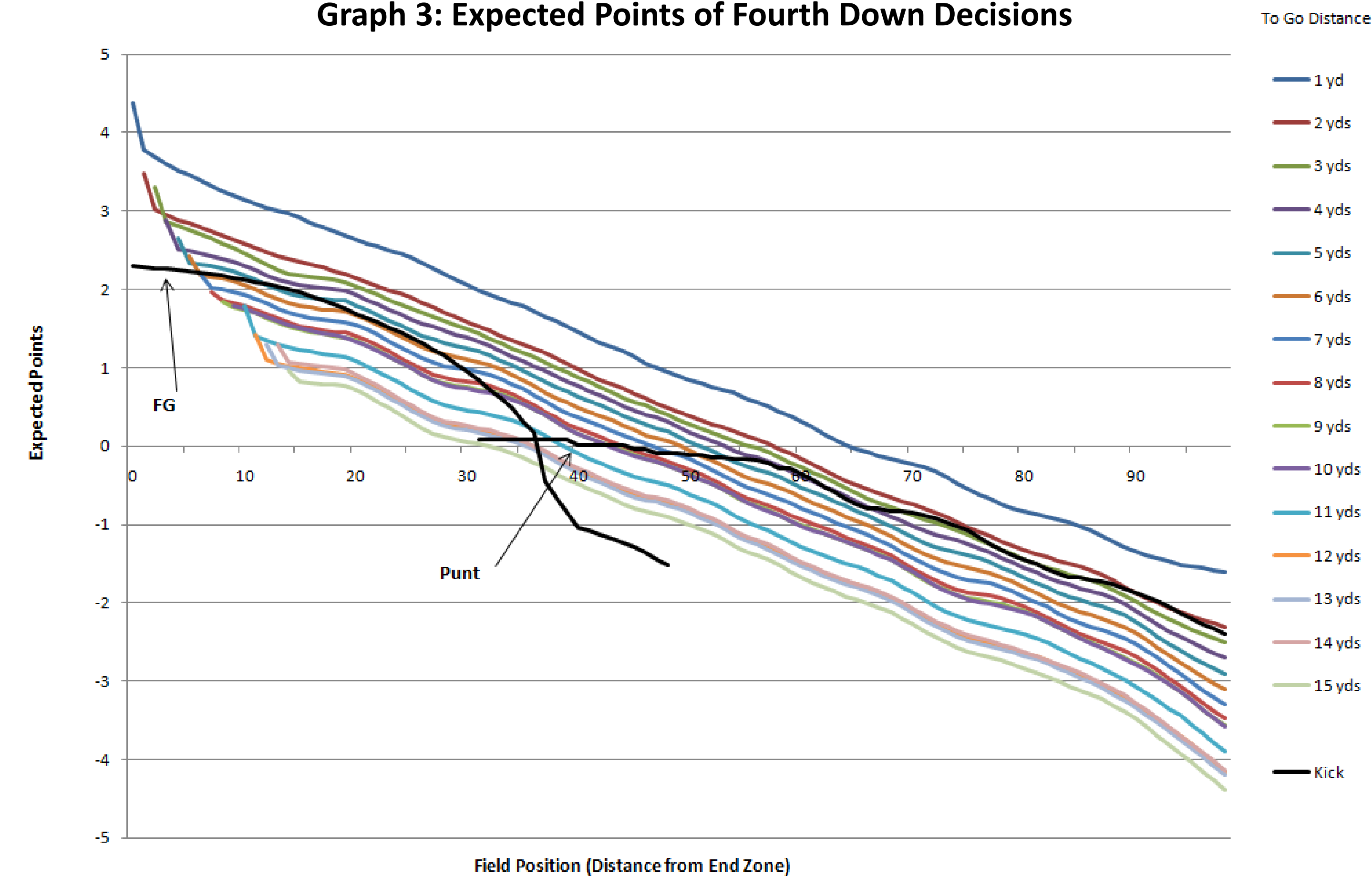


The EP (Expected Points) value of a punt is calculated using the average net distance for punts from each yard line. Using the net distance of the punt we know the expected subsequent field position for the opponent and therefore their EP (Your EP is the opposite of the opponents EP). The EP value of a FG attempt is based on the probability of making the kick, which is dependent on kick distance. The EP of the FG is then:

$$(\text{Probability of making FG} \times \text{EP value of a FG}) - (\text{Probability of a miss} \times \text{EP of the opponent at the yard line of the miss})$$

The value of a successful 4th down conversion attempt would be at least the EP value at the 1st down marker. The minimum value of an unsuccessful conversion attempt would be the EP value of a 1st down for the opponent at the spot of the attempt. The probability of a successful conversion is primarily dependent on the distance to go. Field position also affects the chances of success due to the compression of the field in the red zone. The graph below plots the EP of a successful 4th down conversion by distance to go along with the EP of Punts and FGs.

Graph 3: Expected Points of Fourth Down Decisions



The figure below on the left illustrates the best decision on fourth down according to EP and the figure on the right illustrates what NFL coaches do on average at every position on the field with various 4th down distances. The chart helps explain that NFL coaches are not attempting enough 4th down conversions according to the numbers.

Figure 1: 4th Down Suggestions According to the Numbers

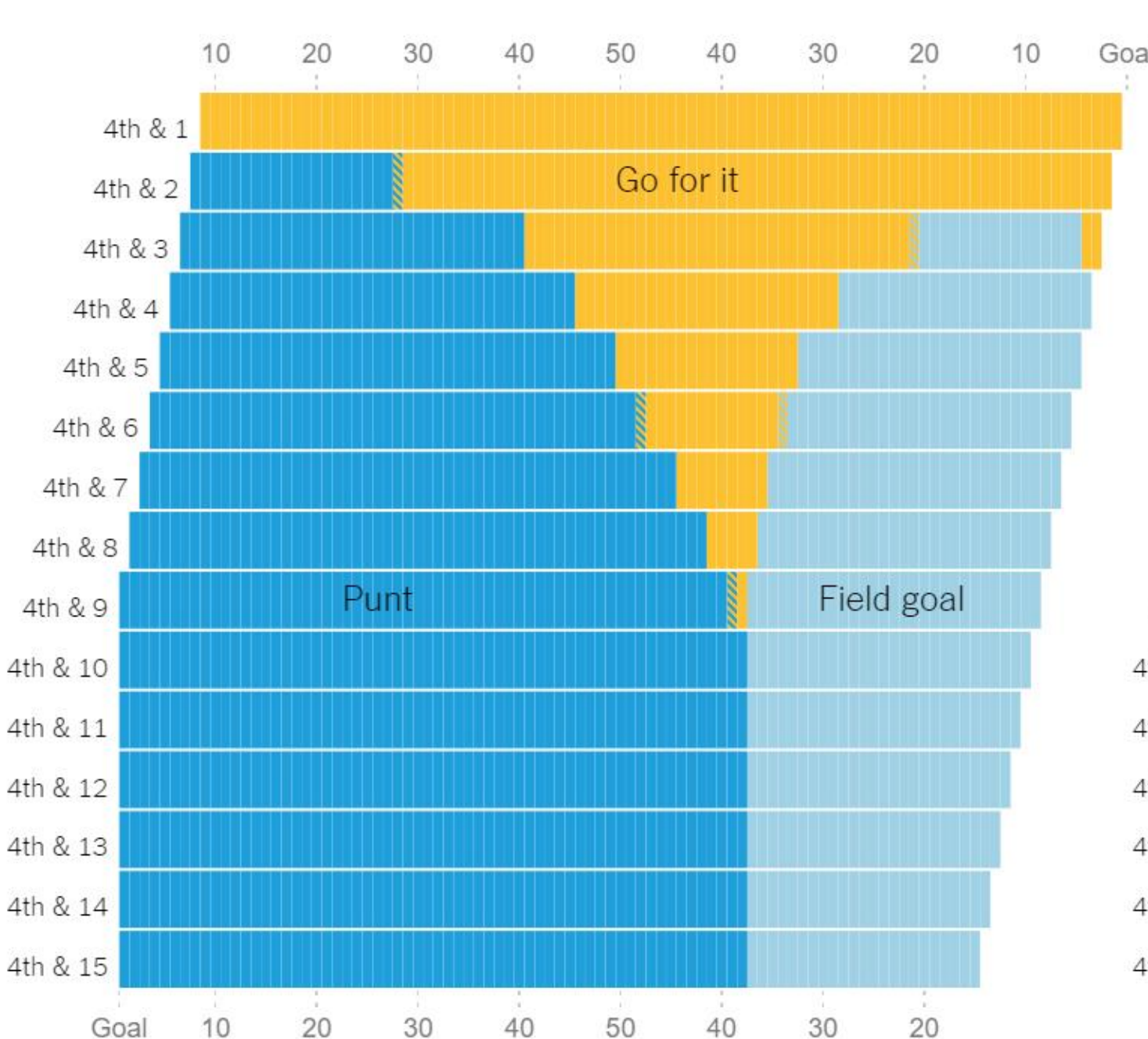
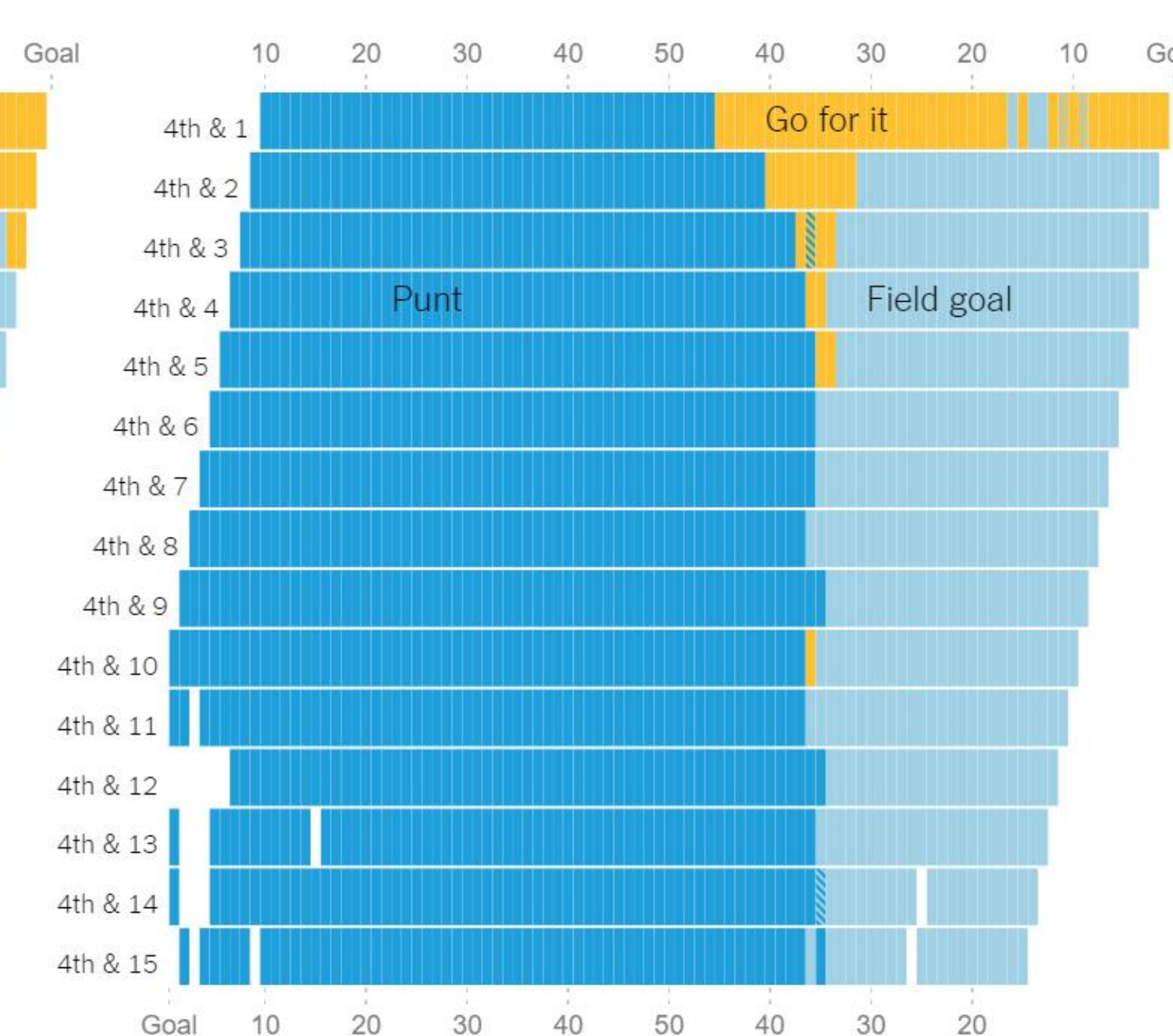


Figure 2: Average NFL Coach's 4th Down Decisions



Another crucial game situation occurs when a team down 7 points scores a touchdown near the end of the fourth quarter. The team can either kick an extra point and likely send the game into overtime or attempt a two point conversion and likely win the game if they succeed (barring any kickoff return for a touchdown or, if there is any time remaining, a quick drive for a score by the opponent). We analyzed the outcomes of 242 overtime games in the NFL since 2001 in order to determine the probability of the home team (54.5%) and away team winning (45.5%) in a game that is sent to overtime (OT). Next we looked at two point conversion rates since 2001 (431 of 913 or 47.2%). Then we examined the extra point success rates for each NFL team during the 2015-2016 season (This was the only season that could be used because prior to the start of the season extra points were moved from the 2 yard line to the 15 yard line).

Next we analyzed the win probabilities of each team if they chose one of three approaches: Attempting an extra point and sending the game into overtime (OT) as the home team, attempting an extra point and sending the game into overtime as the away team, or attempting a two point conversion. To find the win probability in the extra point attempt cases, we multiplied each team's extra point conversion rate by their probability to win in overtime depending on if they are the home or away team. The win probability was then compared to the 2 point conversion rate. The two point conversion rate is considered the win probability of the team because it's unlikely that another score will happen after the two point conversion. The two point conversion rate is considered to not be affected by home or away status. The two win probabilities (EP and OT vs 2-Point Conversion) were then compared for both home and away situations and the higher probability is the recommended decision.

Table 2: Win Probability Late in 4th Quarter After Scoring Touchdown to Tie Game (Before Extra Point (EP) or 2-Point Conversion)

Team	EP and OT (Home)	EP and OT (Away)	2-Point Conversion	Best Decision (Home)	Best Decision (Away)
49ers	51.9%	43.3%	47.2%	OT w/ EP	2-Point Con.
Bears	52.6%	43.9%	47.2%	OT w/ EP	2-Point Con.
Bengals	53.4%	44.6%	47.2%	OT w/ EP	2-Point Con.
Bills	46.3%	38.7%	47.2%	2-Point Con.	2-Point Con.
Broncos	53.0%	44.2%	47.2%	OT w/ EP	2-Point Con.
Browns	50.0%	41.7%	47.2%	OT w/ EP	2-Point Con.
Buccaneers	49.7%	41.5%	47.2%	OT w/ EP	2-Point Con.
Cardinals	49.8%	41.6%	47.2%	OT w/ EP	2-Point Con.
Chargers	47.7%	39.8%	47.2%	OT w/ EP	2-Point Con.
Chiefs	51.8%	43.3%	47.2%	OT w/ EP	2-Point Con.
Colts	49.8%	41.6%	47.2%	OT w/ EP	2-Point Con.
Cowboys	54.5%	45.5%	47.2%	OT w/ EP	2-Point Con.
Dolphins	50.0%	41.7%	47.2%	OT w/ EP	2-Point Con.
Eagles	52.0%	43.4%	47.2%	OT w/ EP	2-Point Con.
Falcons	54.5%	45.5%	47.2%	OT w/ EP	2-Point Con.
Giants	53.3%	44.5%	47.2%	OT w/ EP	2-Point Con.
Jaguars	44.7%	37.3%	47.2%	2-Point Con.	2-Point Con.
Jets	53.2%	44.4%	47.2%	OT w/ EP	2-Point Con.
Lions	50.3%	42.0%	47.2%	OT w/ EP	2-Point Con.
Packers	54.5%	45.5%	47.2%	OT w/ EP	2-Point Con.
Panthers	51.7%	43.2%	47.2%	OT w/ EP	2-Point Con.
Patriots	54.5%	45.5%	47.2%	OT w/ EP	2-Point Con.
Raiders	53.1%	44.3%	47.2%	OT w/ EP	2-Point Con.
Rams	50.7%	42.4%	47.2%	OT w/ EP	2-Point Con.
Ravens	54.5%	45.5%	47.2%	OT w/ EP	2-Point Con.
Redskins	53.2%	44.4%	47.2%	OT w/ EP	2-Point Con.
Saints	52.1%	43.5%	47.2%	OT w/ EP	2-Point Con.
Seahawks	49.5%	41.4%	47.2%	OT w/ EP	2-Point Con.
Steelers	51.3%	42.8%	47.2%	OT w/ EP	2-Point Con.
Texans	48.4%	40.4%	47.2%	OT w/ EP	2-Point Con.
Titans	51.0%	42.6%	47.2%	OT w/ EP	2-Point Con.
Vikings	48.6%	40.6%	47.2%	OT w/ EP	2-Point Con.
Average	51.3%	42.8%	47.2%	OT w/ EP	2-Point Con.

Discussion

Our research has led us to form many suggestions relating to critical football coaching decisions. The data very strongly supports the idea that coaches should attempt more fourth down conversions. The numbers simply say the rewards of successes outweigh the risks on shorter attempts and even on some mid distance attempts, depending on field position. The next conclusion that can be made relates to the type of play on fourth down attempts. Our research shows that run plays were far more successful than pass plays and accounted for a larger number of the total conversions even though there were roughly equal pass and run attempts. Therefore, on fourth and short attempts, especially fourth and 1, a run play has a higher probability of succeeding. Lastly, our research provided us with each team's best option to win after scoring a touchdown when they were down 7 late in the fourth quarter. The probability states that all away teams should attempt a two point conversion in this scenario and all but two teams should kick the extra point and send the game into overtime as the home team. With such a low margin for error as an NFL coach, it would be wise for coaches to stop ignoring these probabilities and keeping his team from a better chance for victory. These statistics could prove to be the difference in securing a win to help a team into the playoffs or even moving on to the next round of the playoffs, generating more money for the team and securing the coaches job for a while.

Sources:

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