Burn Ultimate Analysis

Patriot Games '22

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Credit to Jacob Slade, Chris Mascis, and Elliot Limanek for their collaboration.

Data

Data was collected from the Virginia Tech Burn offense in Patriot Games of Fall 2022 using the DJI drone videos. Each observation is an individual action on offense (pick up or attempted pass). The raw variables are listed below.

Table 1

Variable Name	Description
DJI ID	ID number for each video from DJI
Opponent	
Game ID	
Point ID	
Possession ID	
Defense Type	Either man or zone defense. Can change within points
Handler	The original player with possession before the action. n/a for picking up the disc
Receiver	The player with possession (or intended possession) after the action
Time Thrown	Time on DJI video at the time of disc leaving the handler's hand
Start Area	The area the handler is in before the action
End Area	The area the receiver is in (or intended to be in) after the action
Force/Break	Break throws are throws breaking the intended force or the intended cup. Anything else is considered a force throw
Throw Type	Type of throw by the cut/result. See Table 2 for details
Throw Type	Throw distance. See Table 3 for details
Action Result	The success of the action. 1 for completion, 0 for turn
Possession Result	The success of the possession the action is within. 1 for score, 0 for turn
Point Result	The success of the point the action is within. 1 for score, 0 for opponent score

Table 2

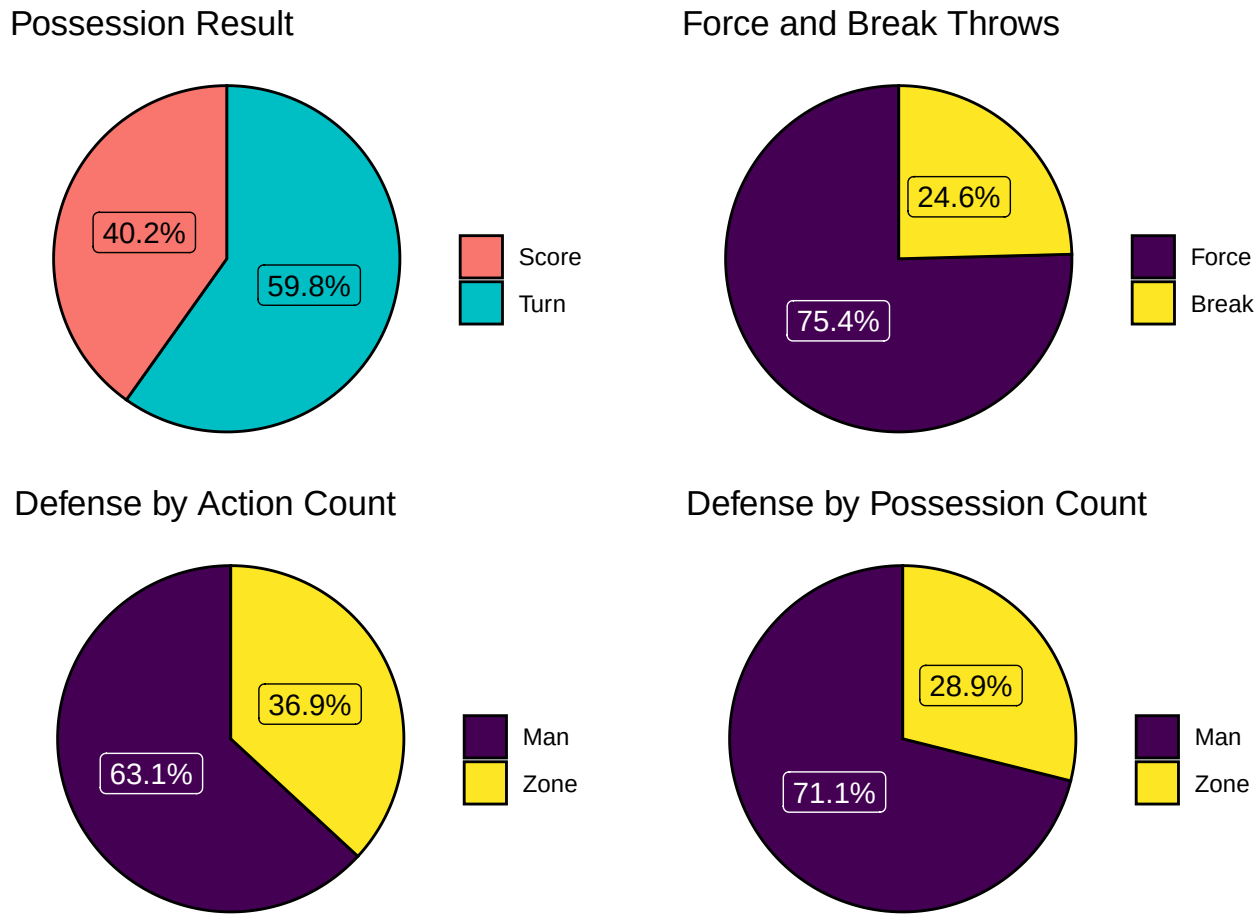
Throw Type	Description
Pick Up	Picking up the disc (or catching it on defense). Man or Zone
Center	Centering the disc after a pick up. Has no defense. Man or Zone
Dump	Throwing backwards more than sideways (by where the receiver ends up). Man or Zone
Swing	Throwing to a significant change of position horizontally more than vertically (by where the receiver ends up). Man or Zone
Up Line	Throwing to an up line cut. Typically Man
Under	Throwing to an under cut. Typically Man
Deep	Throwing to a deep cut. Typically Man
Crash	Throwing to a handler crash. Zone
Through	Throwing through a cup. Zone
Over Top	Throwing over a cup or group of players. Typically Zone
Dish	Thowing with no significant change of position that is not a Crash, Up Line, or Dump. Man or Zone
Open	Throwing to an open cutter that is not classified as any above. Man or Zone

Note: For throws completed to unintended teammates, the throw type is based off the throw to the intended target, and the throw group is based off the end result

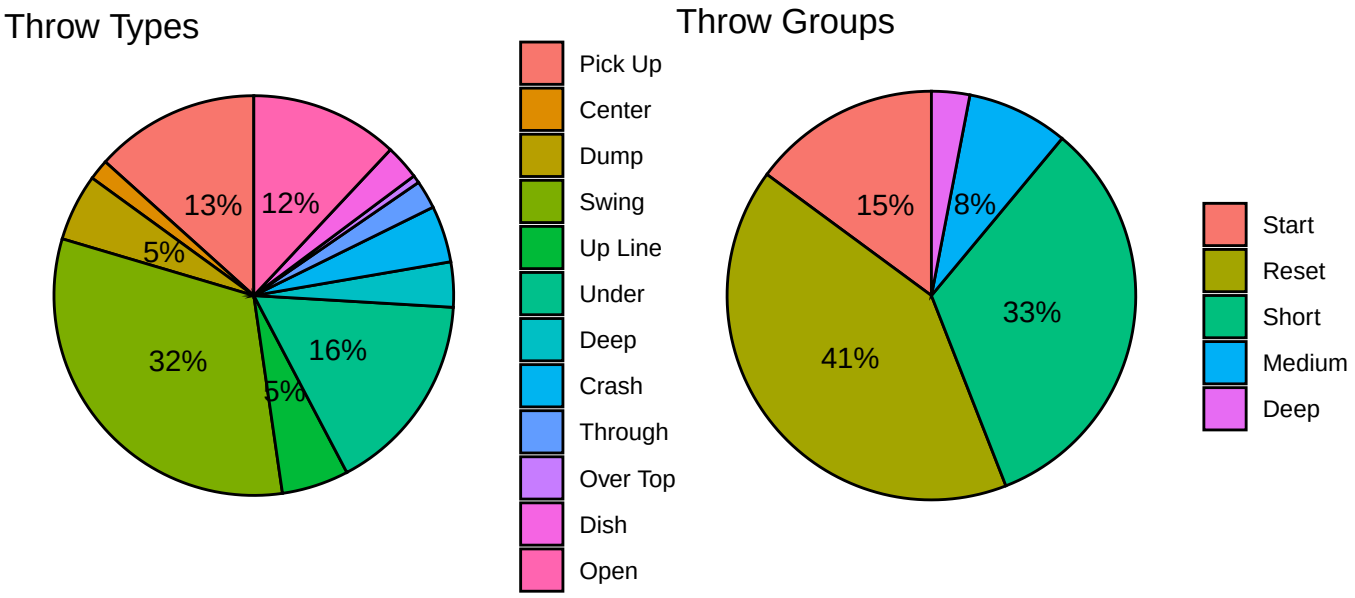
Table 3

Throw Group	Description
Start	Pick Up and Center
Reset	Throws with a negative or insignificant change in vertical position. Typically Dump, Swing, Crash, and Dish
Short	Throws with a small yet significant positive change in vertical position. Typically Up Line, Through, and Open. ~1.5-10 yards
Medium	Throws with a medium positive change in vertical position. Typically Over Top. ~10-20 yards
Deep	Throws with a large positive change in vertical position. Typically Deep (Throw Type). ~20+ yards

Pie Charts



We score on roughly 40% of our possessions. 25% of our throws are breaking the intended force or cup. Most of our possessions come against man defense, though we tend to pass more against zone defense.



We swing the disc quite a lot (32%), while unders and open throws are our next most common throws (16% and 12%, respectively). Other throws to the dump handler, like dumps, up lines, and crashes, are fairly common as well.

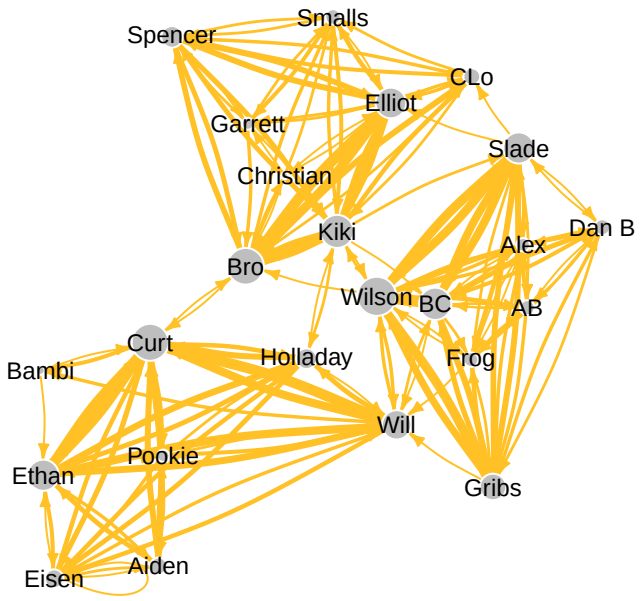
Our throws are around evenly split between reset throws and all the forward throws (short, medium, and deep).

Without more understanding of the context, it's hard to make any conclusions based on these pie charts. However, with more data, we can identify trends in our team's style of play.

Network Maps

Since our team was split into three lines for Patriot Games, we naturally see more connections within the players of each line. Besides that, these won't tell us much. The aim is to find strong and weak connections between handlers and receivers as a representation of team chemistry, but because of the almost complete separation of lines, it's limited.

Network Map of Player Connections: Frequency

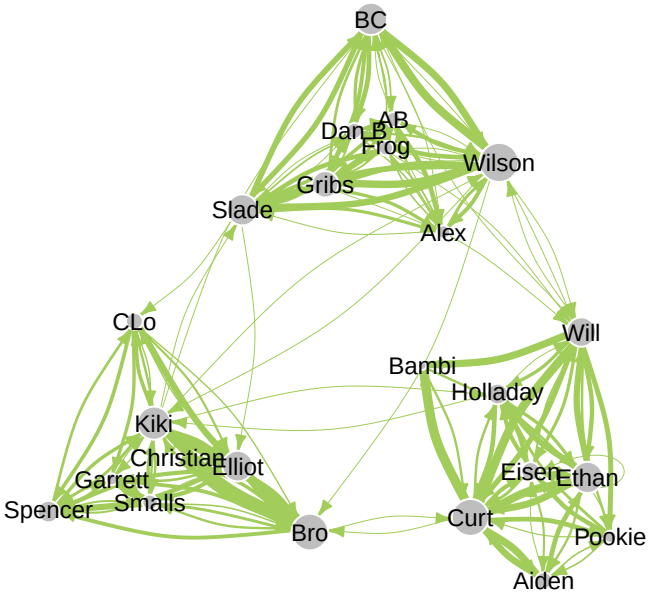


	Handler	Receiver	Frequency
100	Bro	Kiki	32
33	Kiki	Bro	30
27	Wilson	BC	29
64	Bro	Elliot	28
134	Curt	Will	27
73	Curt	Ethan	26
144	BC	Wilson	25
48	Ethan	Curt	22
120	Wilson	Slade	22
93	Wilson	Gribs	21

The node sizes are based off total touches. The edge widths are based off the frequency of throws between players. The relative position of the players signify little besides indicating which players played for which line.

Handlers tend to throw among themselves quite a lot, which isn't surprising.

Network Map of Player Connections: Relative Frequency



	Handler	Receiver	Relative Frequency
18	Curt	Bambi	47.1
100	Bro	Kiki	45.7
64	Bro	Elliot	43.8
134	Curt	Will	43.1
33	Kiki	Bro	42.9
73	Curt	Ethan	41.1
27	Wilson	BC	41.0
93	Wilson	Gribs	37.0
7	Curt	Aiden	37.0
19	Will	Bambi	36.1

The node sizes are based off total touches. The edge widths are based off the relative frequency of throws between players. The relative position of the players signify little besides indicating which players played for which line.

When looking at relative frequency, we see plays that occur more often relative to the overall impact of the players involved. Thus, we see the Curt-Bambi connection as first, as although Curt through to many receivers, 4 out of the 7 catch attempts Bambi made came from Curt's throws.

Also, if I'm being honest, my calculation for relative frequency is questionable. It may be worth looking into in the future if this data becomes more relevant.

Heat Maps

Heat maps are created of the field. The field was split into 18 zones: 3 horizontally and 6 vertically. The x-coordinates are numerical, with 1 representing the left side of the field (within ~12.5 yards of the sideline), 2 representing the middle of the field (~15 yards), and 3 representing the right side of the field (withing ~12.5 yards of the sideline). The y-coordinates are alphabetical, with a representing our team's endzone (20 yards), b representing when we'd run our endzone set (~15 yards),

c representing being on our endzone's half of the field (~20 yards), d representing being on our opponent endzone's half of the field (~20 yards), e representing when our opponent would run their endzone set (~15 yards), and f representing our opponent's endzone (20 yards).

The assignment of the starting and ending area for each play was estimated from DJI drone footage. This data likely contains a slight dose of human error, though this ultimately should be insignificant.

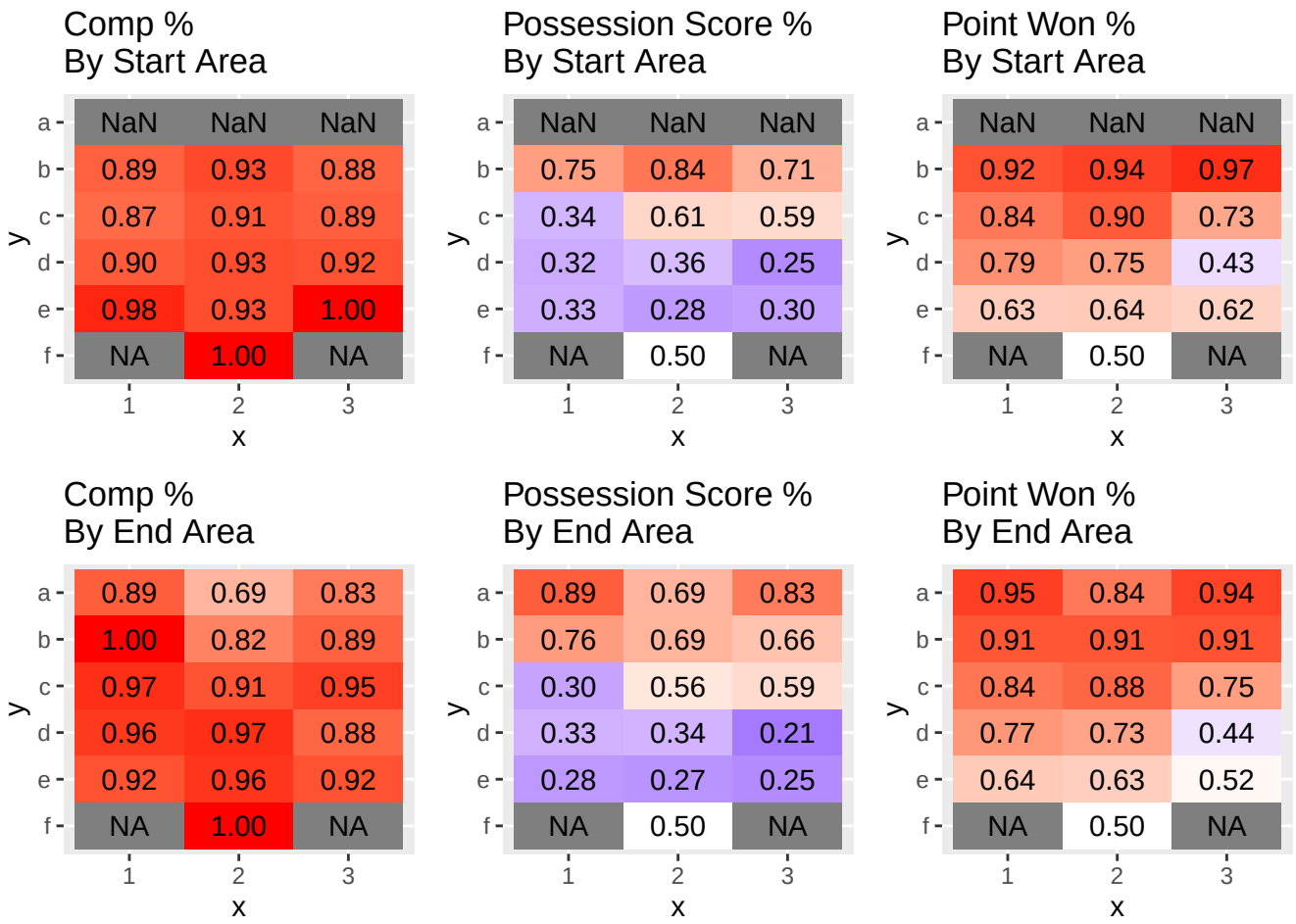
Completion and Turnover Counts by Start and End Area

There is no data for throws starting in our endzone, which makes sense.

Our team tends to have the disc in the middle third of the field. This is sensible, but it also highlights that the percentages in the heat maps below are more stable in the middle zones.

We threw from and to the left side more than the right side, yet we have more turnovers ending on the right than the left.

Throw, Possession, and Point Percentages by Start and End Area



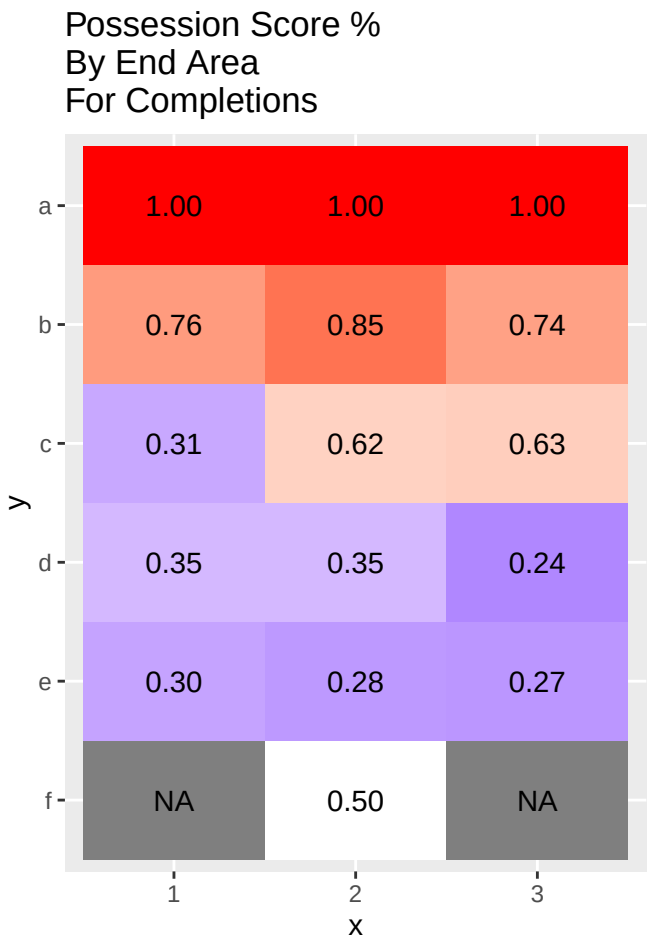
There is no data for throws starting in our endzone, which makes sense.

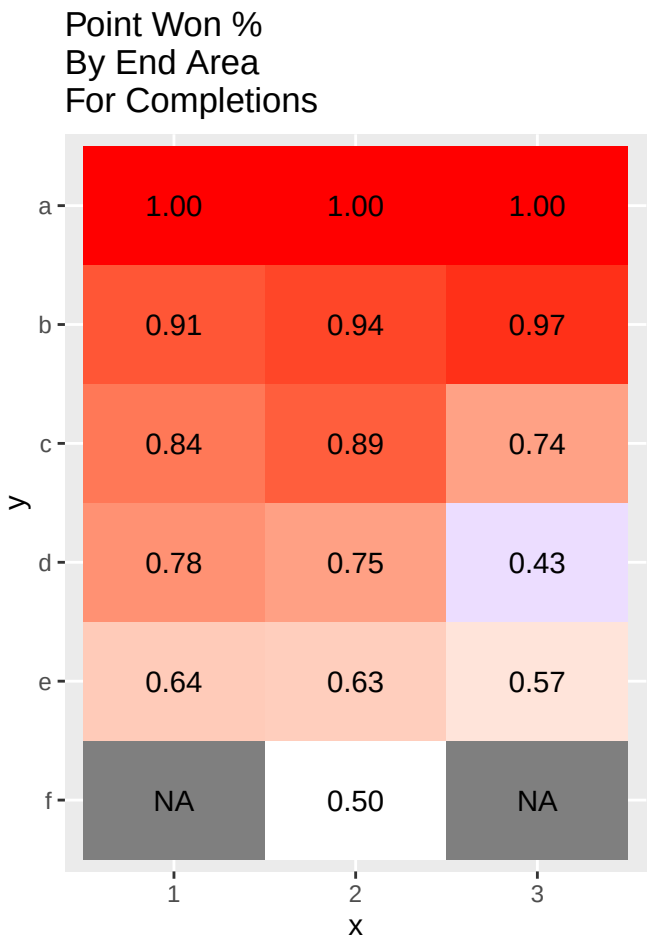
Our completion percentage is fairly even by start area, though it seems we do slightly better throwing from the middle third of the field. In completion by end area, the middle third appears to be easier to throw to when on the opponent's half of the field, but progressively harder to throw to as we approach our endzone. Our low completion percentage of 69% for area a2 is particularly concerning.

Our likelihood of scoring on a possession gets better as we move up the field, which makes sense. Moving into our half of the field seems to be particularly beneficial. The middle third still appears to be the stronger place to throw from but weaker place to throw to. Our low completion percentage at a2 is even more stark in the heat map of possession score percentage by end area.

The difference between the point and possession heat maps indicates how easily our defense got the disc back off turnovers. Our team appears to better on the left side than the right side for both start area and end area. This may have several causes: random variability, our opponents' force, or superior backhands.

Possession and Point Percentages for Completions

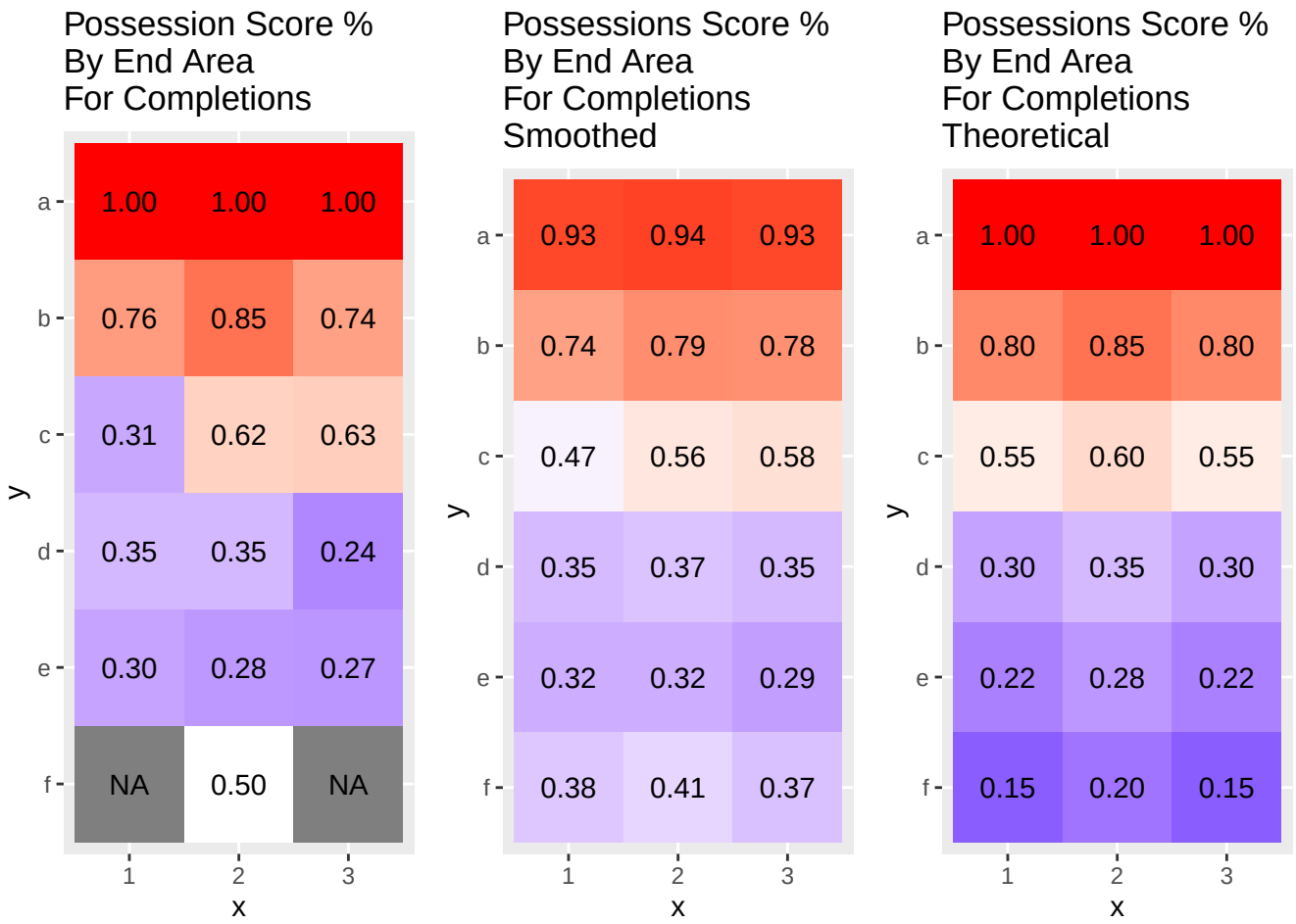




These heatmaps are only for completions, which is why are score percentage is 100% when ending in endzone.

The middle third is now pretty solidly better to end up than the side thirds. Crossing to the other half of the field is still very important.

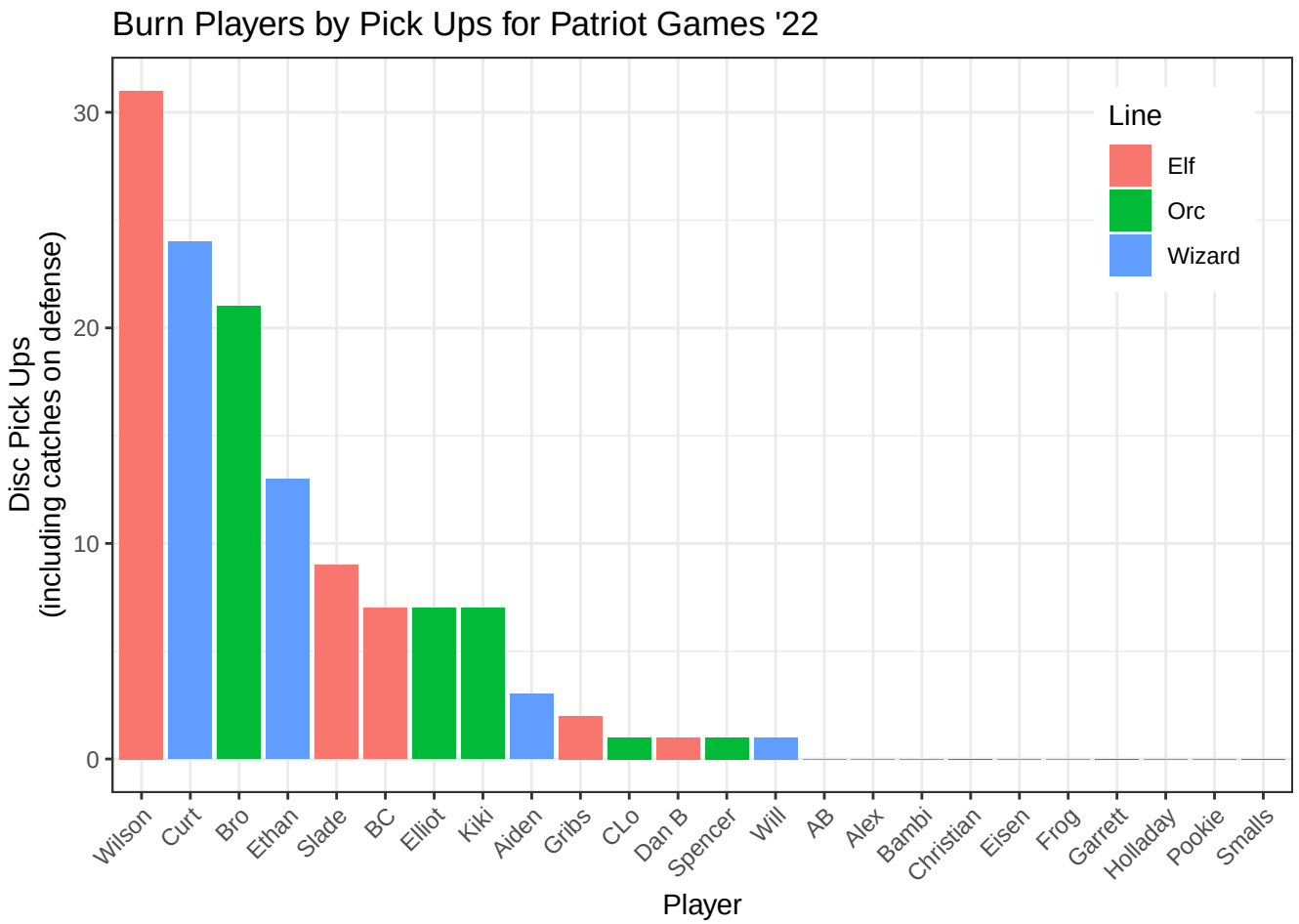
Actual, Smoothed, and Theoretical Possession Percentages for Completions



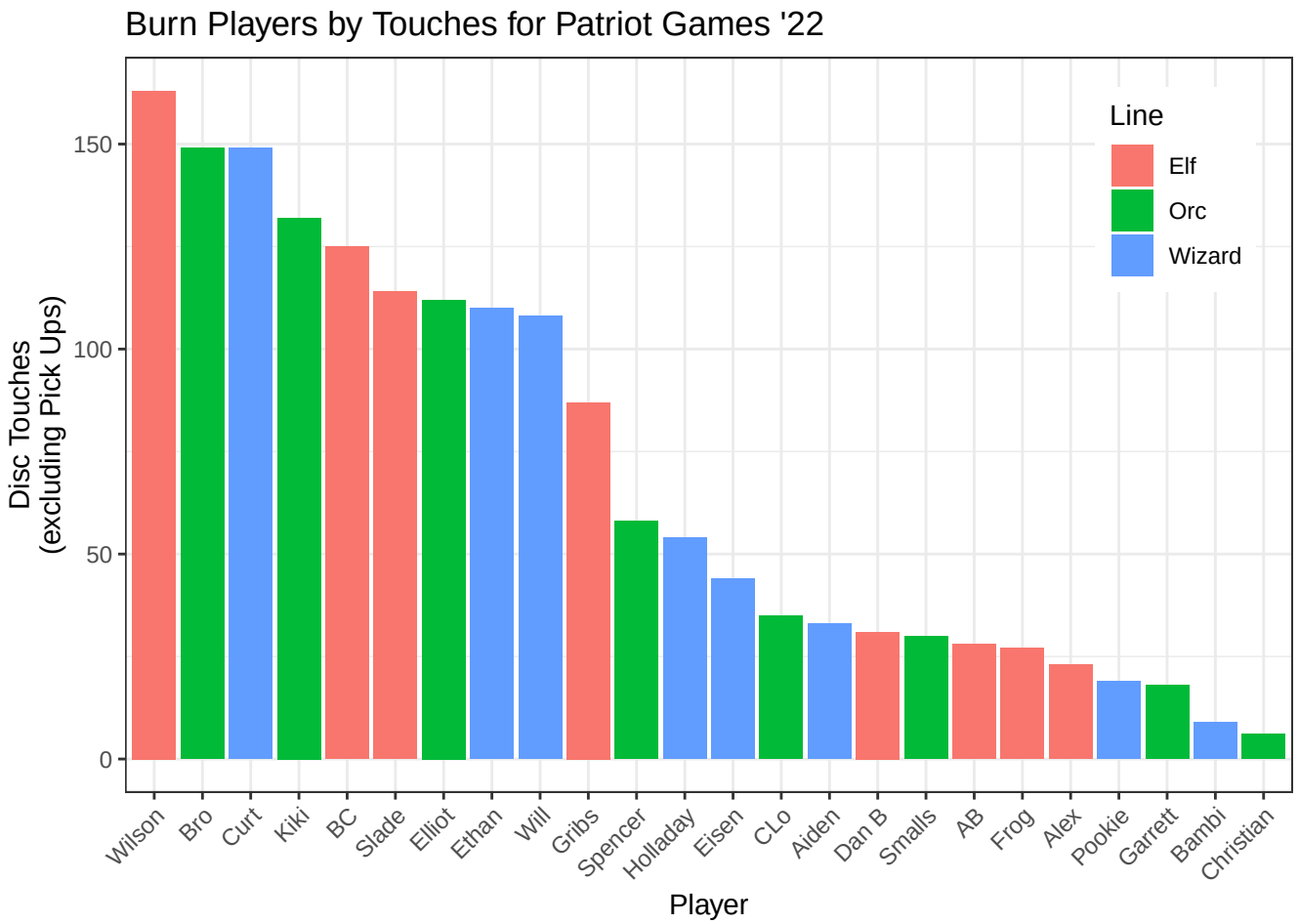
The first heatmap is the actual possession score percentage. It's the same as the first heatmap in the previous set of visuals. The second heatmap is a smoothed version of the first. This is why the score percentage for completions in the endzone is no longer 100%. The third heatmap is a theoretical version using a combination of evidence from the first two and game knowledge. As more data from our tournaments come in, it'll be possible to make a heatmap even closer to the true probabilities.

Player Visuals

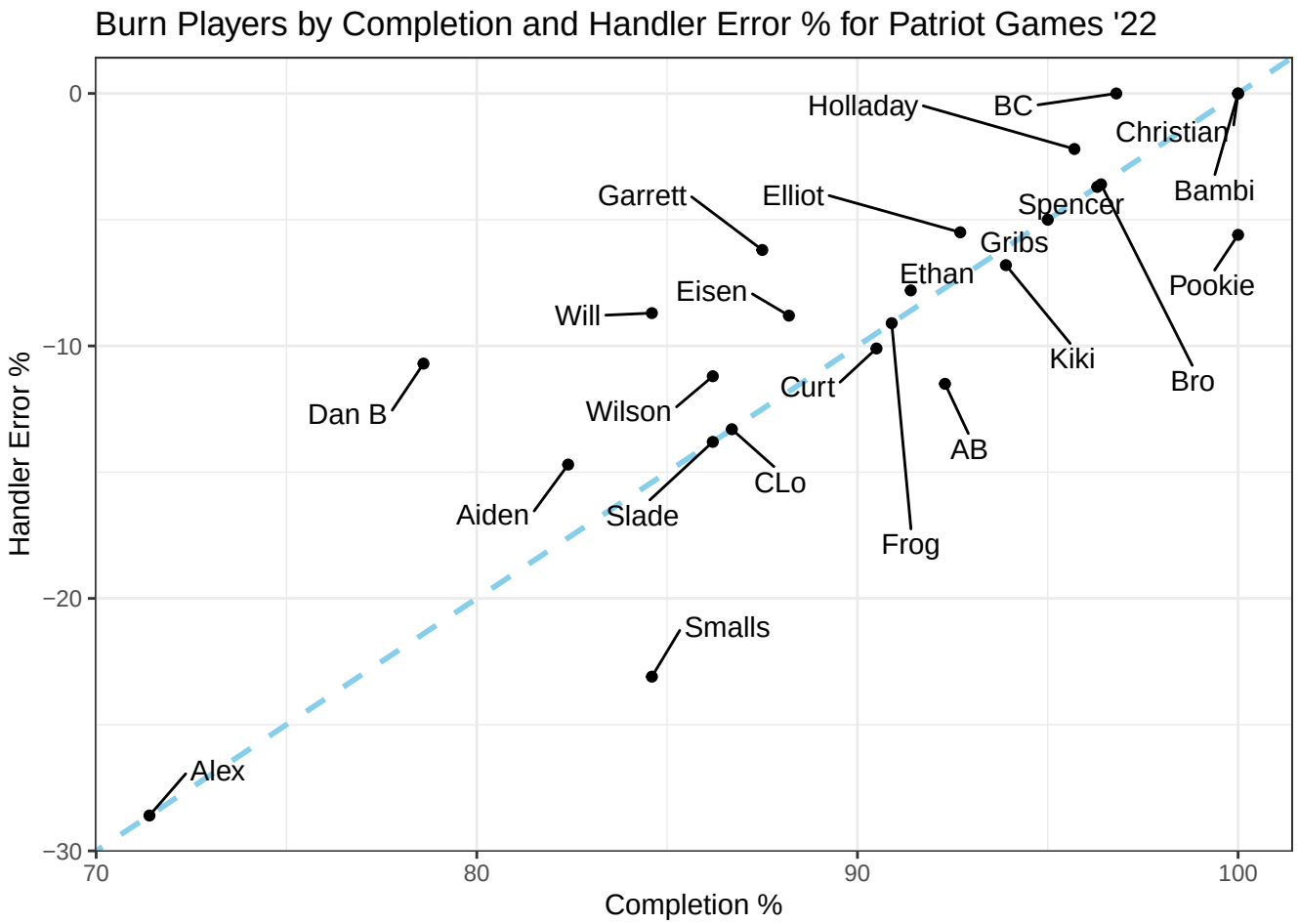
Player data was compiled and calculated off of the raw data previously described. While this portion of visuals is likely the more useful portion, it should be emphasized that these are not a perfectly accurate description of player ability. At best, it's a rough representation of player performance at this specific tournament for the ~80% of points captured by the DJI drone. It can give us insights on player tendencies, and it has implications of player ability, but it is not infallible.



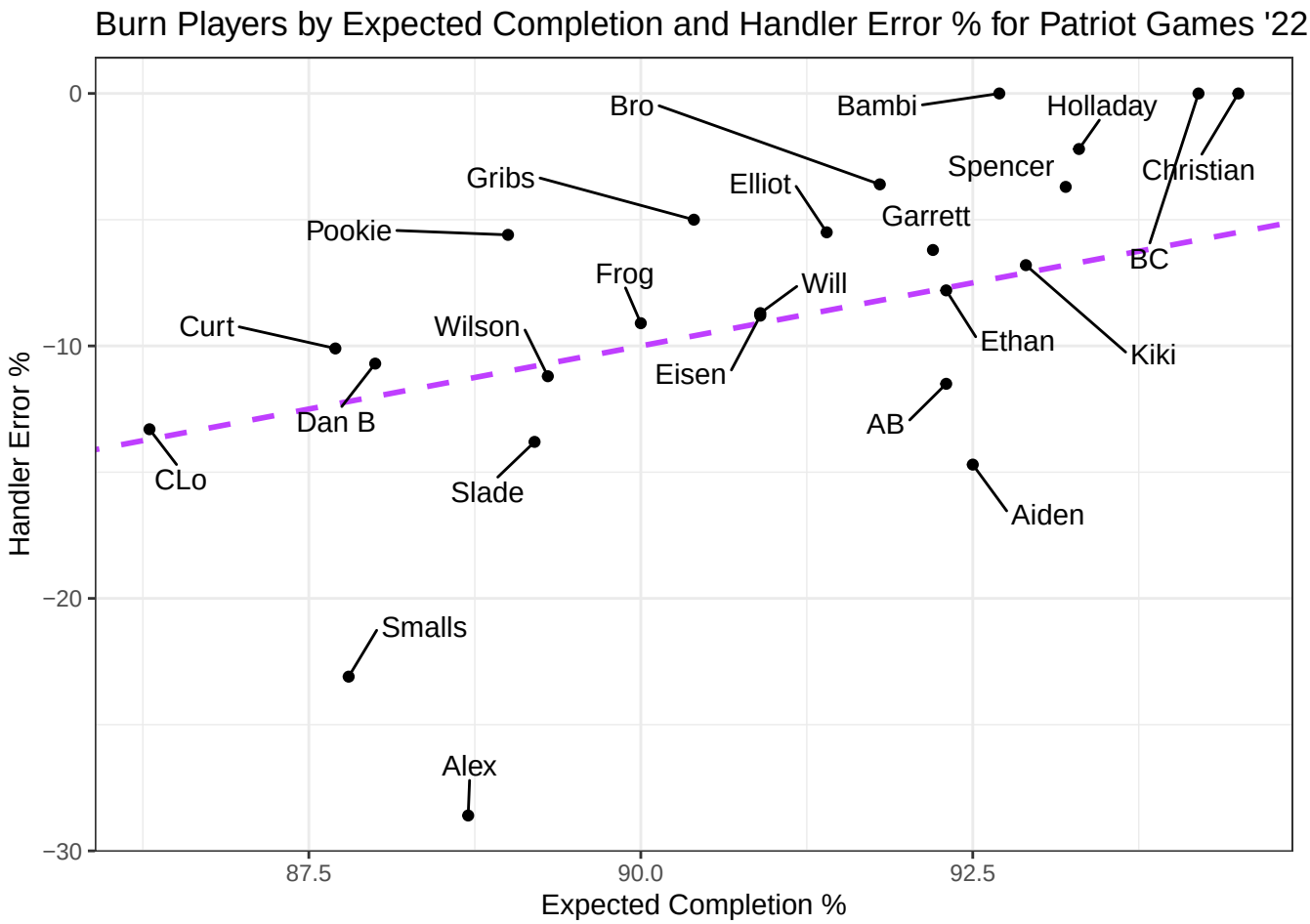
This is a good indication of who the primary handlers are and who the secondary handlers are for each line.

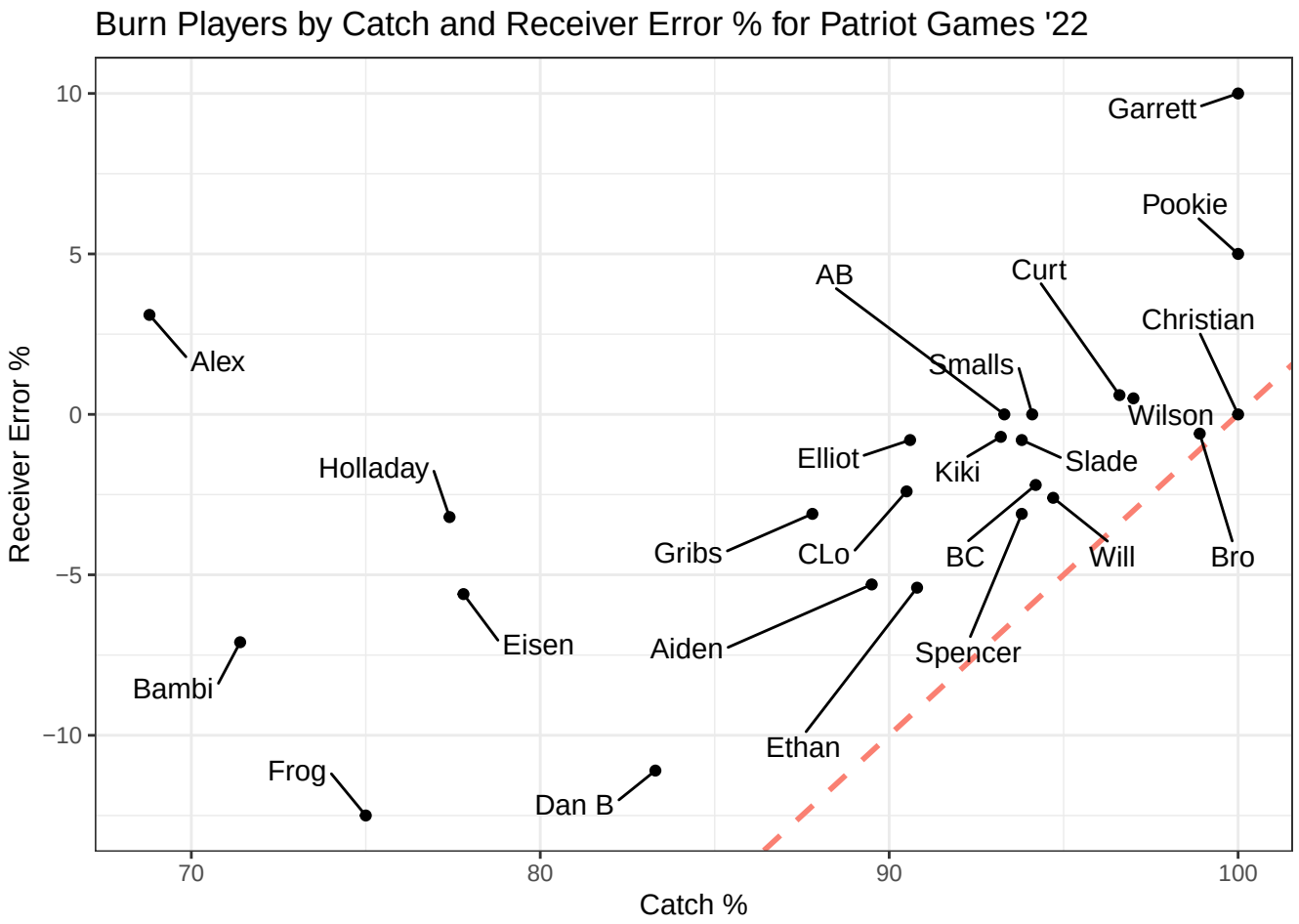


This shows who touches the disc the most. Handlers touch it more often, which makes sense.



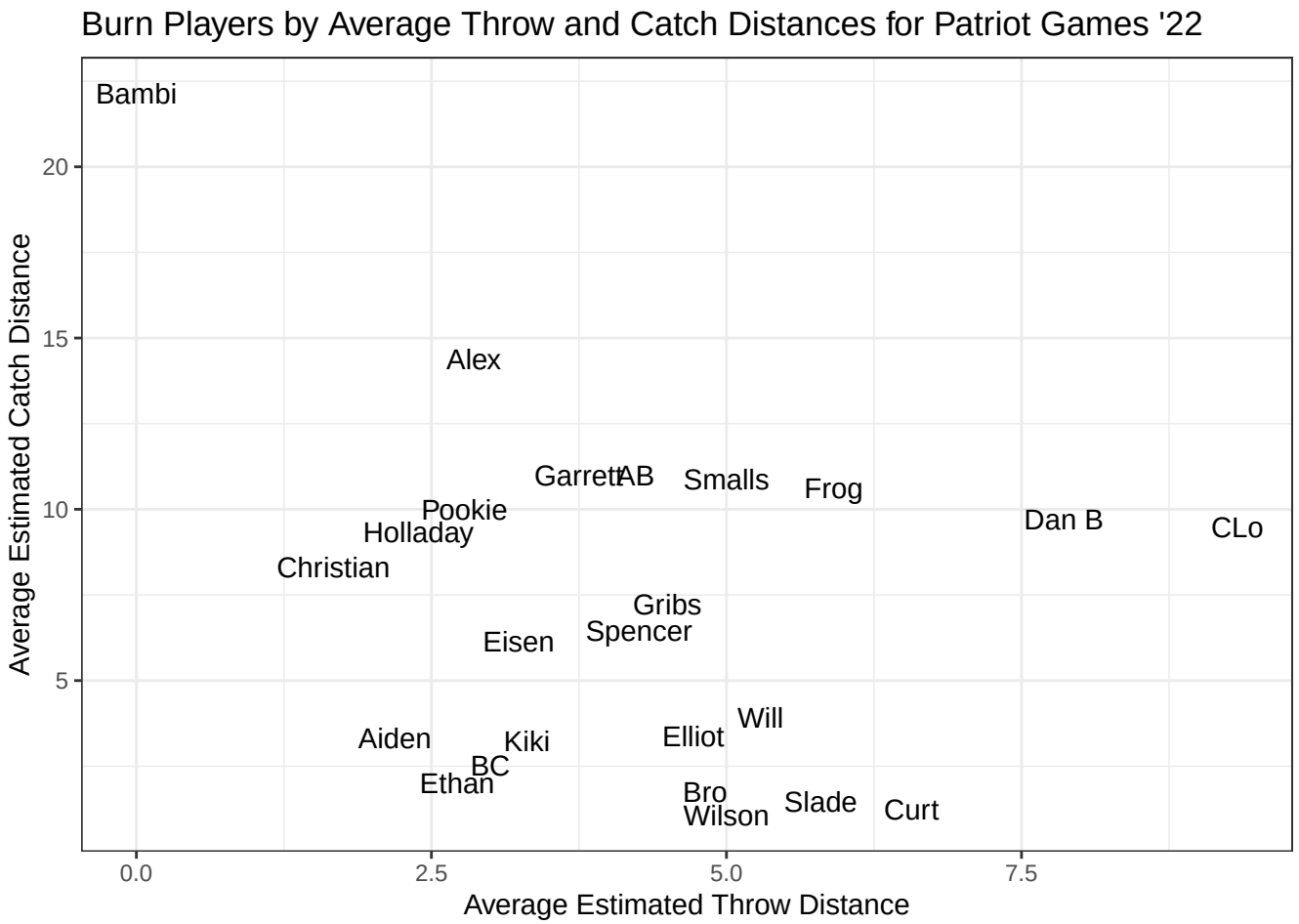
Completion % is essentially how often players were involved in turnovers as a handler. Handler Error % is how often players caused turnovers as a handler. They are close to the same for most players. It suggests that Will, Dan B, and Garrett were involved in turnovers that weren't caused by them. Conversely, it suggests Smalls, AB, and Pookie had shaky throws that were luckily caught.


Burn Players by Expected Completion and Handler Error % for Patriot Games '22
Handler Error %
0
−10
−20
−30
87.5
90.0
92.5
Expected Completion %
Bro
Bambi
Holladay
Spencer
Christian
Gribs
Elliot
Garrett
Pookie
BC
Frog
Will
Curt
Wilson
Ethan
Kiki
Eisen
Dan B
AB
CLo
Slade
Aiden
Smalls
Alex



Catch % is essentially how often players were involved in turnovers as a receiver. Receiver Error % is how often players caused turnovers as a receiver. Unlike Handler Error, no one is below the dashed line, as there were no plays measured to have a receiver make an error that did not result in a turnover. This is because, if a receiver makes a mistake and the disc ends up being caught, then either he caught it (so mistake is negated by himself) or another receiver caught it (and they are then listed as the receiver in the data, so the intended receiver is ignored). Additionally, there are plays where a receiver saves a turnover by making an admirable catch (layouts, sky grabs, etc.), which is why some players receiver error is positive.

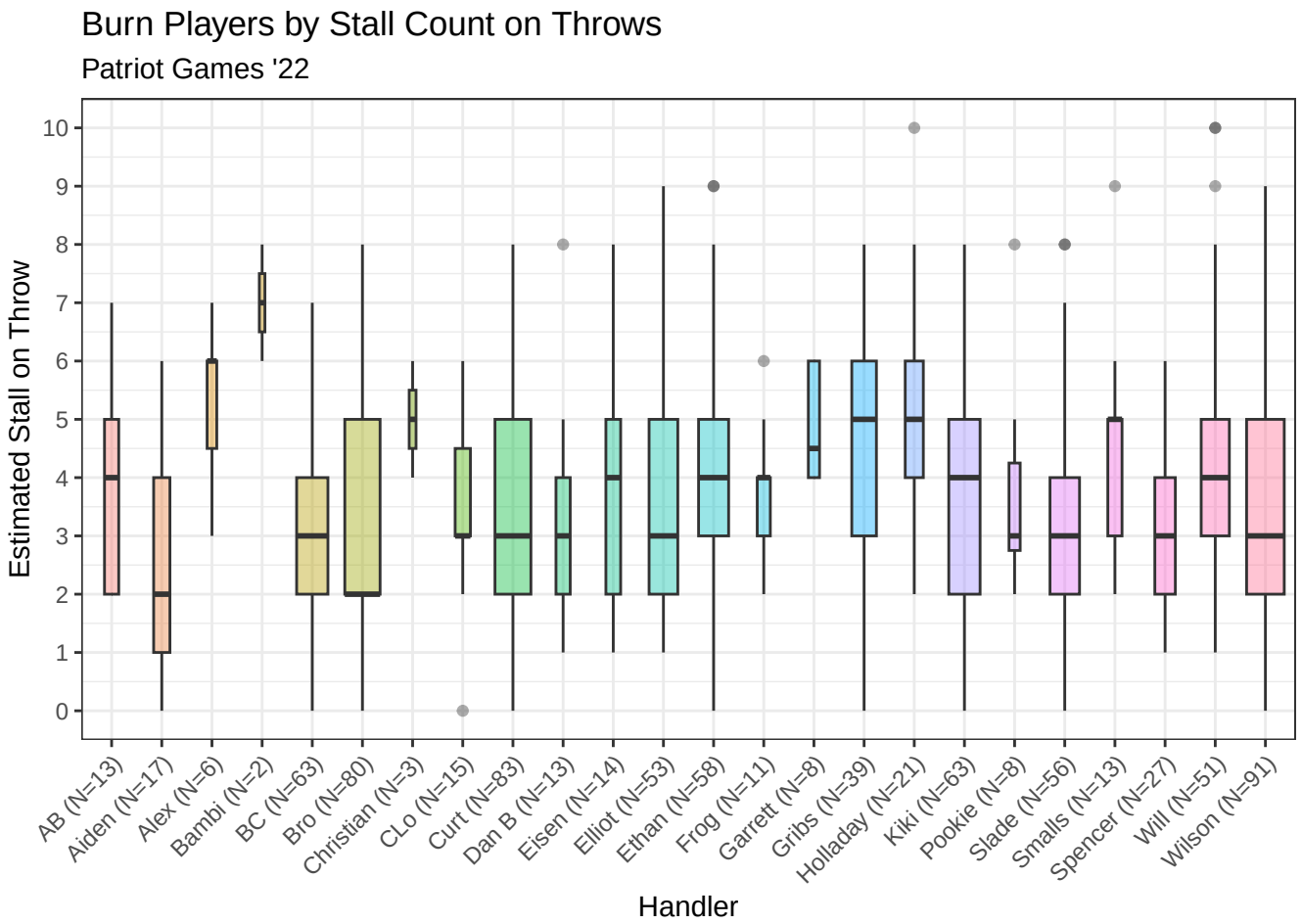
The scatterplot shows Alex, Bambi, Holladay, Eisen, and Garrett having the largest distance from the dashed line, suggesting they were being thrown poor passes or made great catches more often than others. This may be in part due to catching ability, cut tendencies, overrated ability perceived by their handlers, and/or the poor throwing ability of their handlers.



Average throw distance is calculated using throw groups. Reset throws are calculated as 0 (yards), short throws as 5, medium 15, and deep 35. Start throws (pick ups and centers) are not used in the calculation.

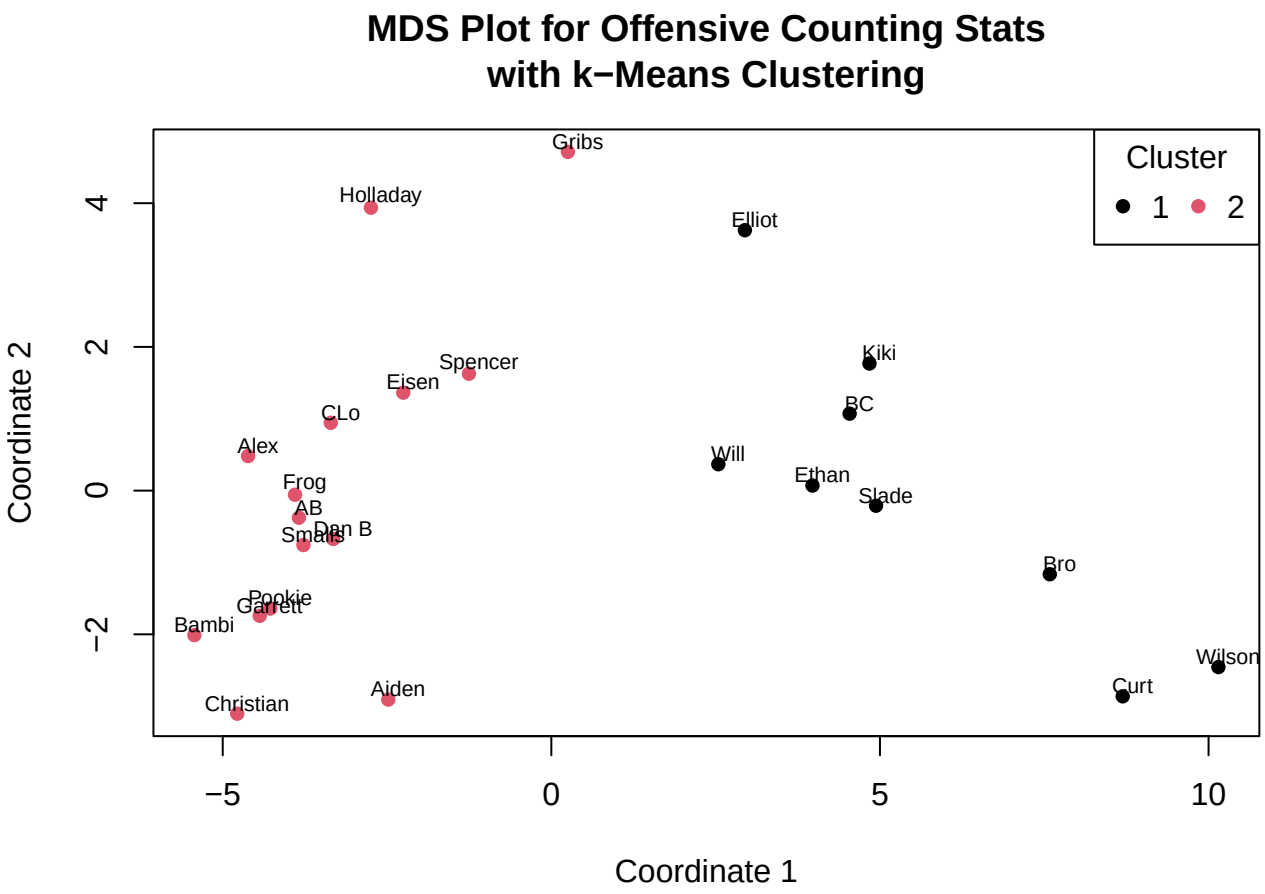
Average catch distance is calculated similarly.

There are handlers that throw it deep (Curt, Slade, etc.), handlers that don't (Kiki, BC, etc.), hybrids (Gribs, Spencer, etc.), normal cutters with a surprisingly even spread of average throw distances (CLo, Holladay, etc.), and then deep cutters (Bambi and Alex).

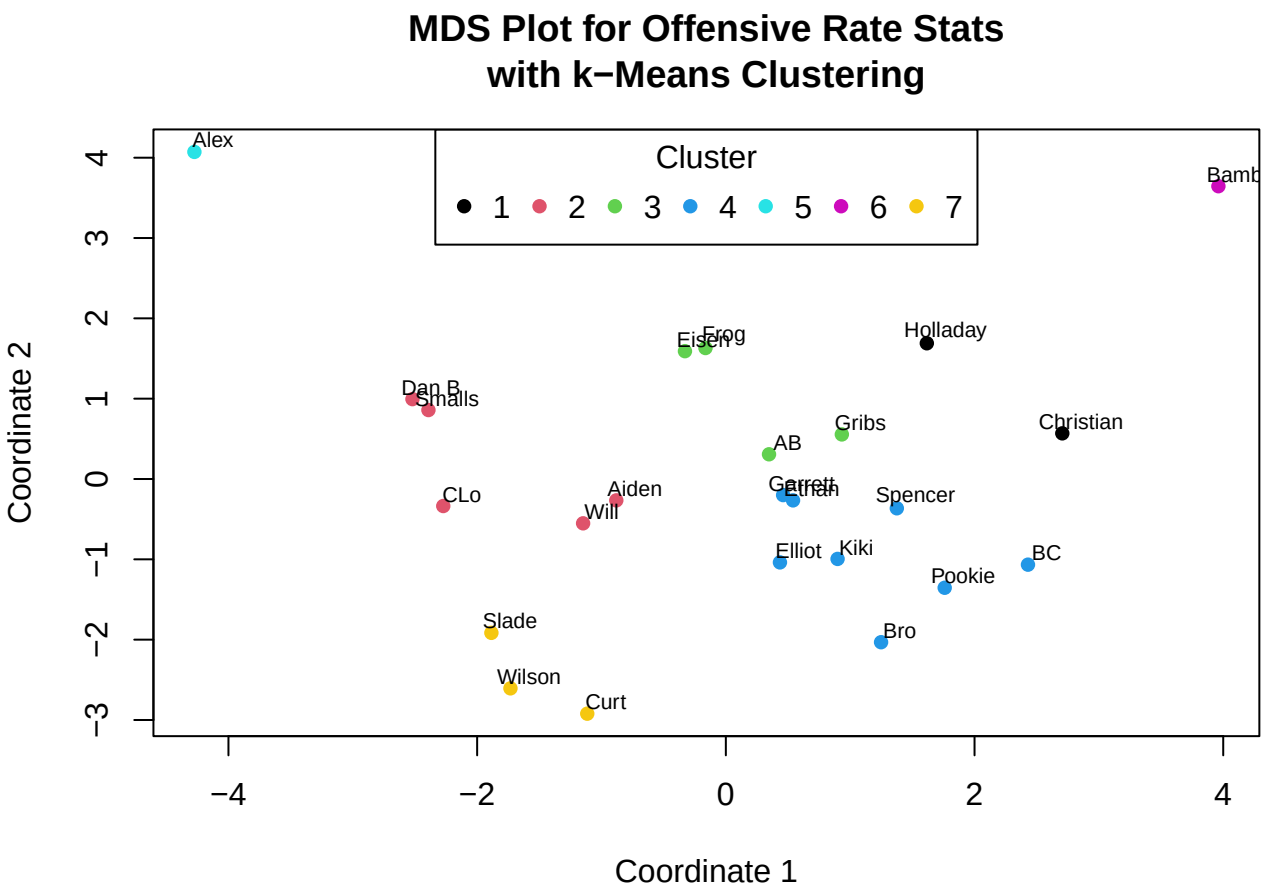


Stall upon throw was calculated by subtracting the DJI drone video time of the previous action from the time of the current action. This does not take into account time the disc is in flight or time where the point is stopped due to violation or injury. Additionally, while stalling is supposed to be at a second pace, players likely stall quicker than that, which this does not take into account. The plot above are the boxplots of every player for stalls that are between 0 and 10 seconds.

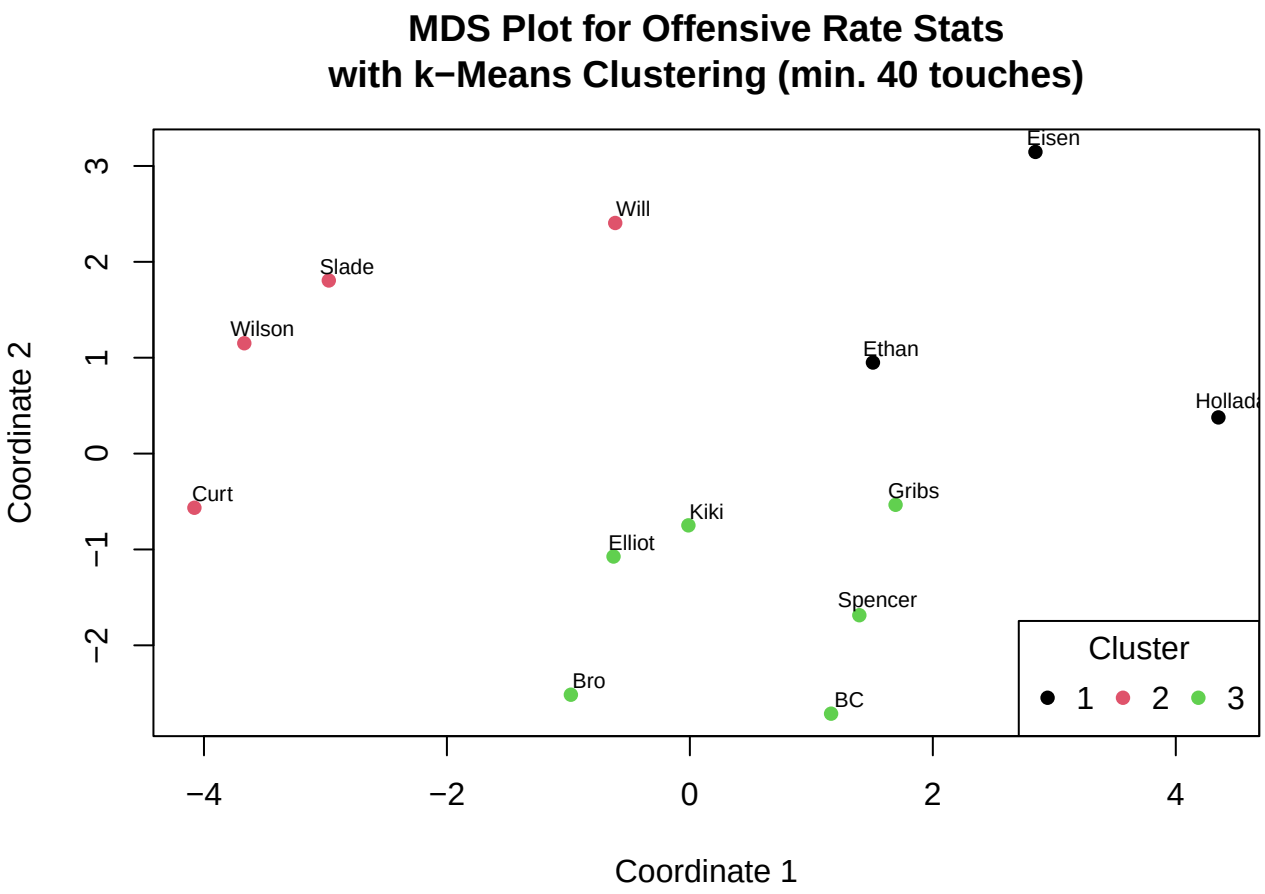
Because this is a very rough estimate, not much can be gained from this plot. However, it's highly likely that stall has a large impact on play, and we could theoretically gather a more accurate set of stall data to look at. We could notice relative stall counts by player, by throw type, by throw distance, by defense, by completion, by starting area. We can calculate if stall count has a significant impact on EPA (a stat I bring up later).



This is a multidimensional scaled scatter plot using kmeans clustering. The variables used were all the counting stats (pick ups, completions, catches, etc.). The number of clusters optimal for this visual was calculated behind the scenes. The team is essentially split between handlers and cutters. Dimension 2 is interesting, but because it's an unknown combination of the variables, it is hard to make conclusions on it.



This is a multidimensional scaled scatter plot using kmeans clustering. The variables used were all the rate stats (completion %, median stall, average throw, etc.). Bambi and Alex throw this plot off, as the rate stats don't account for their low totals. Bambi, for instance, has a team high break throw percentage of 50%, despite only throwing break side once.

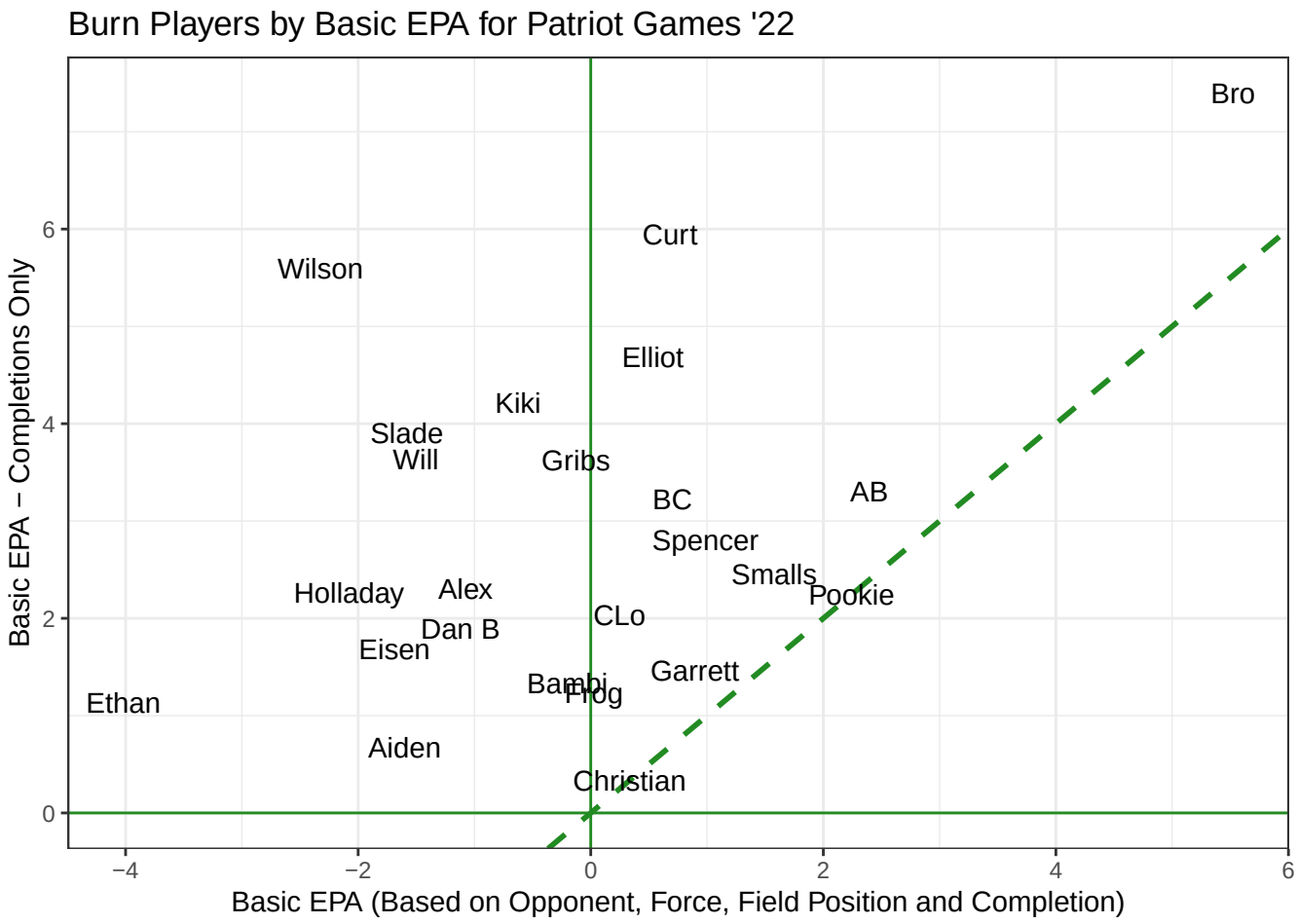


We see a good deal of spread, indicating that our players are all fairly unique in their play style/results.

EPA

EPA stands for Expected Points Added, and is derived from the football statistic of the same name. A more accurate name for the statistic calculated here is "Expected Possession Score Probability Added". At every point in time on a possession, we have a estimated probability of scoring in that possession. After an action, we have a new probability. This statistic attributes the probability gained or lost to the handler and receiver involved.

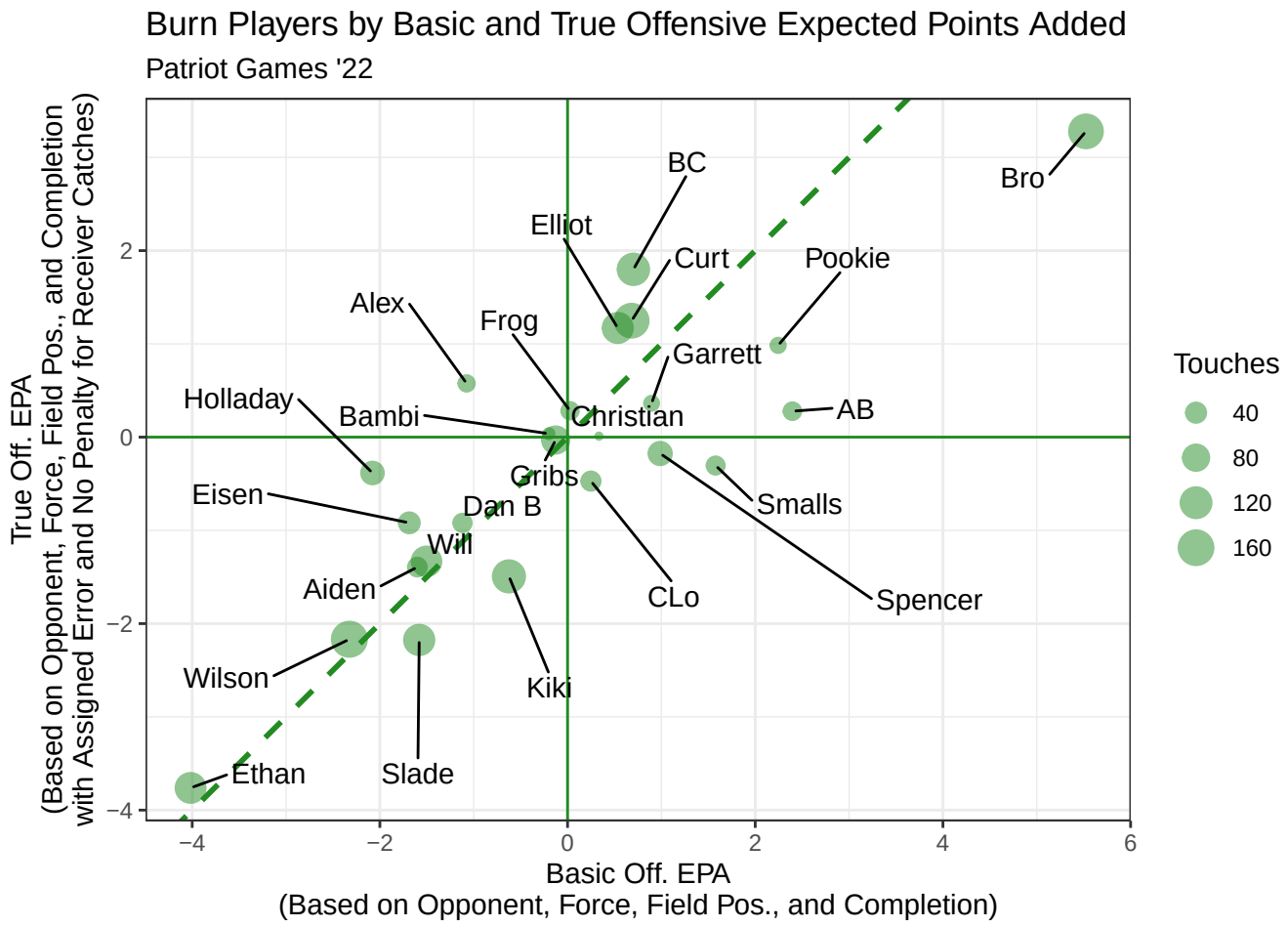
I have calculated various versions of EPA and kept 3 of the most sensible ones. I'll explain the differences between them, but keep in mind this is merely an estimated statistic of how much value each player added at this tournament. It does not measure ability.



Basic EPA (name under construction) is our expected possession score probability added using a logistic regression model of significant factors. Many factors were initially put into the model (defense, starting coordinates, throw type, throw group, etc.) that were found to be insignificant for predicting whether we score or turn the disc. The significant factors were found to be the opponent, whether the throw was a break throw or not, the resulting area (x- and y- coordinates combined, separately they were found to be insignificant), and whether the pass was completed or not. Using these factors in the final model, expected possession score probabilities were calculated at the end of each action, and the difference between an action and its predecessor was calculated as Basic EPA.

Basic EPA places equal responsibility for handlers and receivers on both completions and turnovers. So, if I have the disc with a chance of scoring of 90%, and I throw to CLo for a score, CLo and I both get +0.05 bEPA. Conversely, if I throw it away and my intended target was CLo, we both get -0.9 bEPA.

In the plot, Basic EPA is on the x-axis, and Basic EPA on completions only (ignoring any Basic EPA on turnovers) is on the y-axis. Players not involved in turnovers (Christian and Pookie) have the same value for both, hence they are on the dashed line shown. Obviously, ignoring turnovers results in higher values, which is why everyone is above or on the dashed line. Bro was found to be particularly valuable, and Curt and Wilson provided similar amount of value on completions (but incompletions resulted in a significantly lower Basic EPA total).

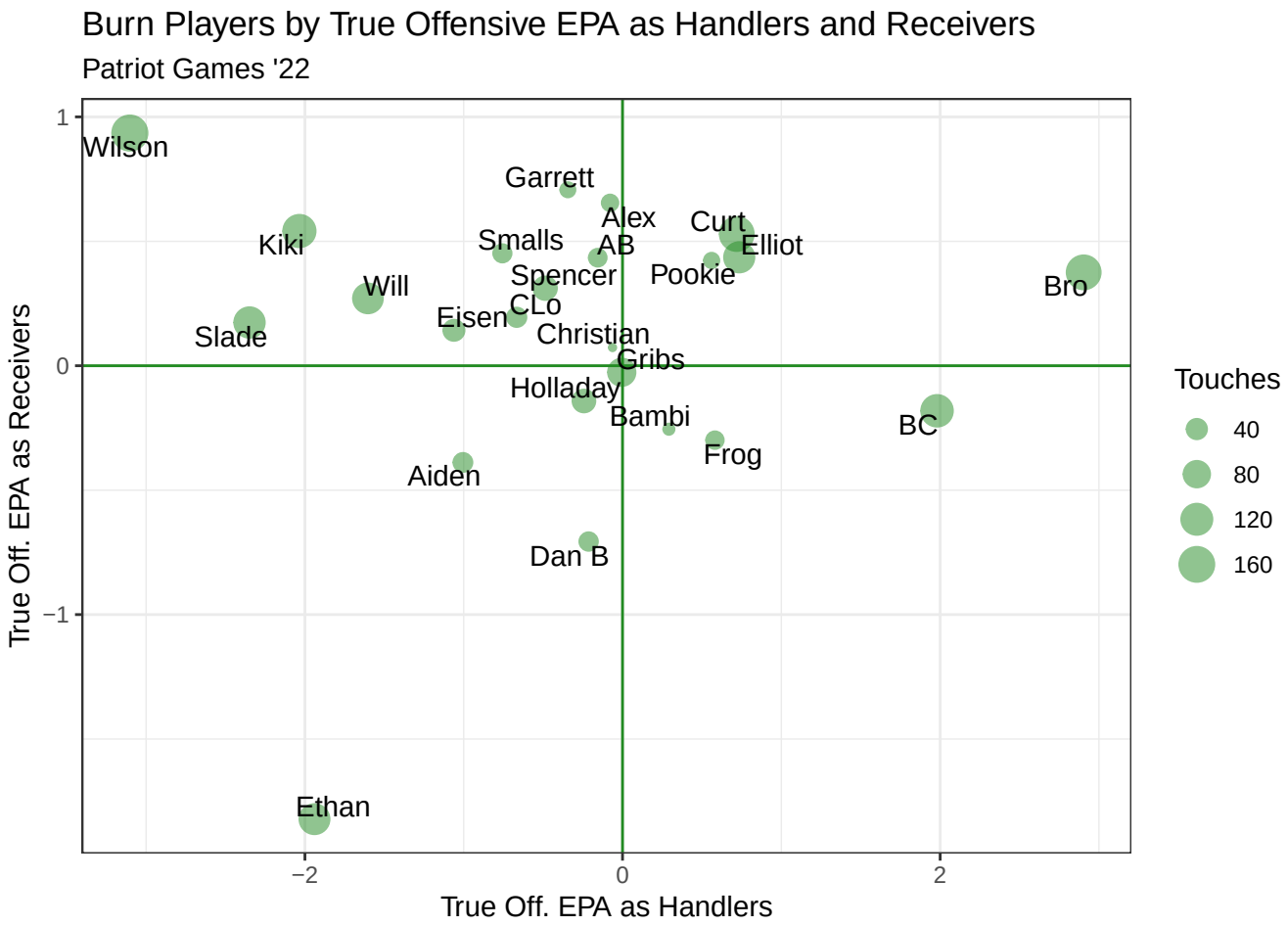


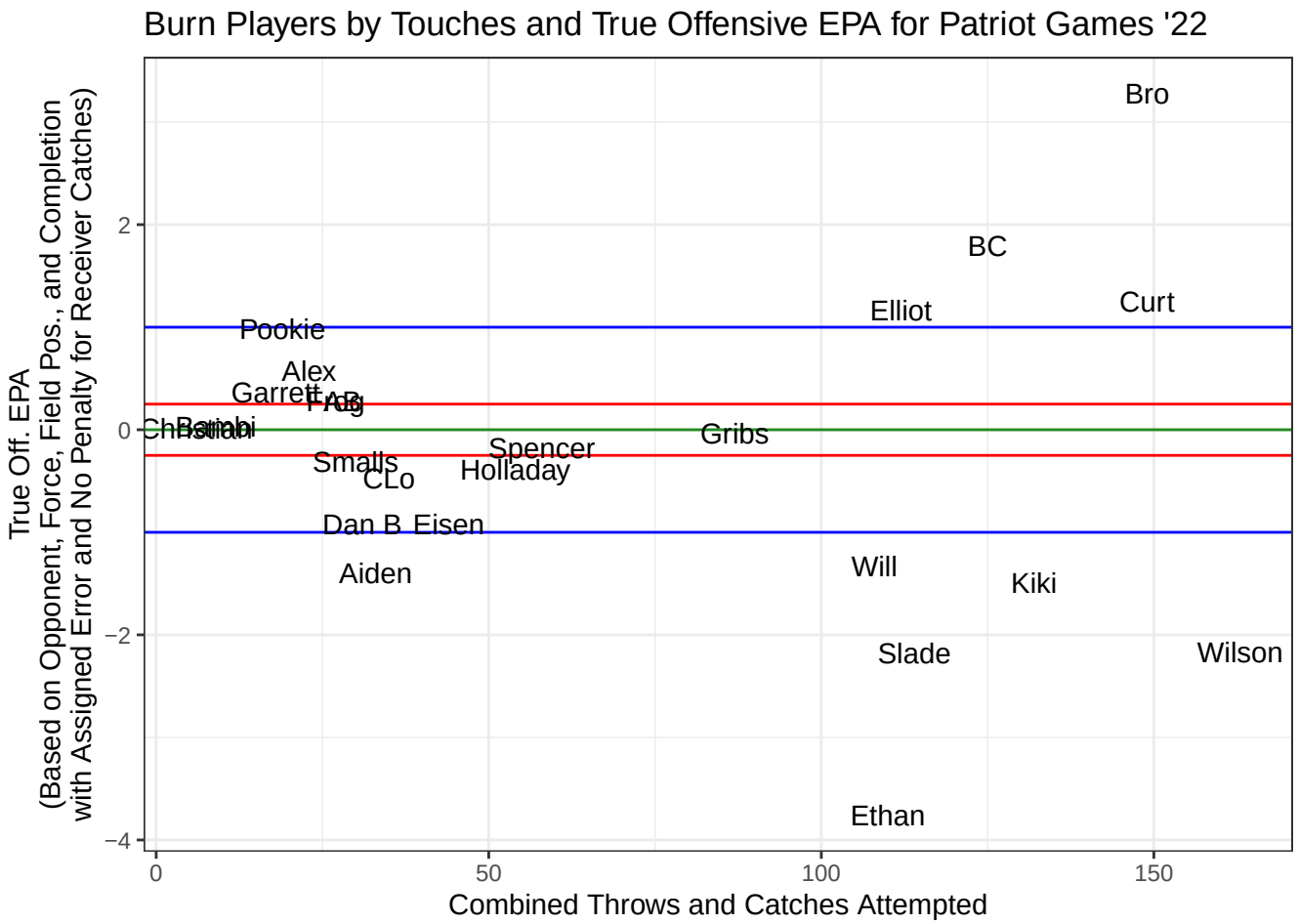
True EPA (name under construction) takes the premise of Basic EPA and goes further. It assigns error on turnovers (and even some completions). It gives no penalty for any negative catches for receivers, and it redistributes positive EPA responsibility to even out the total EPA of handlers and receivers. Errors were estimated with -1, -0.5, 0, 0.5 values and were double checked by a independent secondary source.

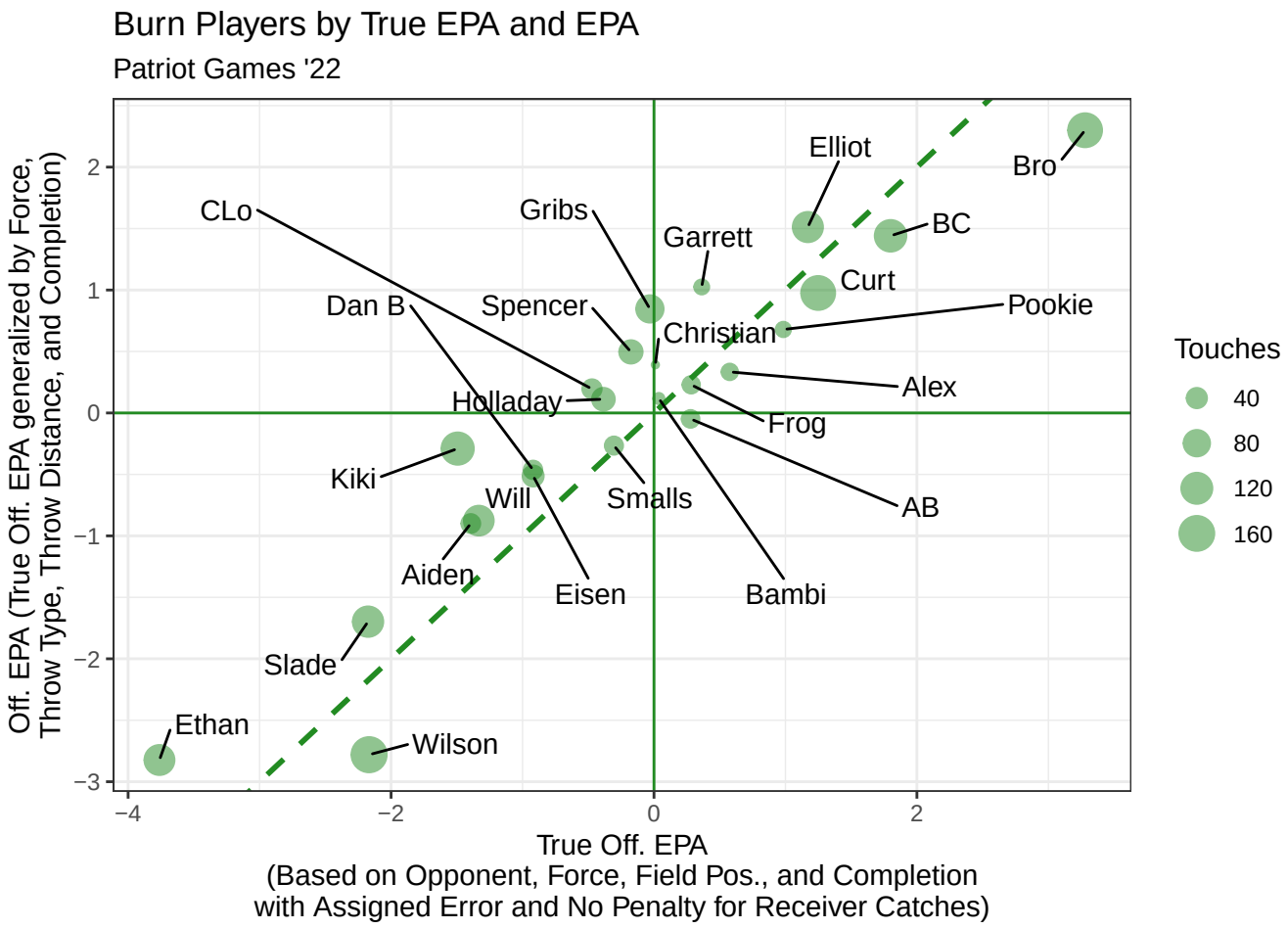
If I throw it away, I get 100% of the negative EPA and the receiver gets 0 EPA. If I make a poor but catchable throw that the receiver is unable to catch, we both get -0.5s and share the negative EPA evenly. If I make a poor but catchable throw and the receiver makes a great catch, I get -0.5 and the receiver gets 0.5, so I lose some EPA for making a risky throw and the receiver gains even more EPA by preventing a turnover. If I make a normal throw and the receiver just drops it, he gets -1 and 100% of the negative EPA.

The no penalty for receivers essentially means that receivers don't get penalized for catching a dump throw (any throw that hurts the team's position despite a completion). Instead, all the penalty goes to the handler for failing to make a better completion.

Because of this "blame game", handlers end up getting hurt in this metric, and most players have negative handler tEPA. To rectify, the positive EPA is redistributed (before error is introduced) between the handlers and receivers to offset the significantly more negative EPA the handlers get.


Burn Players by True Offensive EPA as Handlers and Receivers
Patriot Games '22
Wilson
Garrett
Alex
Curt
Kiki
Smalls
AB
Elliot
Spencer
Pookie
Bro
Will
CLo
Eisen
Slade
Christian
Gribs
Holladay
Bambi
BC
Frog
Aiden
Dan B
Ethan
1
0
−1
−2
0
2
True Off. EPA as Receivers
True Off. EPA as Handlers
Touches
40
80
120
160

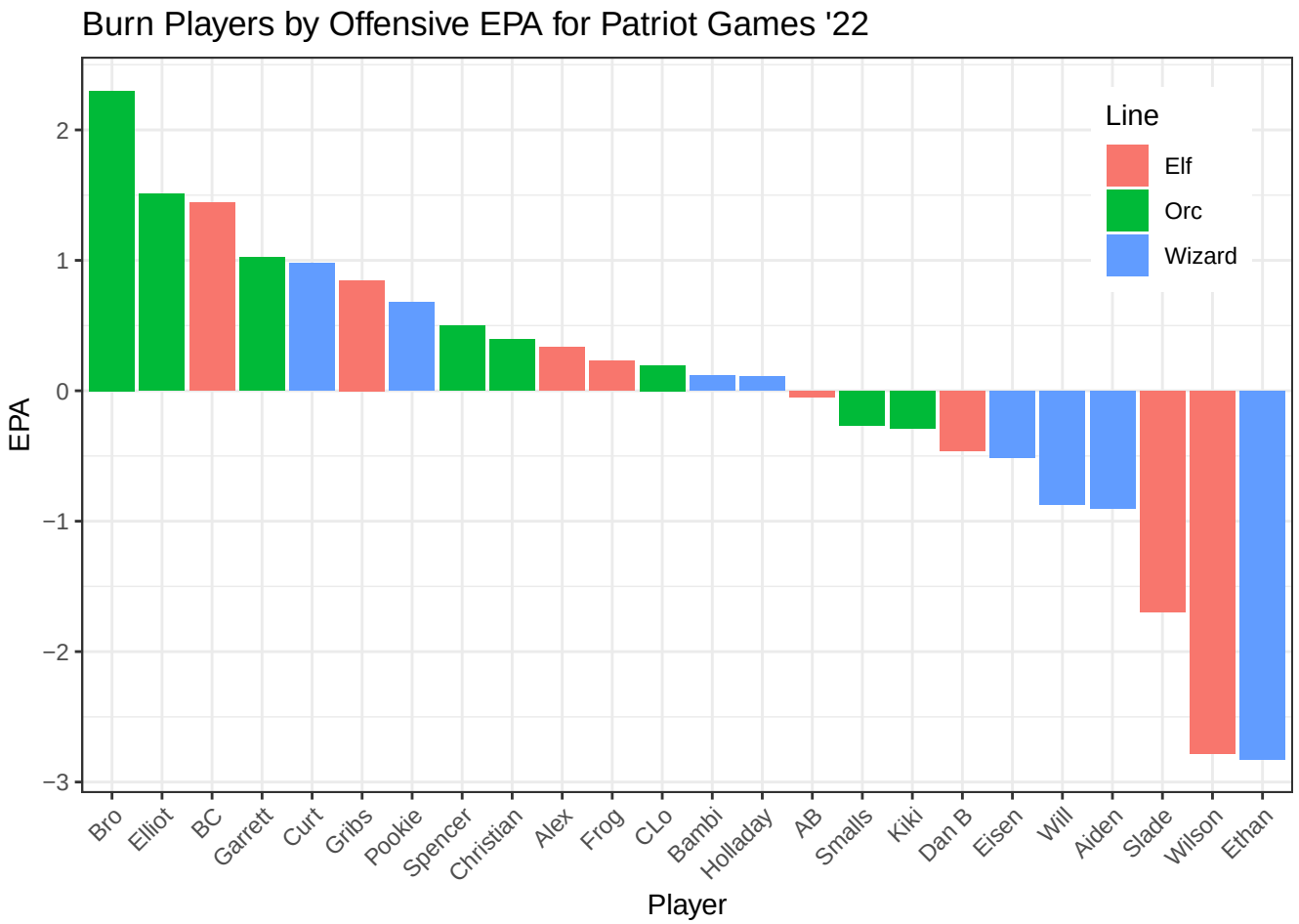

Burn Players by Touches and True Offensive EPA for Patriot Games '22
True Off. EPA
(Based on Opponent, Force, Field Pos., and Completion
with Assigned Error and No Penalty for Receiver Catches)
2
0
−2
−4
0
50
100
150
Combined Throws and Catches Attempted
Bro
BC
Elliot
Curt
Pookie
Alex
Garrett
Gribs
Spencer
Smalls
Holladay
CLo
Dan B
Eisen
Aiden
Will
Kiki
Slade
Wilson
Ethan



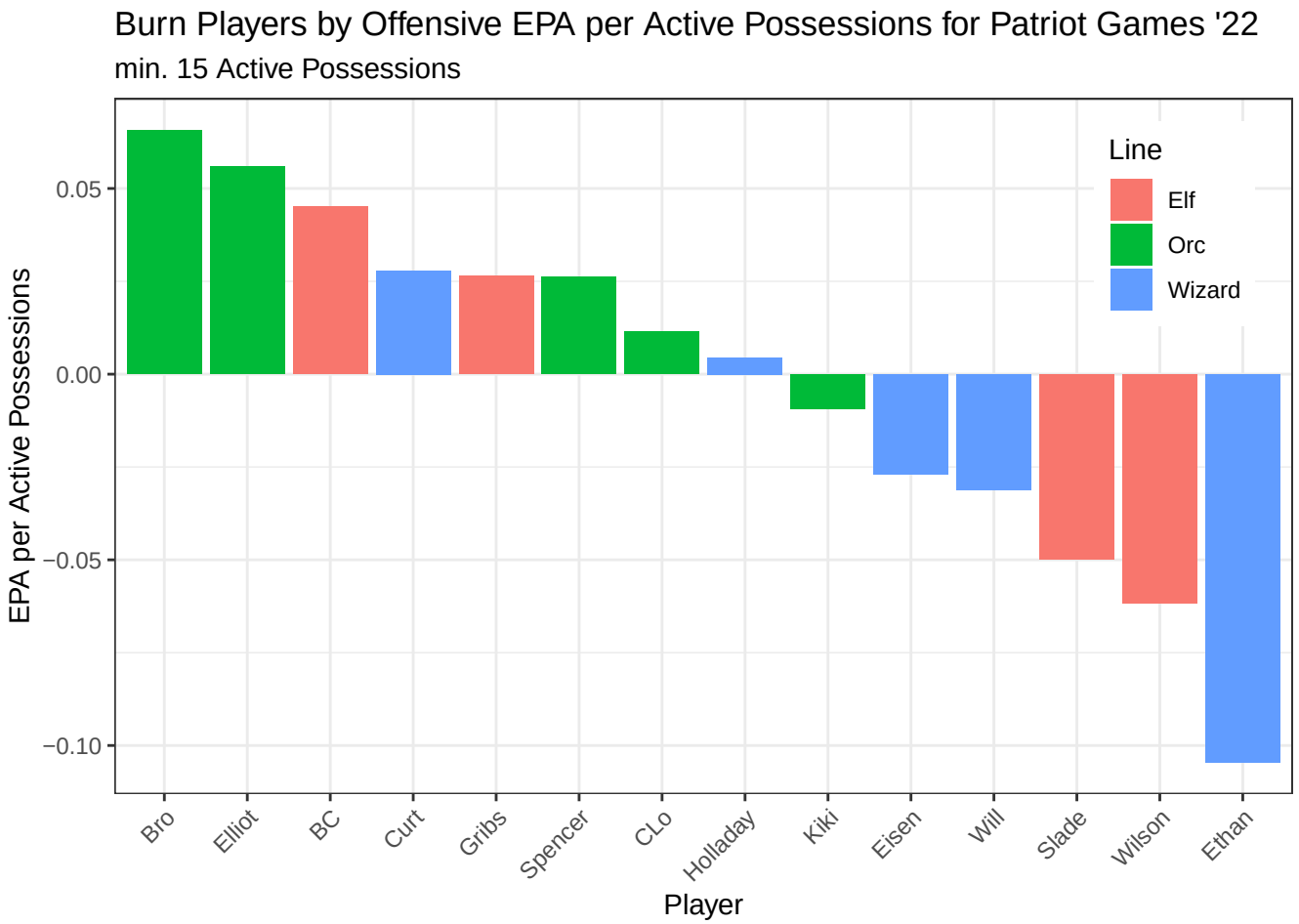
EPA (name definitely under construction) takes the premise of True EPA even further. Since the lines that separate the field zones are arbitrary, this metric generalizes each throw by force, throw type, throw distance, and completion and recalculates the EPA the exact same way. This is what I believe to be the most accurate measure of offensive value added I have created thus far.

While one upline may cross the line between d2 and c2 (thus accruing positive EPA), an equal upline may stay in the same zone (thus accruing 0 EPA). To remedy this, a logistic regression model was made to predict the EPA for each completed throw (a logistic regression model on top a logistic regression model). Now, for instance, uplines of a similar nature (force side, throw distance) are considered the same value. Error is still assigned, there is still no penalty for receiver catches, and the positive epa is still redistributed between handlers and receivers.

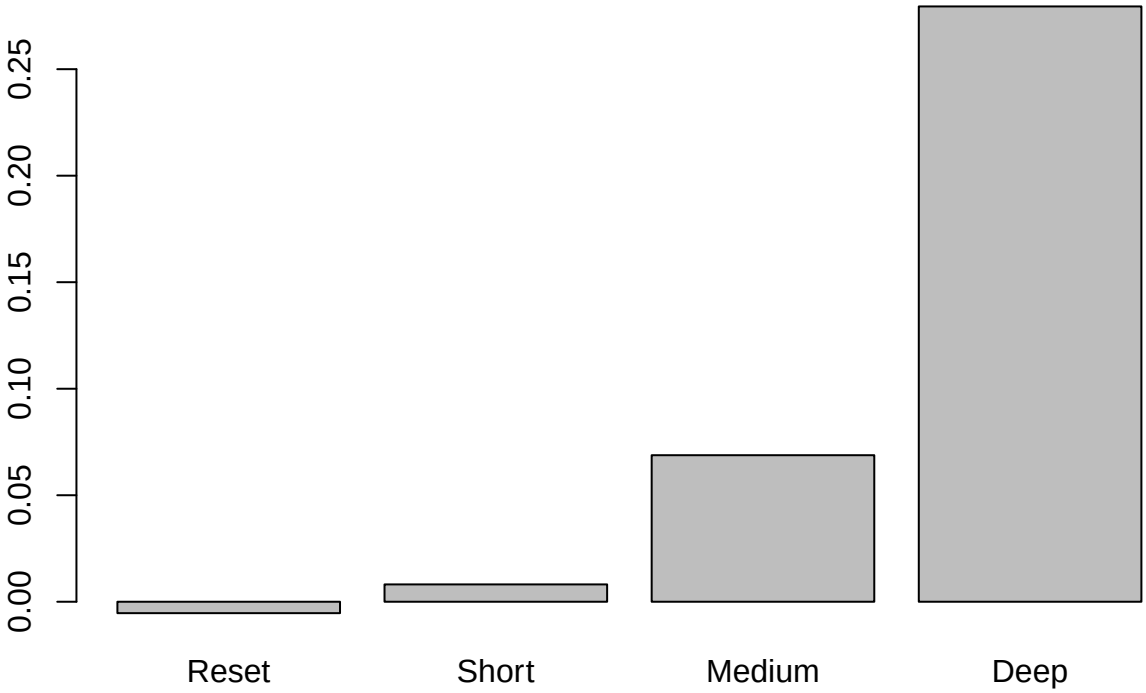
The other new thing about this EPA is that it is centered so the team has a total EPA of 0. This means it can essentially function as a points above average metric.

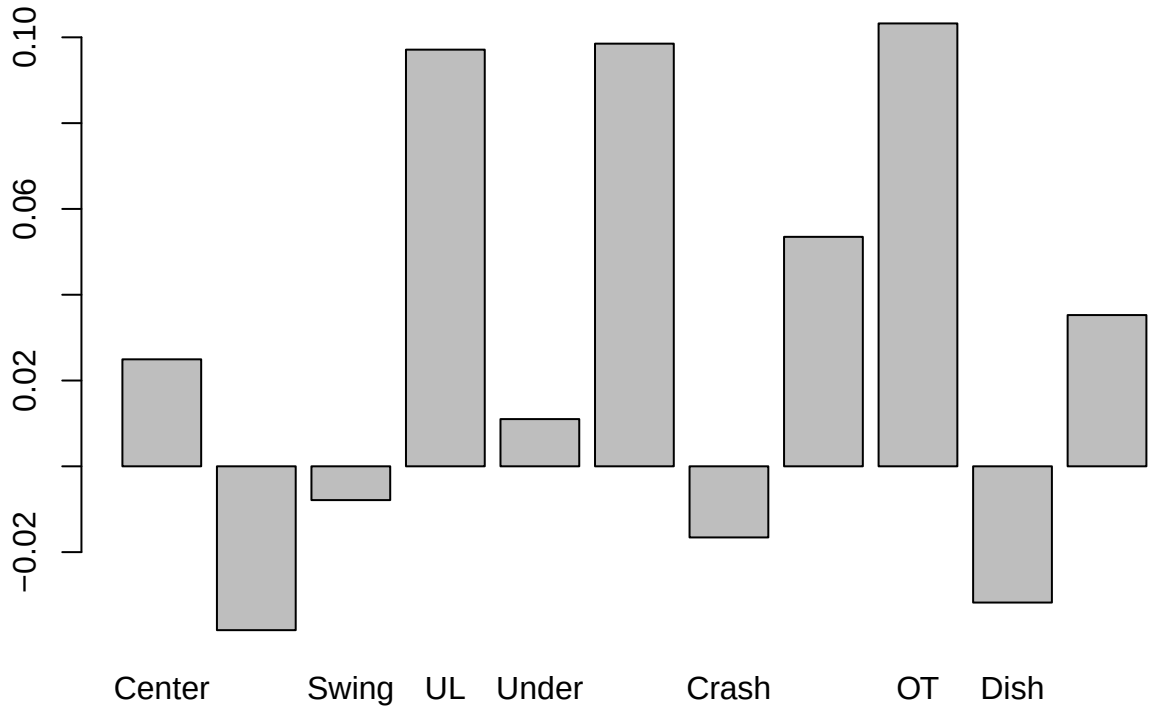


When looking at total EPA for players, we see that Orc players (green) are rated much higher than Elf players (red), who are rated a little higher than Wizard players (blue). When viewing this visual, we should see a mixture of player placements that aren't surprising and player placement that are surprising (a quality of a good metric).



This is essentially an EPA/possession plot. I chose possession as the denominator instead of play to avoid harming players who were forced to face a zone defense (where swings and crashes are more abundant).


0.00
0.05
0.10
0.15
0.20
0.25
Reset
Short
Medium
Deep


0.10
0.06
0.02
−0.02
Center
Swing
UL
Under
Crash
OT
Dish