**Under the Radar: Finding the NFL’s Least Appreciated Stars**

**By Cole Foster and Zoey Lee**

**1. Introduction-**

In the National Football League (NFL), there are few accolades more prestigious than the Pro Bowl, an award given to the best players at their position. This award is commonly used in debates between fans, but most importantly in contract negotiations for players. As the award is voted on by fans, coaches, and media, standards are incredibly inconsistent. An example of this is Matthew Stafford’s 2011 season, where he passed for over 5000 yards, a feat that has only been accomplished 12 times in the history of the 16-game season, yet he did not make the Pro Bowl. Our goal is to produce a model that will determine whether a player had a season deserving of a Pro Bowl selection. We will use this knowledge to find the most underrated and overrated players in the NFL. This will also allow us to determine the most important stats that contribute to a player being selected to the Pro Bowl.

**2. State of the art-**

Current research into the NFL is dominated by analysis of chronic traumatic encephalopathy (CTE). CTE is a condition that causes neurodegeneration, usually present in former athletes who sustained decades of head trauma playing contact sports such as football and combat sports such as boxing [1]. According to Ann et al., CTE is impossible to diagnose in living patients, so large-scale research is difficult at the moment. Current studies are constrained to using postmortem brains, and with such small sample sizes, studies are currently focused on understanding the mechanisms behind CTE rather than formulating a treatment [2]. The most common method of CTE prevention that is currently being researched is the impact of concussions. Many papers attempt to analyze concussions themselves, searching for better ways of identifying and treating concussions to avoid permanent neural damage. One of these papers studied 1631 college football players, 94 of which were concussed. The researchers found that standard concussion recovery times were much shorter than what players actually required for their health and well being, leading to pressure from medical experts on the NFL to change their concussion rules [3]. As for the Pro Bowl itself, one recent paper sought to answer the question, “How do we get players to play in the game?”. This was conducted using an in-depth analysis of player opportunity cost, weighing contract incentives versus injury risks and many other facts, attempting to construct a reasonable model for determining the worth of pro bowl attendance [4]. Overall, though modern research into the NFL is dominated by CTE and improving player safety, there is still research interest in aspects of the game and its culture, such as the pro bowl.

**Materials and Methods-**

*3.1 Data*

The player data used to train our model was obtained from the NFL’s website [5], while the Pro Bowl data was obtained from Pro Football Reference, a website dedicated to football stat keeping [6]. Both datasets were obtained using the beautifulsoup package in Python and saved in a csv file for importation into R. Since rules surrounding passing were drastically changed in 1994, we obtained data from 1994-2020, since the season was lengthened to 17 games in 2021. The dataset is split into three groups: Quarterbacks (QBs), Running Backs (RBs), and Wide Receivers (WRs). Each group has its own important stats:

|  |  |  |  |
| --- | --- | --- | --- |
|  | QBs | RBs | WRs |
| Stats | * Passing yards * Yards per attempt * Attempts * Completions * Completion% * Touchdowns * Interceptions * Rate * 1st downs * 1st down% * 20 yard passes * 40 yard passes * Longest pass * Sacks taken * Sack yards lost | * Rushing yards * Attempts * Touchdowns * 20 yard rushes * 40 yard rushes * Longest rush * 1st downs * 1st down% * Fumbles | * Receptions * Yards * Touchdowns * 20 yard receptions * 40 yard receptions * Longest reception * 1st downs * 1st down% * Fumbles |
| Number of Players | 165 | 224 | 240 |
| Number of Seasons | 675 | 674 | 645 |

The dataset was min-max scaled to gauge relative feature importance. Unimportant variables such as player name and year were removed. The dataset was divided into passing, rushing, and receiving stats, then each of these three groups were split 80/20 into a training set and test set.

*3.2 Statistical Learning Approaches*

We tested 3 classification models in order to compare which was best for evaluating our data: Radial SVM, LDA, and RandomForest. These models were selected because of their explainability and relative simplicity due to data constraints. Radial SVM cost and gamma hyperparameters were tuned to maximize performance. The best threshold was selected using the Receiver Operating Characteristic (ROC) curve. For RandomForest, the ntrees hyperparameter was tuned manually. No hyperparameter tuning was necessary for LDA.

*3.3 Performance Evaluation*

The first metric we used to compare models was the confusion matrix, specifically the F1 score. However, if the F1 scores of two models were similar (within 0.01), we took into account the shift in total pro bowls assigned. Since the Pro Bowl is a limited award, we wanted to encourage the model to award a similar amount of Pro Bowls overall. As such, models that awarded much more Pro Bowls (less strict) and much less (more strict) were penalized.

**4. Results-**

*4.1 Stat Importance*

LDA and RandomForest were used in order to understand which stats are most important for predicting whether a player will earn a Pro Bowl. These results are displayed for each position in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Model | QB | RB | WR |
| LDA |  |  |  |
| Random Forest |  |  |  |

A couple of interesting insights from this data are the value of volume, explosive plays, and turnovers. Volume refers to how many attempts or receptions a player has (how often they have the ball). An unexpected outcome is that high rushing attempts and receptions are inversely correlated with Pro Bowls while passing attempts are one of the most important stats for QBs. We speculate this may be a result of increased injury likelihood or lack of efficiency for skill positions. Next, an explosive play is a play that travels longer than 20 yards, and a highly explosive play travels longer than 40 yards. Though these plays do not seem very important to most positions, highly explosive plays are relatively more important for WRs than other positions. We speculate this may be a result of the subjective “explosiveness” of a player influencing voters. Finally, we would expect turnovers to hurt a player’s Pro Bowl odds, and while this is extremely true for QBs, it is nowhere near as much as a factor for WRs and RBs, we speculate this may be a result of interceptions being “unforced errors” (the QB messed up) while fumbles are “forced errors” (the player was hit incredibly hard). Overall, this data gives us a better understanding of the stats that voters consider when selecting players, whether consciously or subconsciously. Notably, both methods agreed in these aspects.

*4.2 Model Comparison*

Next, we used Radial SVM, LDA, and RandomForest to attempt to predict whether a player made a Pro Bowl or not based on their stats. The relevant statistics regarding accuracy for each model are in the tables below.

|  |  |  |  |
| --- | --- | --- | --- |
| **QB** | Radial SVM  (cost = 1, gamma = 0.5) | LDA | **RandomForest**  **(ntrees = 1000)** |
| Confusion Matrix |  |  |  |
| F1 Score | 0.5476 | 0.5000 | **0.5455** |
| Change in Total Pro Bowls | 16 | -47 | **-13** |

|  |  |  |  |
| --- | --- | --- | --- |
| **RB** | **Radial SVM**  **(cost = 1, gamma = 0.5)** | LDA | RandomForest (ntrees = 1000) |
| Confusion Matrix |  |  |  |
| F1 Score | **0.7532** | 0.7419 | 0.6479 |
| Change in Total Pro Bowls | **-5** | -45 | 1 |

|  |  |  |  |
| --- | --- | --- | --- |
| **WR** | Radial SVM  (cost = 1, gamma = 0.5) | LDA | **RandomForest**  **(ntrees = 1000)** |
| Confusion Matrix |  |  |  |
| F1 Score | 0.6744 | 0.7089 | **0.7000** |
| Change in Total Pro Bowls | -3 | -42 | **-5** |

The best model for each position was selected based on a combination of highest F1 score and lowest change in total Pro Bowls. As a result, we can see that RandomForest outcompetes the other models for QBs and WRs, while Radial SVM is superior for RBs. We speculate this may be a result of RBs being more separable with a Bayes classifier, while QBs and WRs are more complex, potentially due to WRs and QBs being more common in media narratives that influence voters. A related observation is that models for RBs and WRs perform much better than they do on QBs, likely due to them being the most prevalent in media narratives leading to voter bias. Throughout all models, LDA is shown to be much more “strict” when choosing Pro Bowlers, consistently removing more than 40 Pro Bowl seasons, while the other models tend to be much closer to even.

*4.3 Player Evaluation*

Next, we use our models to determine the most overrated and underrated players in the last 30 years. The results are shown in the table below.

|  |  |  |
| --- | --- | --- |
| **QB** | Overrated | Underrated |
| 1 | Dan Marino (-2) | Trent Green (+2) |
| 2 | Rich Gannon (-2) | Ryan Tannehill (+1) |
| 3 | Troy Aikman (-2) | Chad Pennington (+1) |
| 4 | Brad Johnson (-1) | N/A |
| 5 | Brian Griese (-1) | N/A |

|  |  |  |
| --- | --- | --- |
| **RB** | Overrated | Underrated |
| 1 | Marshall Faulk (-3) | Fred Taylor (+3) |
| 2 | Jerome Bettis (-2) | Clinton Portis (+2) |
| 3 | Ahman Green (-1) | Tiki Barber (+1) |
| 4 | Arian Foster (-1) | Shaun Alexander (+1) |
| 5 | Le’Veon Bell (-1) | LaDainian Tomlinson (+1) |

|  |  |  |
| --- | --- | --- |
| **WR** | Overrated | Underrated |
| 1 | Amari Cooper (-1) | Roddy White (+3) |
| 2 | Antonio Freeman (-1) | Steve Smith (+2) |
| 3 | Calvin Johnson (-1) | Marques Colston (+1) |
| 4 | Chris Godwin (-1) | Dez Bryant (+1) |
| 5 | Cris Carter (-1) | Demaryius Thomas (+1) |

A notable trend in the QB position is that the most “overrated” players are all from the beginning of our data range, which started in 1994. This shows how much the QB position has grown due to skill increases and rule changes. While we would expect to see a similar trend with WRs, a more fascinating trend emerges. Most of the underrated players were active from 2005-2015 and played in the NFC South. As one of the weakest divisions in the league, it makes sense that NFC South teams wouldn’t receive as much media attention, potentially leading to players not being selected to the Pro Bowl. While Cris Carter and Antonio Freeman are older WRs and would fit the idea of the older WRs being slightly “overrated”, the “overrated” WRs are well spread throughout the decades. For the RBs, though they all were in their primes in the early-to-mid 2000s, it’s difficult to see exactly why this period would cause RBs across the league to be underrated. One idea is the passing explosion across the league was causing decreased focus on RBs, but this is just speculation.

**5. Conclusion-**

In this study, we researched the NFL Pro Bowl. Our questions were: “What stats are most important for Pro Bowl Selection?”, “Can we make a model to predict whether a player will be a Pro Bowler or not?”, and “Can we use our model to find the most overrated and underrated players in the NFL?”. For the first question, we found that important stats differed greatly across positions, such as volume being an asset for QBs while a detriment for WRs and RBs. Inversely, we found that QBs are punished much more for turnovers than WRs and RBs. We also found that there is much more emphasis on explosive plays for WRs compared to RBs and QBs. As for our models, we found Pro Bowl selection prediction to be a difficult computational task. However, this was expected due to the previous pro bowl selections containing media bias. The idea behind our model is similar to a variational graph autoencoder, we want our model to be as accurate as possible, while slight information loss (class flips) gives us information about which player seasons may have been deserving/undeserving of a Pro Bowl. RandomForest performed best for QBs and WRs, while Radial SVM performed the best for RBs. QBs were notably more difficult to classify than RBs and WRs. As for “overrated”/“underrated” players, a couple interesting trends arose. “Overrated” QBs tended to be from the 90s, since the passing rule changes weren’t widely adopted and the passing explosion was just starting. “Underrated” RBs tended to be from the early-to-mid 2000s, potentially being overshadowed as the passing explosion started to pick up steam. For WRs, many of the “underrated” WRs played in the NFC South, a historically bad division during an era of inconsistency. This inconsistency resulted in less media attention for these teams, potentially leading to their players becoming “underrated”. For “overrated” WRs, we expected to see older WRs similar to how we observed older QBs being more “overrated”, but this was not the case. The clear progression of this work would be to include other positions such as CBs, DBs, etc., and expand the window of players to more years, finding some way to account for year-to-year rule changes and the evolution of the game. A similar model can also be applied to other awards in the NFL, such as the All-Pro award, or awards in other sports, such as the All-Star game in the NBA.

**6. Citations-**

1. Ann C. McKee, Robert C. Cantu, Christopher J. Nowinski, E. Tessa Hedley-Whyte, Brandon E. Gavett, Andrew E. Budson, Veronica E. Santini, Hyo-Soon Lee, Caroline A. Kubilus, Robert A. Stern, Chronic Traumatic Encephalopathy in Athletes: Progressive Tauopathy After Repetitive Head Injury, Journal of Neuropathology & Experimental Neurology, Volume 68, Issue 7, July 2009, Pages 709–735
2. McKee AC, Stern RA, Nowinski CJ, Stein TD, Alvarez VE, Daneshvar DH, Lee HS, Wojtowicz SM, Hall G, Baugh CM, Riley DO, Kubilus CA, Cormier KA, Jacobs MA, Martin BR, Abraham CR, Ikezu T, Reichard RR, Wolozin BL, Budson AE, Goldstein LE, Kowall NW, Cantu RC. The spectrum of disease in chronic traumatic encephalopathy. Brain. 2013 Jan;136(Pt 1):43-64. doi: 10.1093/brain/aws307. Epub 2012 Dec 2. Erratum in: Brain. 2013 Oct;136(Pt 10):e255. PMID: 23208308; PMCID: PMC3624697.
3. McCrea M, Guskiewicz KM, Marshall SW, Barr W, Randolph C, Cantu RC, Onate JA, Yang J, Kelly JP. Acute effects and recovery time following concussion in collegiate football players: the NCAA Concussion Study. JAMA. 2003 Nov 19;290(19):2556-63. doi: 10.1001/jama.290.19.2556. PMID: 14625332.\
4. Kunz-Kaltenhäuser, Philipp. Is the NFL's Pro Bowl Broken?: Considering the Players' Perspective. No. 149. Ilmenau University of Technology, Institute of Economics, 2021.
5. “Official Site of the National Football League.” NFL.Com, National Football League, www.nfl.com/stats/player-stats/. Accessed 9 Apr. 2024.
6. “NFL pro Bowlers.” Pro Football Reference, www.pro-football-reference.com/years/1994/probowl.htm. Accessed 9 Apr. 2024.