SUSTAINABILITY & SPORTS SCIENCE JOURNAL

ORIGINAL ARTICLE

Carbon emission in football games: Footprint impact of power five conference realignment

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ABSTRACT

Abstract: The environmental impact of carbon dioxide emissions arising from travel has emerged as a significant concern. Notably, the recent frequent realignments within the Power Five conferences have led to substantial fluctuations in the annual carbon footprint of football games played between member teams. In this comprehensive study, we collected and analysed conference data spanning the previous decade, as well as forthcoming schedules (wherever available), to evaluate shifts in this carbon emissions footprint. Our findings underscore the potential environmental ramifications of the impending realignment, commencing in 2024, revealing the possibility of an almost twofold increase in carbon emissions.

Keywords: Environment, Power Five, Carbon dioxide emissions, Footprint, Environmental consciousness, Climate change.

Cite this article as:
Hong, J., Sheguri, S., Askin, R. G., & Maciejewski, R. (2024). Carbon emission in football games: Footprint impact of power five conference realignment. *Sustainability and Sports Science Journal*, *2*(2), 98-106. https://doi.org/10.61486/KDVT9069

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Submitted for publication February 19, 2024.
Accepted for publication March 13, 2024.
Published March 15, 2024.
Sustainability and Sports Science Journal. ISSN 2990-2975.

Identifier: https://doi.org/10.61486/KDVT9069

INTRODUCTION

Social development has given rise to increased greenhouse gas emissions, contributing to climate change as evidenced by global warming. According to the Environmental Protection Agency's annual report for 2021[1], transportation accounted for the largest share of U.S. Greenhouse Gas Emissions by Economic Sector. This concern is also prevalent in the sports community, as regular games involve extensive domestic and international travel, resulting in a substantial carbon footprint (Trendafilova et al., 2014). (We note that increased travel across time zones may also impact individual health and student educational experience, but we focus on environmental impacts in this paper). It is also worth noting that major sporting events can potentially serve as a platform to raise public awareness about environmental sustainability (Casper et al., 2014). In this work, we examined the carbon footprint generated by the Power Five Football Conferences, spanning from 2010 to the most recent schedule announcements. We specifically focused on the Power Five College Football Conferences, which are part of the Football Bowl Subdivision (FBS) of the National Collegiate Athletic Association (NCAA) and comprise the top-performing teams in the United States. These conferences include the Atlantic Coast Conference (ACC), Big Ten Conference, Big 12 Conference, Pac-12 Conference, and Southeastern Conference (SEC). The alignment of schools in these conferences has evolved over time. Before 2000, schools were grouped into conferences primarily consistent with proximate geographical locations. However, as time has progressed, conferences have undergone frequent realignments. Notably, in 2024, there are plans for the realignment of numerous institutions, resulting in new cross-country trips for schools such as UCLA, USC, Cal-Berkeley, Oregon, Washington, and Stanford. Our data collection process involved gathering information on conference matches, including venue locations, home and away teams, the flight distances involved, as well as the approximate carbon costs. Our analysis indicates that the new alignments will produce nearly twice the amount of carbon dioxide emissions.

MATERIAL AND METHODS

In this section, we report our methods of collecting and processing data to obtain the footprint of games. Since the footprint depends on the distance between the away team and the game stadium, we first extracted the schedules (2010-2023) from College Football Data API[2], which was chosen for its comprehensive coverage of NCAA football games with a specific focus on the Power Five conferences. We obtained the future schedules from the conferences' official websites. The conference alignments in 2010 and 2024 are visualized in Figure 1. We calculated the estimated carbon emission for each game based on the following formula:

Carbon Emissions (kg CO_2) = Distance (nautical miles) × 1.852 × Emission Factor (kg CO_2 per km) × Number of Trips × Number of Travelling Passengers

This formula takes into account several factors. First, the "*Distance*" is initially converted from nautical miles to kilometers using the conversion factor of 1.852. This conversion aligns with standard practices in navigation, where 1 nautical mile is approximately equal to 1.852 kilometers[3]. The "*Emission Factor*" is a key component that varies based on the mode of transportation. For air travel, a typical emission factor for a

[1] *Retrieved from [Accessed March 13, 2024]: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks*
[2] *Retrieved from [Accessed March 13, 2024]: https://collegefootballdata.com/exporter/games*
[3] *Retrieved from [Accessed March 13, 2024]: https://oceanservice.noaa.gov/facts/nautical-mile-knot.html?ref=driverlayer.com/web*

Boeing 737 is 115g of CO_2 per passenger per kilometer[4]. Conversely, for bus travel, an emission factor of 20.04g of CO_2 per kilometer is utilized[5]. In the context of NCAA football games and sustainability considerations related to conference realignments, the "*Number of Trips*" is fixed at 2. The number accounts for one trip to the game venue and one return trip to the university. This approach is crucial for providing an accurate assessment of the environmental impact associated with travel to and from sporting events.

In our analysis process, we made assumptions as follows:

- We only consider the intra-conference matches as we aim to explore the effects of alignments on carbon costs within Power Five;
- We calculated the carbon footprint based on the travel distance between the away team stadium and venue, standardizing the calculations for factors such as the airplane type and the number of individuals , including team members, staff, and associated personnel assumed to be a 65% full Boeing 737-400;
- We did not account for the carbon footprint from the team stadium to the airport, as its impact is negligible;
- We assume that teams travel by plane if the distance is longer than 200 miles. Otherwise, we assume that they travel by bus for the match. For the bus travel, we used road miles instead of nautical miles;
- We calculated the average carbon footprint of each match in different seasons for every conference.
- Only team travel is considered, fan travel to venues could be substantial but is difficult to estimate. Effectively, we assume fan travel patterns would remain similar and thus simply serve to provide a multiplicative effect to observed differences in carbon footprint.

For all teams in the Power Five conferences, we extracted season, venue, home, and away teams. Season indicates the year when the game was played. Venue refers to the location of the game, which is crucial for assessing travel-related sustainability factors. Home and away teams provide context for each game and support the distance calculation. Then, for each venue, we collected the geo-position data from Google Map and calculated the travel distance for the away team. We simulated the carbon costs of flights with the Python Library codecarbon.

We visualize the carbon cost change trends of individual conferences in football games with line charts as shown below. We also added detailed information of conference realignments on the charts. We estimated the average carbon cost per game of each conference and reported them following the descending order of their average travel distance in 2024.

First, we examined the ACC conference footprint (Figure 2). Up until 2024, the carbon cost of the ACC conference remained relatively stable. When Pittsburgh and Syracuse joined in 2013, there was an increase of 1,553 kg compared to 2012. In 2014, with Louisville joining and Maryland leaving, the carbon cost rose by 750 kg. The upcoming realignment in 2024 is expected to significantly escalate carbon dioxide emissions, soaring from approximately 26,395 kg to 52,412 kg, mainly due to the addition of California, Stanford, and SMU to the ACC. Consequently, emissions in 2024 are projected to nearly double compared to 2023.

[4] *Retrieved from [Accessed March 13, 2024]: https://www.carbonindependent.org/22.html#:~:text=CO2%20emissions%20from%20aviation%20fuel%20are%203.15,90%20kg%20CO2%20per%20passenger%20per%20hour*

[5] *Retrieved from [Accessed March 13, 2024]: https://travelandclimate.org/transport-calculations#:~:text=The%20calculation%20is%20also%20based,of%20CO2%20per%20passenger%20kilometer*

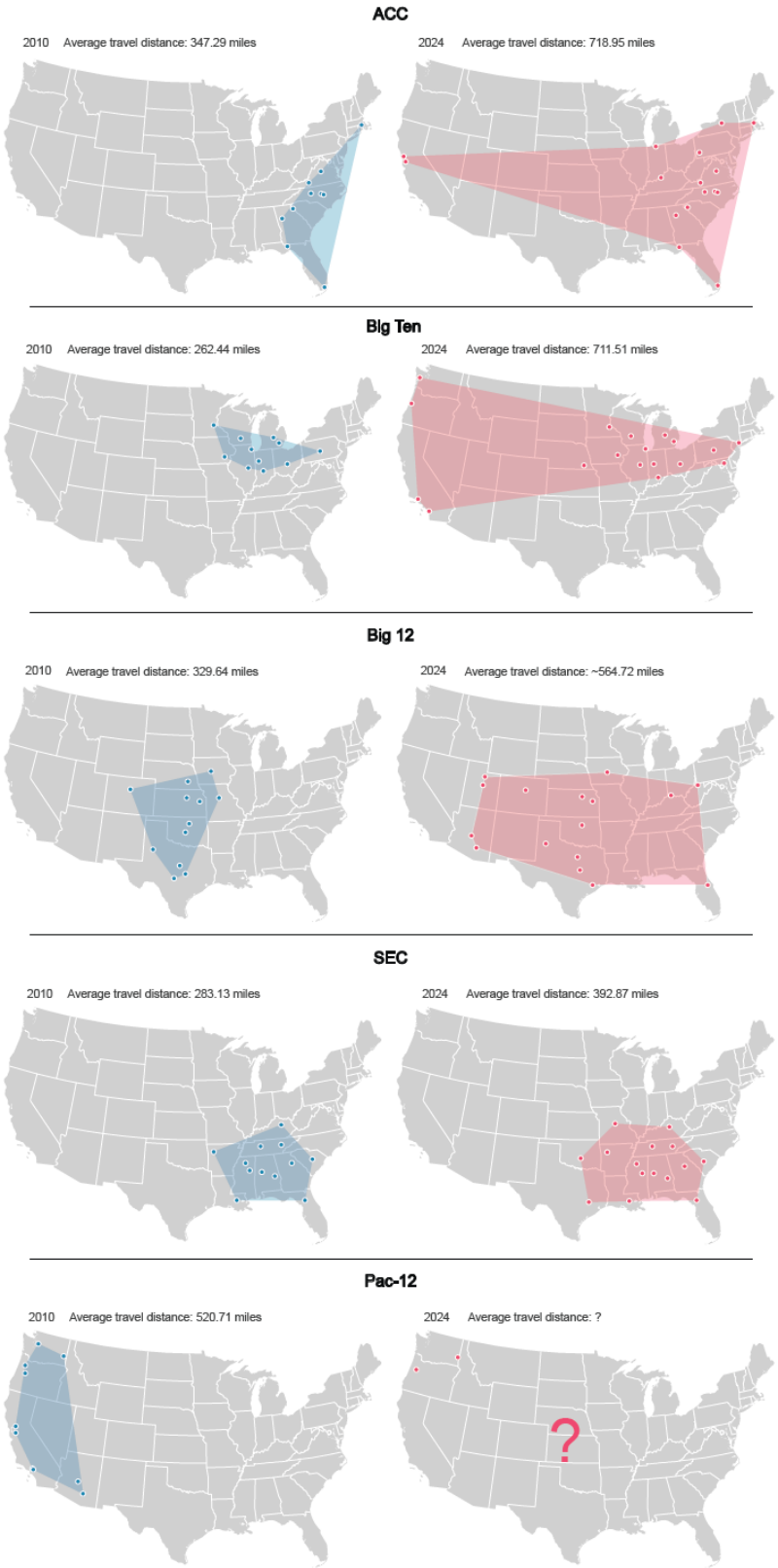

Figure 1. The alignment changes of each conference from 2010 to 2024 (arranged in descending order of average travel distance in 2024).

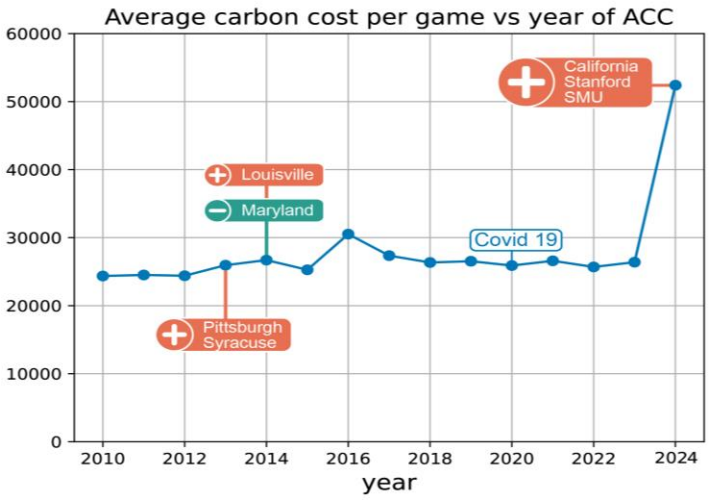

Figure 2. The average carbon cost per intraconference game of ACC football games from 2010-2024.

RESULTS

Every realignment of the Big Ten conference leads to a rise in carbon emissions, reflecting the conference's ongoing growth. When Nebraska joined in 2011, emissions increased by 16% the following year. In 2014, with Maryland and Rutgers joining, emissions rose by 6% compared to the previous year. The trend is expected to continue in 2024, mirroring the ACC's emissions pattern. Projections for 2024 show emissions reaching 56,502 kg, a 2.48-fold increase from 2023's 22,790 kg. This surge is primarily due to new member schools from the west coast, such as USC, UCLA, Oregon, and Washington, moving from the Pac-12 to the Big Ten. These additions will necessitate numerous cross-country trips, significantly boosting emissions. However, emissions are predicted to stabilize in the subsequent years, as depicted in Figure 3.

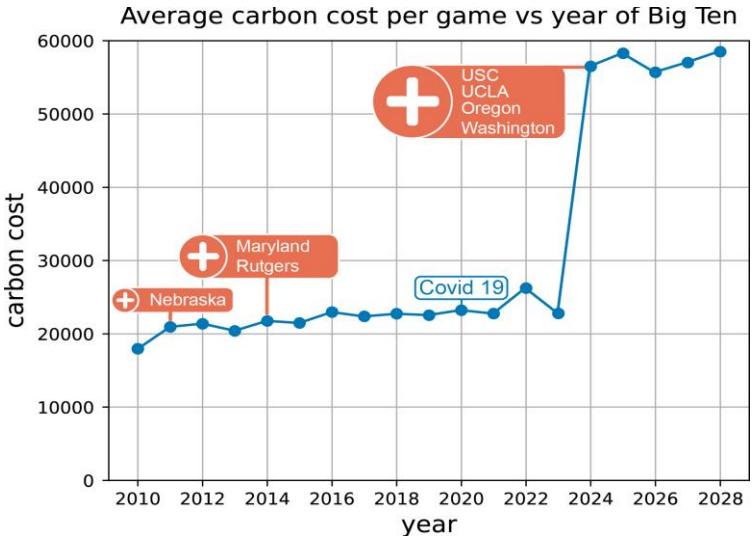

Figure 3. The carbon cost of Big Ten football intraconference games from 2010-2028.

Despite losing two teams, Colorado and Nebraska, in 2011, the Big 12 saw a 1,915 kg increase in the average carbon cost per game. Subsequently, in 2012, when Missouri and Texas A&M departed and West Virginia and TCU joined, the carbon cost rose by 6,381 kg, accounting for over 25.37% of the costs in 2011. The trend of increasing carbon dioxide emissions is expected to continue for the Big 12 in 2023 and 2024 (see Figure 4). In 2023, four schools—BYU, Cincinnati, Houston, and UCF—joined the conference, leading to a 32.59% increase in carbon cost. This trend is set to continue in 2024, with Colorado, Utah, Arizona, and Arizona State joining, resulting in a 23.65% increase in carbon cost.

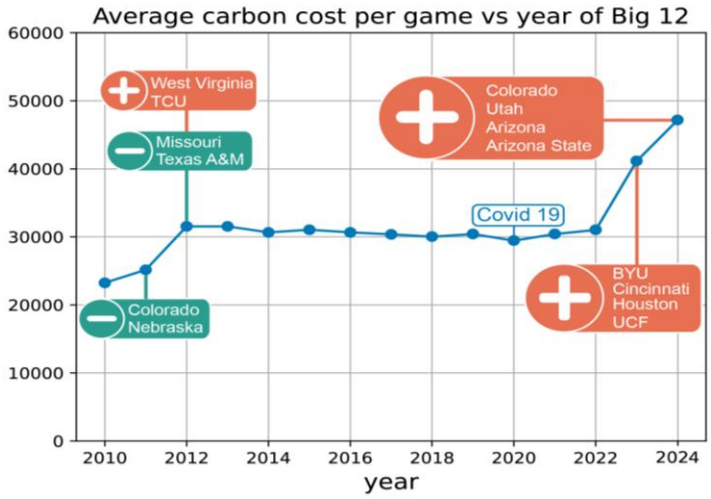

Figure 4. The carbon cost of Big 12 intraconference football games from 2010-2024.

The carbon footprint remained roughly stable during the years (2010-2022) for the Pac-12, though in 2020, because of Covid-19, the carbon emission decreased from 37740kg in 2019 to 32279kg in 2020, and in 2023, it increased a little bit compared again as seen in Figure 5. It creased from around 37816kg to about 44224kg, indicating a growth of 6418kg. The potential carbon dioxide emission in 2024 remains unknown as ten schools are leaving the Pac-12, namely USC, UCLA, Oregon, Washington, Colorado, Utah, Arizona, Arizona State, California, and Stanford.

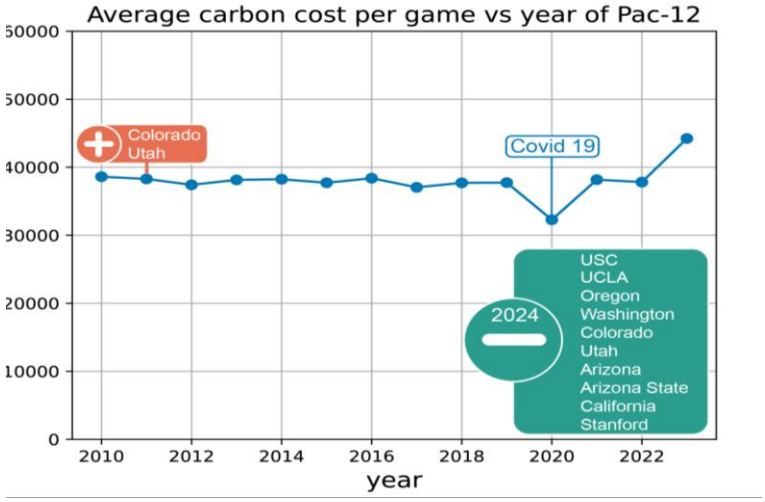

Figure 5. The carbon cost of Pac-12 intraconference football games from 2010-2023.

Overall, SEC is the conference that produced the least carbon cost per game. When Missouri and Texas A&M joined the SEC in 2012, carbon costs increased by 3,007 kg, marking a 15.19% rise from 2011. Despite no changes in membership since then, the SEC will experience a 5.31% increase in carbon costs in 2024 compared to 2023, as Texas and Oklahoma are set to join the conference (Figure 6).

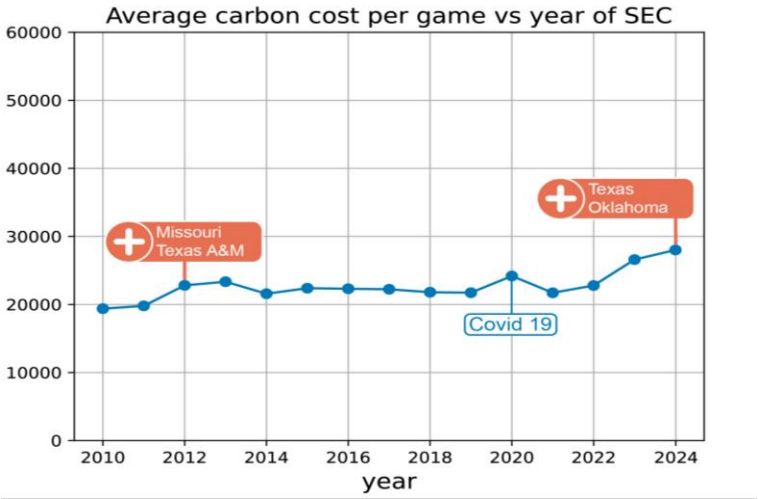

Figure 6. The carbon cost of SEC intraconference football games from 2010-2024.

DISCUSSION

Analyzing the results, it becomes evident that recent realignments have, on the whole, led to a significant increase in carbon dioxide emissions. This escalation can be primarily attributed to the broadening of conference boundaries, particularly in the cases of the ACC, Big Ten, and Big 12 conferences as seen in Figure 1. To illustrate this point, we take California as an example. According to its most recent schedule announcement, California teams will travel extensively across the country in 2024. These journeys include destinations such as Miami, Pittsburgh, Syracuse, and Oregon State, covering considerable distances. It is important to acknowledge that realignment decisions are multifaceted, taking into account factors such as recruiting opportunities, the economic impact on fans and schools, and the intensity of games. Yet, we contend that there is potential to strike a more optimal balance between the benefits and environmental costs of these realignments. One potential avenue for achieving this goal is to consider the geographical proximity and competitive skill levels of schools when making realignment decisions. By aligning schools that are closer to each other both geographically and in terms of performance, tradition, and academic mission, it may be possible to reduce the carbon footprint associated with travel as well as maintain the excitement of games. Additionally, a strategic approach could involve a thorough review of the scheduling process. For instance, in the case of the 2024 realignment in the Big Ten, where teams are spread across the country, it may not be feasible for every team to play every other team. In such scenarios, organizing matches between teams with shorter travel distances can be an ideal solution. The use of geographically defined conference divisions, since every team can not play every other team in large conferences anyway, is a simple and logical approach for reducing carbon footprint. Furthermore, arranging games in close proximity to each other can also help minimize travel-related emissions. For example, the Big 12 includes Arizona, Arizona State, and Iowa State in 2024. If a scheduling arrangement is made for Iowa State to compete against both Arizona and Arizona State, a more practical approach would be to schedule these games in close temporal proximity. By doing so, Iowa State can avoid the need for two separate trips to Arizona, significantly reducing travel-related

emissions. Similarly, when one team is required to cover a substantial distance to participate in a game, it makes sense to consider scheduling additional matches with teams located along the way. This approach not only minimizes the overall travel burden but also contributes to a reduction in carbon emissions associated with air travel. While this may be impractical for football, this approach is often applied to other sports such as baseball and basketball, and could be extended. Even in football, consideration of schedules such as Saturday - Wednesday instead of Saturday only might facilitate combining two distant trips. As for future work, we plan to develop more statistically driven descriptive simulation approaches and prescriptive optimization approaches to assess the impact of realignments and minimize environmental/personal impacts, thus providing decision-makers with insights to identify the most sustainable solutions for school alignments. Incorporating demographic data by geographic region will provide an opportunity to prescribe conference and division alignments that minimize environmental impact subject to desired levels of population and economic fan-based coverage. Additionally, we aim to create an interactive tool to facilitate this decision-making process.

CONCLUSIONS

In this manuscript, we comprehensively studied the carbon emissions associated with football intra-conference matches within the Power Five since 2010. Our analysis revealed a significant surge in carbon footprint in the year 2023, and it is projected to continue its upward trajectory in the subsequent years. This increase can be primarily attributed to the spatial expansion resulting from recent realignment initiatives.

AUTHOR CONTRIBUTIONS

Jiayi Hong: formal analysis, writing - original draft. Sia Sheguri: formal analysis, writing - original draft. Ronald G. Askin: methodology, writing - review & editing. Ross Maciejewski: conceptualization, methodology, writing - review & editing, supervision, project administration.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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