



# Testing the Impact of Penalty Areas on Golfer Performance

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*Dave Pierce, August 23, 2023*

## 1. Summary

A study on the impact of penalty areas on golfers' driving behaviors and performance was completed on the 1<sup>st</sup> hole of Pinehurst Resort Course No. 2 in July 2021. The golfers were incentivized to perform well in a competitive format by awarding prizes for the lowest gross and net scores.

All of the golfers tested decided to hit their driver on every tee shot. All verbally stated that they were most confident choosing to hit driver on a Par 4 hole of at least medium length and did not alter their swing effort. Also, nearly all golfers tested verbally stated that they did not change their aim point while a few did state that they somewhat favored the side of the fairway opposite a one-sided hazard situation.

TrackMan launch conditions did match their verbal statements for swing speed but did not always match their verbal statement for aim point. While golfers swing speed was unchanged throughout, they strongly aimed away from the close out of bounds hazard when on the fade side. Golfers somewhat aimed to the draw side when two sided hazards were in play, indicating that at least subconsciously, they knew a fade hazard was more in-play and needed to compensate by aiming away from it.

Specifically, penalty areas outside of a 30-yard-wide fairway with 5 yards of rough on either side are in play and affect a golfer's aiming behavior. However, based on no measured changes in swing speed, it is unlikely that players will consciously or subconsciously reduce their driving distance based on penalty areas or out of bounds.

## 2. Introduction

It has been hypothesized that increasing the risk associated with inaccurate hitting from the tee may lead golfers to take more care in how they drive the ball, either by reducing their swing speed or changing their club selection. They may also change their aiming point. It is the goal of this testing to help determine how players will respond to significant changes in the proximity of penalty areas and if it could potentially reduce driving distance.

Recreational golfers who are members of Pinehurst Country Club hit golf balls onto a marked hole with swing speed, distance, accuracy, and club selection measured using a TrackMan 4 launch monitor. Each player was scored based on accuracy and distance. The type and proximity of penalty areas to the fairway were changed after each set of five tee shots: the player was notified of the change, and then proceed to hit five tee shots (swing speed, distance, accuracy, and club selection again measured).

The objectives of this research are:

- Test the effects of a significant increase in the penalty for off-fairway hits.
- Incentivize distance in a consistent way through the test.
- Be simple for facilitators to explain and for players to understand.

The desired key outcomes are:

- Quantitative assessment of the effects of increasing the demand for accuracy on player behavior in terms of club choice, club head speed (where drivers are used), accuracy and distance.
- Determine attitudinal responses on the change in approach given increased accuracy demand (if any).

Note: several non-standard terms and definitions have been introduced in this report and will be defined when first used.

### 3. Discussion / Analysis

Pinehurst Course No. 2 was shut down for maintenance for the week of July 26, 2021. We set up a 30-yard-wide fairway with zones left and right of the fairway using green, yellow, and white stakes.



Eighteen golfers participated in a contest with prizes for the lowest gross and net scores. Scoring was based only on the tee shot with longer and more accurate drives scoring lower and shorter and less accurate drives scoring higher (see Appendix for set-up details). The distance to reach various zones was based on the normal tee (playing distance) played by the competitor and scaled accordingly.



### 3.1. Golfer Demographics

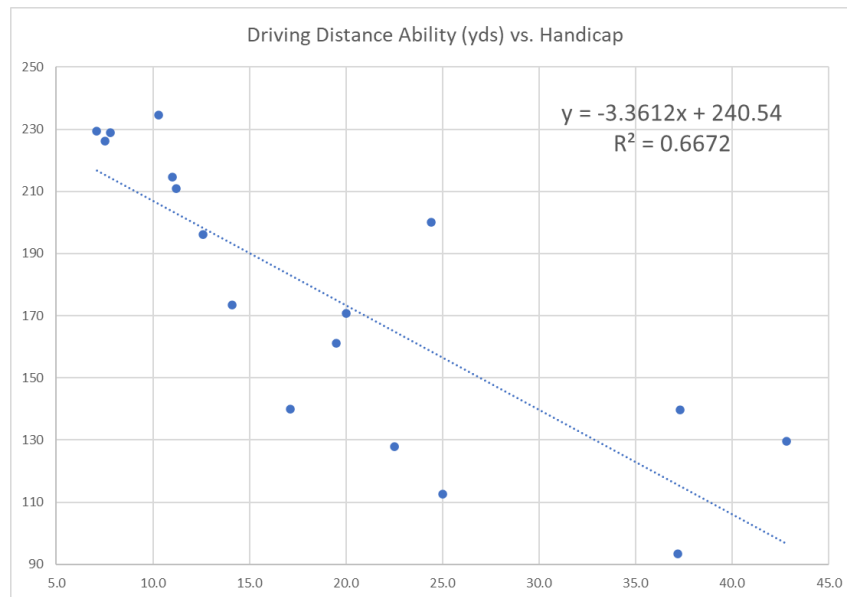
Of the 18 golfers who participated, one had only been playing a few weeks, so their data were excluded from the analysis. Of the 17 remaining golfers, there were 7 male and 10 female golfers. All played or practiced more than once a week. All the golfers were older than 45 with most in the 60 – 74 years old bin. Experience level varied from a few in the 3 to 7 year bin to most in the >30 years of experience. Handicap Indexes® ranged from 7 to 43.

During the pre-test interview, each golfer was asked which tee they typically play on No. 2 and what their estimated driving distance was including bounce and roll (total driving distance).

### 3.2 General Launch Condition Results

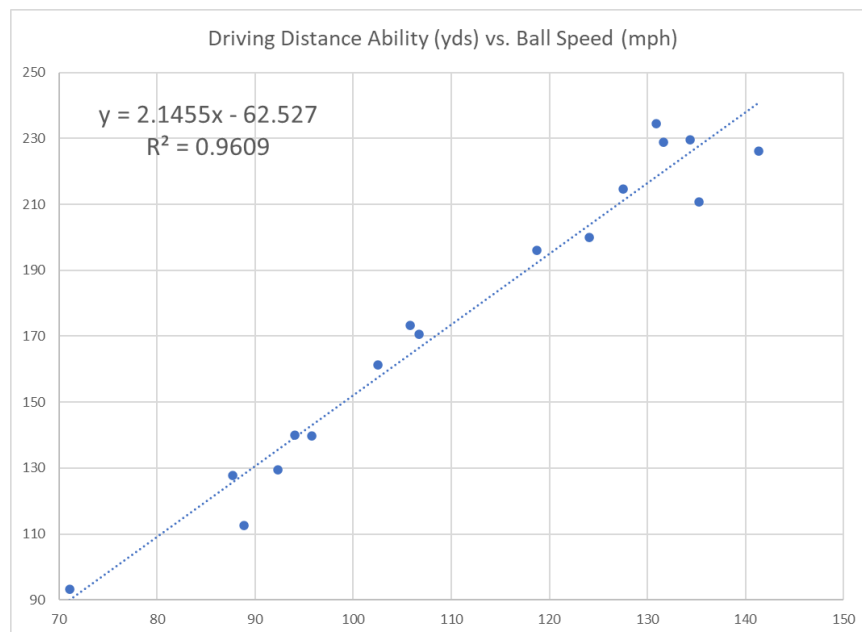
Overall, the golfers' performance followed the trends typically expected. Figure 1 shows that Driving Distance Ability (median of the 10 tee shots) increased as Handicap Index decreased, although the

correlation is on the weaker side. Each 1-point reduction in Handicap Index adds 3.4 yards of total driving distance on average.



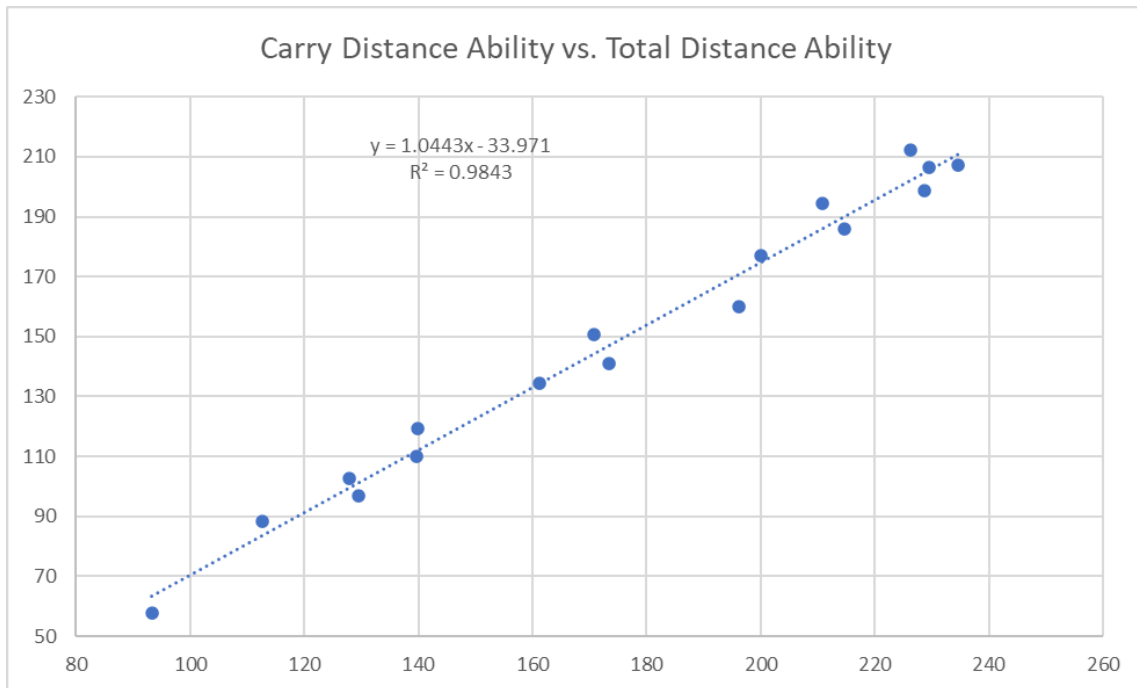
*Figure 1 Relationship between golfer Handicap Index and Driving Distance Ability*

Figure 2 shows that the golfers' Driving Distance Ability correlates strongly with their measured Ball Speed. Each 1 MPH increase in ball speed adds 2.1 yards in total driving distance.



*Figure 2 Relationship between golfer Driving Distance Ability and Ball Speed*

Figure 3 shows that the golfers' Carry Distance Ability correlates strongly with their Total Distance Ability for Driver. Carry Distance is about 30 yards shorter than total distance for a golfer who hits a 100-yard total distance drive. Each 10-yard increase in total driving distance adds 10.4 yards in carry distance so a golfer who hits a 250-yard total distance drive has about 227 yards of carry. Importantly, the golfer who hits a 100-yard drive, 30% of the total distance is bounce and roll and 70% is carry. For the golfer who hits a 250-yard total drive, 91% is carry and only 9% is bounce and roll. Note that this result is based on TrackMan's proprietary bounce and roll model, not field measurement.



*Figure 3 Relationship between golfer Total Distance Ability and Carry Distance Ability for Driver*

### 3.3 Penalty Area Test Results

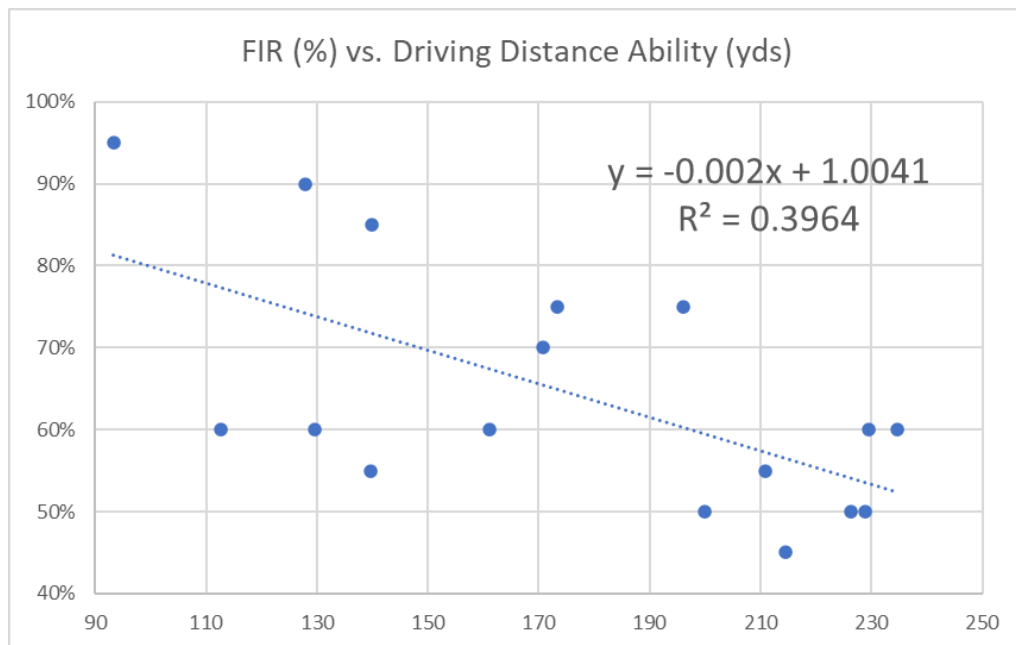
1. Golfers swing speed was essentially unchanged for all 20 drives as the table shows. These small increases are likely due to warming up slightly. These averages are not statistically different from each other as the population's pooled standard deviation is about 1.3 MPH. Note that for this study, all golfers were right-handed. If a left-handed golfer had been tested, the one-sided hazards would have been flipped so that they remained either fade or draw hazards for the left-handed golfers.

<b>Test Condition</b>	<b>Difference in Average Club Head Speed (MPH)</b>
Fairway and Rough Only	Base Condition – Reference Average Speed
Draw-side Penalty / O.B. areas	+0.4
Two-sided Penalty / O.B. areas	+0.1
Fade-side Close O.B. area	+0.5

2. Golfers scored similarly with right side close O.B. (fade) as with no hazards (+0.4 strokes).
  - a. Golfers' path strongly negative for right side close O.B. (fade) while face slightly positive (path -5 degrees / face +1 degree).
3. Golfers scored 2nd worse with left side (draw) hazard (+1.3 strokes)
  - a. Golfers' path and face essentially unchanged for left side (draw) hazard
4. Golfers scored worst with two-side hazards (+2.0 strokes)
  - a. Golfers' path and face somewhat negative for two-sided hazards (path -1 degrees / face -1 degree)
5. On average, golfers next swings are not affected by the previous swing.

Previous Swing Result	Average Score for Next Shot
Good Result (Fairway)	4.6
Neutral Result (Rough or first shot in test conditions)	4.6
Bad Result (Penalty Area, O.B. or Miss-hit)	4.7

6. On average, 60% finished in the fairway (FIR = fairway in regulation) and 22% of drives finished in the rough, with slightly greater FIR% for females. This is likely because golfers that hit longer drives had lower FIR% as shown in Figure 4. Although the correlation coefficient is not high indicating significant scatter around the trend line, it is interesting to note that the intercept is 1.00 (100%) meaning that a 0-yard drive has a 100% chance of being in the fairway, which is intuitive.



*Figure 4 Relationship between Driving Distance and Accuracy as measured by FIR%*

7. Golfers' capabilities (defined as average of best two drives) slightly exceeded their estimated driving distance [average was 101% of estimate driving distance] for this group of golfers.
8. Golfers' ability (defined as the median) averaged 94% of their stated driving distance with males at 100% and females at 91%.
9. The range of Smash Factors was identical across gender and ranged from 1.36 to 1.48.

#### **4. Conclusions**

1. Golfers are challenged by 30-yard-wide fairways and when hazards within 5 & 10 yards of the fairway are in play.
2. Based on no measured changes in swing speed, it is unlikely that players will consciously or subconsciously reduce their driving distance based on penalty areas or O.B.
3. Hazards within 20 & 25 yards of fairway centerline affect golfer's swing path.
4. Golfers subconsciously adjust swing path significantly for fade hazards and mildly for two-side hazards even though in general they don't verbally confirm this intention.
5. A fairway of constant width is more challenging for longer hitters than shorter hitters.
6. Golfers in this study (experienced and avid golfers) know their driving distance accurately.

## Appendix - Testing plan for the “effect of penalty area”

*Effectiveness of changing penalty for inaccurate drives on distance*

*USGA Green Section*

*First distributed July 8, 2021*

*Adapted from ES procedure of 16-Jun-2021 by Steve Quintavalla*

### Change Notes

7/12/21	Added note to flip the 4 <sup>th</sup> set-up to left side OB for left-handed golfers (on the slice side)
7/12/21	Added items to required equipment list
7/12/21	Added notes about when to tell golfer of incentive and confidentiality request
7/12/21	Use Trackman for shot distance and scout in the field with radio for zone determination
8/26/21	Added “miss hit” zones to scoring scenarios

### Goal

It has been hypothesized that increasing the risk associated with inaccurate hitting from the tee may lead golfers to take more care in how they drive the ball, either by reducing their swing speed or changing their club selection. They may also change their aiming point. It is the goal of this testing to help determine how players will respond to significant and known changes in the proximity of penalty areas on driving distance.

### Overview

Recreational golfers will hit golf balls onto a marked hole, with swing speed, distance, accuracy, and club selection recorded. Each player will be scored based on accuracy and distance. The type and proximity of penalty areas to the fairway will be changed: the player will be notified of the change, and be given further hits (swing speed, distance, accuracy, and club selection again recorded). Changes in hitting distance and accuracy will be analyzed at the conclusion of this research.

### Requirements

- a. Test the effects of a significant increase in the penalty for off-fairway hits.
- b. Incentivize distance in a consistent way through the test.
- c. Be simple for facilitators to explain and for players to understand.
- d. Can be set up and conducted by two testers at a driving range.

### Key outcomes

- a. Quantitative assessment of the effects of increasing the demand for accuracy on player behavior in terms of club choice, club head speed (where drivers are used), accuracy and distance.
- b. Attitudinal responses on the change in approach given increased accuracy demand (if any).



- i. How do players' expectations of their own distance and accuracy (i.e., % fairways hit) off the tee compare with experimental data?

## Equipment

- a. 1x TrackMan 4 RADAR launch monitor with laptop.
- b. One dozen each of green, red and white stakes or similar for marking range.
- c. Tees.
- d. Pro V1 golf balls.
- e. Preferable: flagstick or cones for marking fairway centerline.
- f. Radios
- g. Rangefinder
- h. Shag bag
- i. Table & chairs

## Site Preparation (Figure A-1)

- a. The plan is to use the 1<sup>st</sup> hole on Course #2 at the Pinehurst Resort (during a maintenance shutdown). [Picture below]
- b. Identify the centerline of a 30-yard wide 'fairway' hitting area.
- c. Set up teeing area for one golfer. Warm-up will be done offline at the driving range prior to the test.
- d. Using a flag stick (if available) or traffic/safety cone, or similar, mark a target
- e. Using colored stakes or similar, mark the boundaries of the 'fairway' hitting area
  - a. Green stakes will signify the Zone 2 / Zone 1 (fairway) boundary
  - b. Red stakes will signify the Zone 3 / Zone 2 boundary
  - c. White stakes will signify the Zone 4 / Zone 3 boundary



- f. Set up TrackMan RADAR behind back tee.

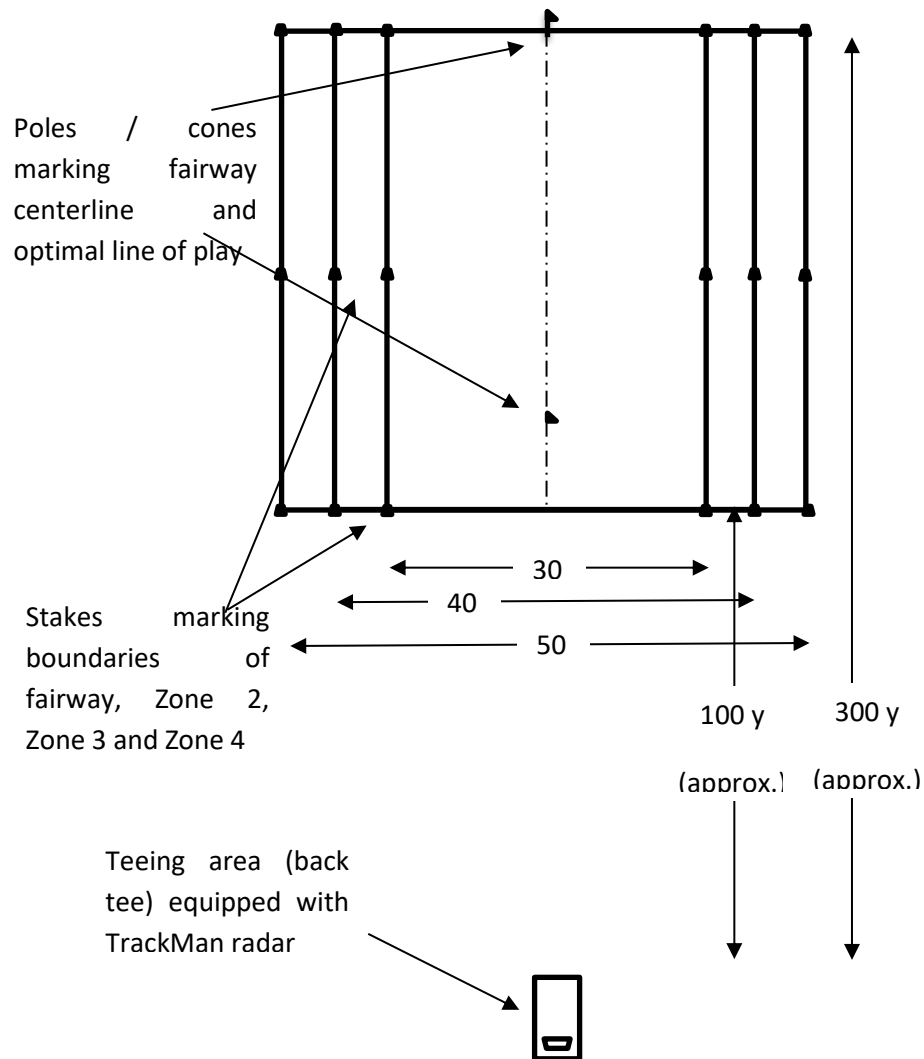


Figure A-1: Site diagram.

## Player preparation

1. Allow player time to warm up as necessary.
2. Gather brief demographic info including hitting distance for Driver, 7-iron and PW.
  - a. Ask the player what their normal or preferred tee is (or alternatively their preferred playing distance – match to closest available)
3. As an incentive to perform at their best, the lowest score of the session will be rewarded with Pro-shop credit.
  - a. Only tell the golfer after the tee selection is made
  - b. Ask the golfer to keep it confidential – do not tell golfers later in the test
4. Perform the test:

- a. Introduce the scoring format (described in the next section):
    - i. Players will strive to minimize their score based on the results of their tee shot.
    - ii. Inform the player of the low score prizes.
    - iii. Players will be given 20 hits total 5 each under 4 different course set-ups.
      1. The final position of the ball including bounce and roll distance will determine the score
        - a. TrackMan will determine the total distance
        - b. Exact zone of the ball at rest determined by scout in the field (radio the result back to player / scorekeeper)
      - iv. The use of and proximity of penalty areas changes during the session
    - iv. The use of and proximity of penalty areas changes during the session
  - b. Hole conditions – player will be asked what tee they normally play which will translate into a hole distance for that player which will scale the hitting distance zones.
  - c. Track hits using RADAR. Players may be given any information at their request at any time, including distance, hole score, or current total.
  - d. Record:
    - i. Club used (if multiple clubs are used, how many hits with each)
    - ii. Club speed
    - iii. Distance
    - iv. Landing Zone
    - v. Player comments
  - e. Player interaction
    - i. The player can be informed of their score on a particular shot, but not where they stand relative to 1<sup>st</sup> place, either during the test or after. All results will be available after the complete test (by the end of the week).
5. Repeat step 2 for the scoring formats 2 - 4.

## Scoring formats

The following formats described in Tables A-1, 2, 3 & 4 were developed based on distances for amateur male and female golfers, as identified in the Distance Insights Report, and an attempt to incentivize distance and penalize inaccuracy, in a way that is consistent with golf. The number in each zone represents the most likely score on a medium length par 4 hole based on the final location of the ball after a tee shot.



**Table A-2: One-sided Penalty Area Format**

Hole Length:

Blue Tee = 400 yds (typical approach = 160 yds)

White Tee = 350 yds (typical approach = 140 yds)

Green Tee = 300 yds (typical approach = 120 yds)

Red Tee = 250 yds (typical approach = 100 yds)

Note: O.B. = Out of Bounds

Long Drive	Blue = >260 White = >230 Green = >200 Red = >170	O.B. <b>6.4</b>	Lateral Hazard <b>5.2</b>	Rough <b>4.2</b>	Fairway <b>4.0</b>	Rough <b>4.2</b>	Rough <b>4.2</b>	Rough <b>4.2</b>
Typical Drive	Blue = 220 - 260 White = 190 - 230 Green = 160 - 200 Red = 130 - 170	O.B. <b>6.4</b>	Lateral Hazard <b>5.6</b>	Rough <b>4.6</b>	Fairway <b>4.3</b>	Rough <b>4.6</b>	Rough <b>4.6</b>	Rough <b>4.6</b>
Short Drive	Blue = <220 White = <190 Green = <160 Red = <130	O.B. <b>6.4</b>	Lateral Hazard <b>6.2</b>	Rough <b>5.2</b>	Fairway <b>4.8</b>	Rough <b>5.2</b>	Rough <b>5.2</b>	Rough <b>5.2</b>
Miss Hit Drive	Blue = <150 White = <120 Green = <90 Red = <60	O.B. <b>6.4</b>	Lateral Hazard <b>6.4</b>	Rough <b>6.0</b>	Fairway <b>5.5</b>	Rough <b>6.0</b>	Rough <b>6.0</b>	Rough <b>6.0</b>

**Table A-3: Two-sided Penalty Area Format**

Hole Length:

Blue Tee = 400 yds (typical approach = 160 yds)

White Tee = 350 yds (typical approach = 140 yds)

Green Tee = 300 yds (typical approach = 120 yds)

Red Tee = 250 yds (typical approach = 100 yds)

Note: O.B. = Out of Bounds

Long Drive	Blue = >260 White = >230 Green = >200 Red = >170	O.B.   <b>6.4</b>	Lateral Hazard  <b>5.2</b>	Rough   <b>4.2</b>	Fairway   <b>4.0</b>	Rough   <b>4.2</b>	Lateral Hazard  <b>5.2</b>	O.B.   <b>6.4</b>
Typical Drive	Blue = 220 - 260 White = 190 - 230 Green = 160 - 200 Red = 130 - 170	O.B.   <b>6.4</b>	Lateral Hazard  <b>5.6</b>	Rough   <b>4.6</b>	Fairway   <b>4.3</b>	Rough   <b>4.6</b>	Lateral Hazard  <b>5.6</b>	O.B.   <b>6.4</b>
Short Drive	Blue = <220 White = <190 Green = <160 Red = <130	O.B.   <b>6.4</b>	Lateral Hazard  <b>6.2</b>	Rough   <b>5.2</b>	Fairway   <b>4.8</b>	Rough   <b>5.2</b>	Lateral Hazard  <b>6.2</b>	O.B.   <b>6.4</b>
Miss Hit Drive	Blue = <150 White = <120 Green = <90 Red = <60	O.B.   <b>6.4</b>	Lateral Hazard  <b>6.4</b>	Rough   <b>6.0</b>	Fairway   <b>5.5</b>	Rough   <b>6.0</b>	Lateral Hazard  <b>6.4</b>	O.B.   <b>6.4</b>

**Table A-4: One-sided Penalty Area Format – Close OB Right**

Hole Length:

Blue Tee = 400 yds (typical approach = 160 yds)

White Tee = 350 yds (typical approach = 140 yds)

Green Tee = 300 yds (typical approach = 120 yds)

Red Tee = 250 yds (typical approach = 100 yds)

Note: O.B. = Out of Bounds

\*\*\*Flip O.B. to left side for left-handed golfers\*\*\*

Long Drive	Blue = >260 White = >230 Green = >200 Red = >170	Rough 4.2	Rough 4.2	Rough 4.2	Fairway 4.0	Rough 4.2	O.B. 6.4	O.B. 6.4
Typical Drive	Blue = 220 - 260 White = 190 - 230 Green = 160 - 200 Red = 130 - 170	Rough 4.6	Rough 4.6	Rough 4.6	Fairway 4.3	Rough 4.6	O.B. 6.4	O.B. 6.4
Short Drive	Blue = <220 White = <190 Green = <160 Red = <130	Rough 5.2	Rough 5.2	Rough 5.2	Fairway 4.8	Rough 5.2	O.B. 6.4	O.B. 6.4
Miss Hit Drive	Blue = <150 White = <120 Green = <90 Red = <60	Rough 6.0	Rough 6.0	Rough 6.0	Fairway 5.5	Rough 6.0	O.B. 6.4	O.B. 6.4

## Technical Background

### Rationale for Distance levels and bins

Average distances for amateur golfers are available from the Distance Insights Report.

### Compensation for high altitude (not needed for Pinehurst)

Higher altitude provides an advantage to drive distance that is greater for higher swing speeds. In order to identify the likely effects on candidate golfers, USGA models for aerodynamic properties of a modern, high performance, golf balls were used, along with publicly available launch condition information for PGA TOUR, LPGA Tour, and average male amateurs. Also included were launch conditions for amateur women golfers, based on a compilation of studies conducted by R&A Rules, Ltd. Finally, distance was simulated at 30 in Hg (approximately representing sea level) and 24.5 in Hg (approximately representing Aurora, Colorado).

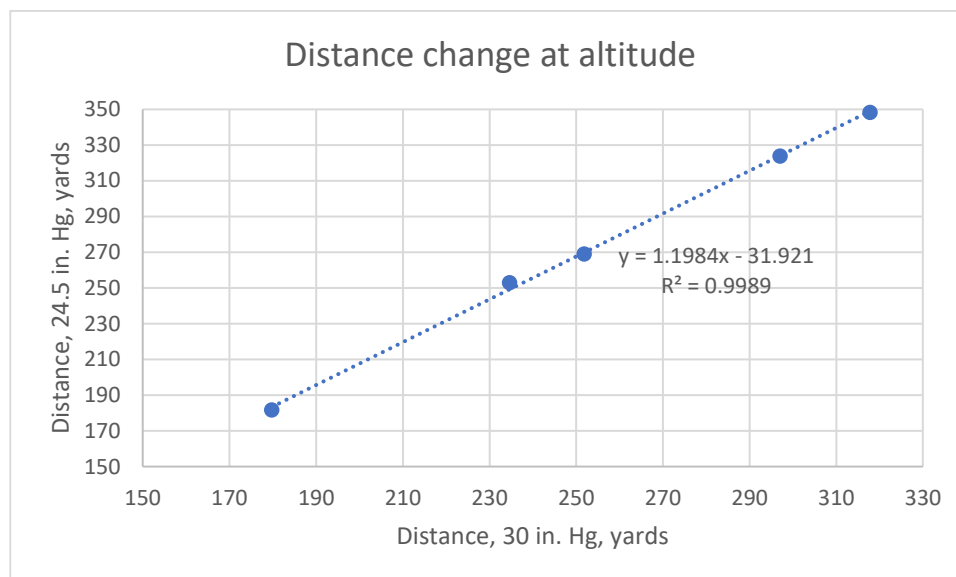


Figure 2

Results were well-correlated. This correlation was used, along with the distance divisions determined for the low-altitude sites, in order to identify appropriate values at high altitude. The result was +30 yards at the longest distances, and +10 yards at the shortest.