Agronomic Impacts on Bounce and Roll Distance

Contents

1. Historical Review

Some have speculated that one factor contributing to increased driving distance is because of superior agronomic practices and maintaining firmer and faster fairways, resulting in a longer bounce and roll distance once the ball hits the turf. However, there is limited historical data about how bounce and roll distance contribute to overall driving distance.

In an article from 1898, British amateur Edward Blackwell, who was regarded as the longest driver at the time, reportedly hit a 280-yard drive with an estimated 20 to 25 yards of bounce and roll distance (The Buffalo Times, Sept 4, 1898). In the 1949 U.S. Open at Medinah Country Club, Robert Trent Jones measured the total drive distance and bounce and roll distance of the entire field. The average bounce and roll distance from that championship was 28.3 yards.

Similar tests were conducting during the third round of the 1953 U.S. Open at Oakmont Country Club, but Robert Trent Jones limited his measurements of total drive distance and bounce and roll to only 60 players. In this championship, the average bounce and roll distance was 21 yards.

The three examples of bounce and roll distance discussed above have a narrow range of 20 to 28.3 yards. Agronomic practices intensified and fairway conditions improved between 1898 and 1953, yet bounce and roll distance in these examples was fairly consistent.

Since 1953, fairway conditions have improved even more, with many golf courses maintaining high-quality playing surfaces despite increases play volume and golf cart use. However, the question “are modern fairway conditions contributing to increases in overall driving distance” remains unanswered.

As technology like ShotLink and TrackMan were developed, it became possible to accurately measure a large volume of driving distances and bounce and roll distances. In 2007, using a combination of ShotLink and TrackMan data gathered by the PGA TOUR, the USGA studied the bounce and roll distance at 19 venues (Quintavalla and Rodgers, 2008). On average, drives that were considered in the fairway had a total bounce and roll distance of 30.1 yards ± 3.5 yards.

The bounce and roll distance documented at the PGA TOUR events in 2007 is higher than the historical range mentioned earlier. Unfortunately, key agronomic information about the fairways was not well documented in any previous studies. Thus, it is unknown as to the degree which various agronomic factors impact overall distance and bounce and roll distance.

2. 2018 Bounce and Roll Testing

In June 2018, the USGA initiated testing to determine how bounce and roll distance was impacted by grass species, mowing height, mowing direction, soil moisture and organic matter content. A total of 624 bounce and roll distance measurements were recorded using a portable golf ball launcher calibrated to simulate inbound drives from various launch angles.

Six different mowing heights were tested ranging from 0.350 to 0.650 inch. Moisture levels of the soils at each test event ranged from 29 to 42 percent, with most readings at a moisture level of 36 percent. There are two categories for mowing direction within the data: down grain and against grain. There are four different types of grass species within the data: Bermudagrass, creeping bentgrass, *Poa annua*/perennial ryegrass and zoysiagrass. One of the golf courses where testing occurred had a single bermudagrass fairway and the remainder were creeping bentgrass fairways. This provided an opportunity to compare the two species within the same basic management regime.

2.1 Materials and Methods

Each of the four test events were conducted independently of each other. Agronomic variables such as mowing height, mowing direction and soil moisture were manipulated at each test site. At each test event, turf conditions were subjectively documented – e.g., turf health, density and organic matter content. Turf density is visually rated on a 1-9 scale with 1 being bare ground and 9 being extremely dense.

Bounce and roll distance was measured using a modified baseball pitching machine. The golf ball launcher was designed to mimic the terminal conditions of a golf ball. In this research, the spin rate was similar to what would be expected from a high-performance golf ball in a driver trajectory.

During previous bounce and roll tests conducted in 2014, the spin was varied from less than 1,000 RPM to over 3,000 RPM, with little observable difference in the bounce and roll distance. Therefore, spin was fixed at 1800 RPM for the tests in 2018.

Four inbound angles were tested to mimic the range of inbound angles produced from drivers. Tests were conducted at inbound angles of 32, 38, 44 and 50 degrees. During one test event, the 50-degree angle was omitted to avoid causing undesirable damage to the turf.

The effect of each agronomic variable analyzed was determined by taking the average bounce and roll distance from 12 golf balls that were fired into the turf.

All mowing height treatments were initiated immediately prior to testing. At the creeping bentgrass test event, the mowing direction treatment was initiated the morning of testing. During the *Poa annua*/perennial ryegrass mowing direction test, mowing occurred in the exact same direction for 5 days prior to our testing. At the zoysiagrass mowing direction test, the mowing patterns had been established for an entire year.

Soil moisture measurements were taken throughout the test areas. Additionally, 10 soil moisture measurements were taken around the golf ball impact zone for each variable analyzed.

2.2 Creeping Bentgrass

Creeping bentgrass was the first grass species tested during the bounce and roll research. The creeping bentgrass fairway was healthy and had density rating of 6 during our testing. The turf exhibited a moderate level of grain, consistent with the lateral growth pattern of creeping bentgrass. The testing involved two different mowing heights (0.350 inch and 0.400 inch), two different mowing directions (down grain and against grain), and pre- and post-irrigation tests.

Bounce and roll testing started in the morning prior to any irrigation. After examining how mowing height and mowing direction impacted bounce and roll distance, the turf was irrigated for 15 minutes, applying approximately 0.15 to 0.2 inch of water. This irrigation event increased soil moisture levels by 5-8 percent. The golf course superintendent reported that after the irrigation cycle, the amount of moisture in the soil was above the level of moisture needed to sustain healthy turf at this location. Bounce and roll tests were then taken immediately following the irrigation event to examine how increases in soil moisture impacted bounce and roll distance in conjunction with the different mowing heights and directions.

2.2.1 Mowing Height

There was not a significant difference in bounce and roll distance between the two mowing heights, 0.350 inch and 0.400 inch.

2.2.2 Mowing Direction

The mowing direction did impact bounce and roll distance. On average, bounce and roll distance was 22.2 yards for the down-grain direction vs. 19.3 yards for the against-grain direction.

2.2.3 Soil Moisture

There was a significant difference in bounce and roll distance between the pre- and post-irrigation test. On average, the pre-irrigation tests resulted in 7.7 yards more bounce and roll than the post-irrigation tests. As soil moisture levels increased, bounce and roll distance decreased.

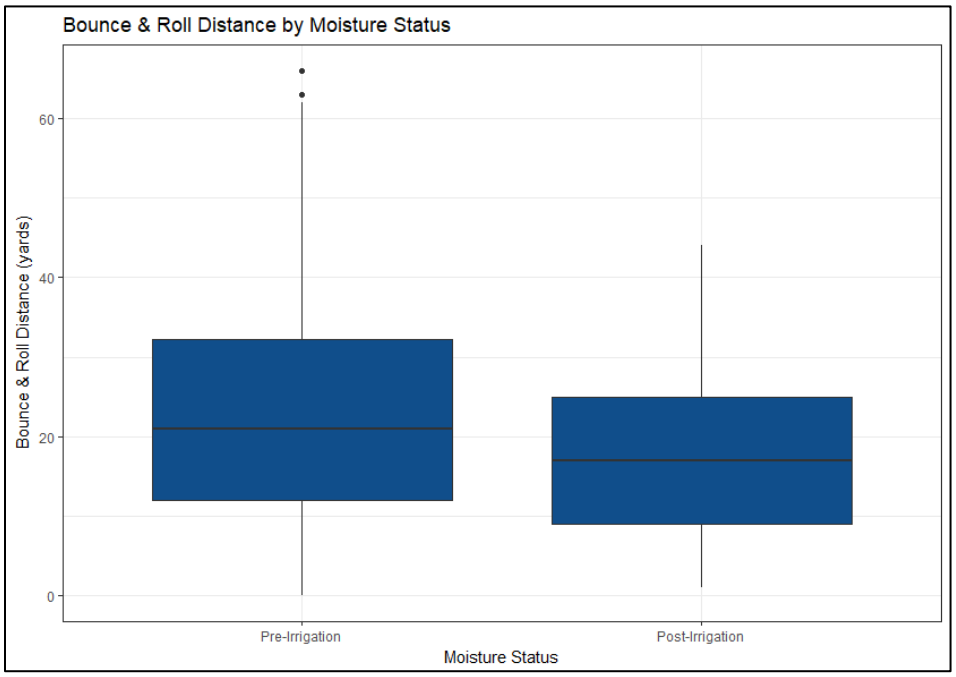

Figure 1 Bounce and Roll Distance by Moisture Status

Figure 1. Bounce and roll distance was significantly impacted by applying a 0.15 to 0.2-inch irrigation cycle, raising the soil moisture levels by 5-8 percent. There are five summary statistics represented by this figure. The middle line is the median (50% of data is below this point and 50% is above), the entire box represents 50% of the data. The lower end of the box is the 1st quartile and upper end is the 3rd quartile. The two lines extend both to the minimum value and the maximum value, with any outliers being represented by points beyond the two limits.

2.2.4 Interactions

There is a significant interaction between the inbound angle of a golf ball and the moisture status. For the 32-degree inbound angle, bounce and roll distance decreased by more than 12 yards after irrigation was applied. For the 38-, 44- and 50-degree angles, bounce and roll distance decreased by less than 5 yards after irrigation was applied.

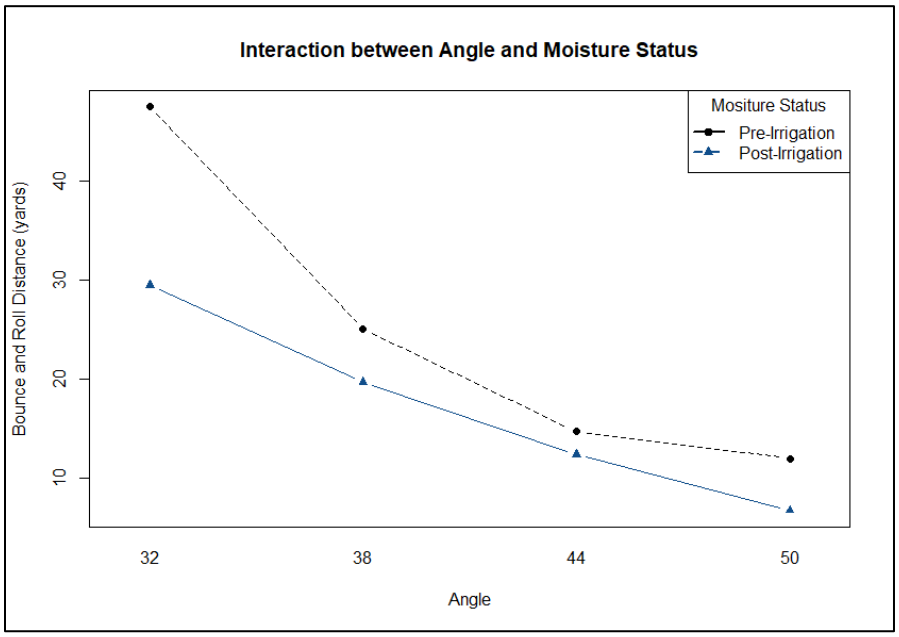

Figure 2 Interaction between Angle and Moisture Status

Figure 2. Bounce and roll distance at the 32-degree angle was reduced by 12 yards following a 0.15 to 0.2-inch irrigation cycle. The other inbound angles experienced a reduction in bounce and roll distance of less than 5 yards following the 0.15 to 0.2-inch irrigation cycle.

2.3 Poa annua and Perennial Ryegrass – PGA TOUR Event

A fairway with a mixture of *Poa annua* and perennial ryegrass was the second test site. These tests were conducted during the 2018 Northern Trust event during the PGA TOUR FedEx Cup Playoffs. Our testing occurred prior to the start of the third round of the tournament. The *Poa annua*/perennial ryegrass fairways were healthy with a density of 8 during our testing. The turf did not have any noticeable grain, consistent with the upright growth patterns of *Poa ann*ua and perennial ryegrass. Mowing direction was the primary variable measured during this test event. However, bounce and roll testing was also

conducted on an adjacent fairway not being prepared for the event. The fairway not being prepared for the event was virtually identical to the fairways used in the tournament, but the mowing height was 0.450 inch. This provides a comparison between a fairway maintained at 0.400 and 0.450 inch.

It should be noted that only three inbound angles – 32, 38 and 44 degrees – were measured at this test site to avoid causing undesirable damage to the fairways.

2.3.1 Mowing Direction

There were no significant differences between the down-grain and against-grain bounce and roll distances.

2.3.2 Mowing Height

There was a significant difference in bounce and roll distance between the 0.400-inch fairway compared to the 0.450-inch fairway. On average, the 0.400-inch mowing height resulted in a 3.1-yard increase in bounce and roll distance compared to the 0.450-inch mowing height.

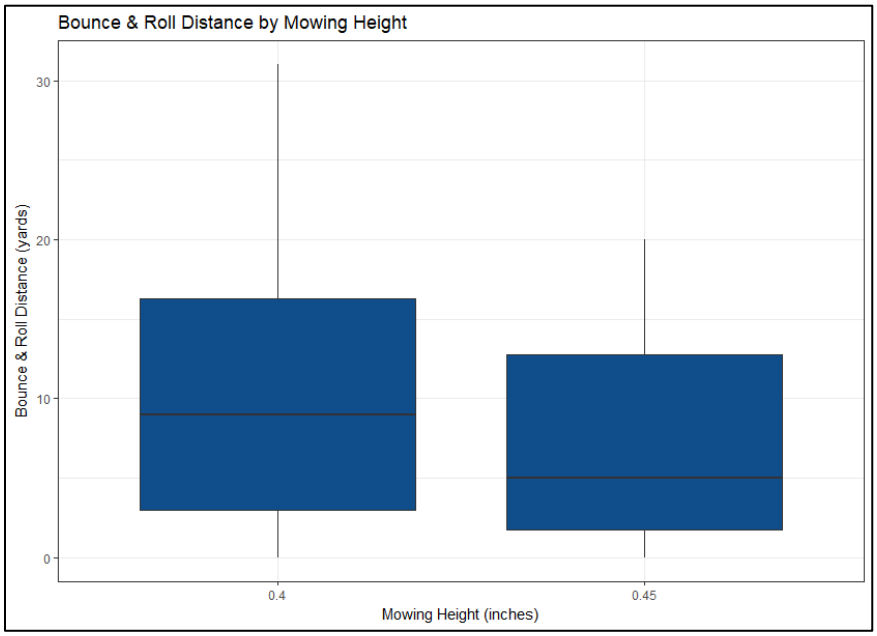

Figure 3 Bound and Roll Distance by Mowing Height

Figure 3. Bounce and roll distance was reduced when the mowing height of the *Poa annua*/perennial ryegrass fairways was increased from 0.400 to 0.450 inch.

2.3.3 Soil Moisture

Soil moisture levels during this test event was above the level of moisture needed to sustain healthy turf at this location due to rain prior to testing. The elevated soil moisture levels are likely the primary reason why overall bounce and roll distance was significantly lower than other test events. Also, the amount moisture in the soil may have negated any impacts from the different mowing directions.

2.3.4 Interactions

There was a significant interaction between the inbound angle and mowing height. For inbound angles of 32 and 38 degrees, bounce and roll distance was reduced by 4 to 5 yards as the mowing height increased to 0.450 inch. At the 44-degree inbound angle, the increase in mowing height only reduced bounce and roll distance by 1 yard.

2.4 Zoysiagrass

The third test event was conducted on a zoysiagrass fairway. The zoysiagrass turf was healthy with density rating of 8 during our testing. The turf exhibited a significant amount of grain. The amount of grain observed is somewhat consistent with the growth habit of zoysiagrass, but it was exacerbated by repetitive mowing in the same direction throughout the year.

The mowing height was 0.625 inch – significantly higher than other test sites. This mowing height is consistent with industry trends for zoysiagrass fairways in the region.

2.4.1 Mowing Direction

The mowing direction – i.e., down grain vs. against grain – significantly influenced bounce and roll distance. On average, bounce and roll distance was 10.9 yards farther down grain compared to against the grain.

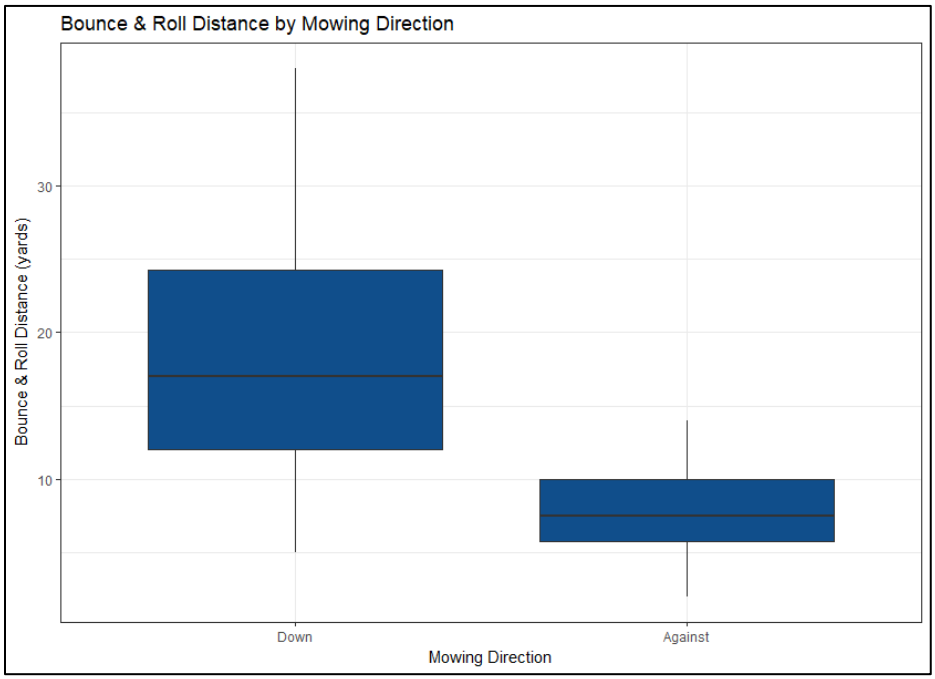

Figure 4 Bounce and Roll Distance by Mowing Direction

Figure 4. Bounce and roll distance was significantly impacted by the mowing direction of the zoysiagrass fairway. The grain was very pronounced at this test site due to mowing the fairways in the exact same direction for the entire year.

2.4.2 Soil Moisture

Soil moisture levels during this test event was above the level of moisture needed to sustain healthy turf at this location due to rain prior to testing. The elevated soil moisture levels are likely a reason why overall bounce and roll distance was lower than other test events.

2.4.3 Interactions

There was a significant interaction between the inbound angle and the mowing direction. The difference in bounce and roll distance down grain vs. against grain was the most extreme at the 32-degree angle.

2.5 Bermudagrass

The final test event occurred on a bermudagrass fairway. The bermudagrass fairway was located on the same course where creeping bentgrass was tested on an earlier date. The bermudagrass turf was healthy with density rating of 8 during our testing. The turf exhibited a moderate level of grain, consistent with the lateral growth pattern of bermudagrass. However, this bermudagrass turf had a high level of organic matter – i.e., thatch – which created a soft surface.

2.5.1 Soil Moisture

Soil moisture levels during this test event was within the optimal level of moisture needed to sustain healthy turf at this location. Soil moisture levels were similar and, in some cases, drier on the bermudagrass fairway compared to the creeping bentgrass fairway tested on an earlier date.

2.5.2 Organic Matter

Bounce and roll distance was noticeably shorter on the bermudagrass fairway compared to previous tests on the creeping bentgrass fairways (pre-irrigation). On average, the bounce and roll distance was 17.4 yards shorter on the bermudagrass fairway compared to previous tests on an adjacent creeping bentgrass fairway. The mowing height was 0.400 inch, comparable to the previous testing on the creeping bentgrass fairway. The large difference between the bounce and roll distance on the creeping bentgrass fairway and the bermudagrass fairway is attributed to the excessive amount of organic matter at the surface.

3. Summary of Bounce and Roll Research and Agronomic Factors

3.1 Soil Moisture

Of all the agronomic variables examined, soil moisture has the most significant impact on bounce and roll distance. On the creeping bentgrass fairway, bounce and roll distances were measured before and after

a 0.15 to 0.2-inch irrigation cycle. After irrigation was applied, soil moisture values increased by 5 to 8 percent compared to the pre-irrigation soil moisture levels. The 0.15 to 0.2-inch irrigation cycle resulted in a 7.7-yard decrease in bounce and roll distance.

While these data are significant, it is important to recognize that soil moisture is managed carefully to ensure turf health remains optimal. Most superintendents irrigate fairways judiciously to ensure responsible water use and optimal playability. Furthermore, turf is more vulnerable to a host of agronomic problems when soil moisture levels are higher than necessary to maintain healthy turf. While bounce and roll distance may decrease as a result of maintaining higher soil moisture, this is not a responsible use of water because it would result in increased water consumption and cost, higher disease pressure and soft playing conditions.

From a historical perspective, advances in irrigation technology and design allowed superintendents to maintain consistent soil moisture levels regardless of rainfall. Prior to these advancements, soil moisture levels were likely to be lower and more variable during a dry period, resulting in longer bounce and roll distance. However, fairways in the past were probably more vulnerable to soft playing conditions and high soil moisture following rain events because of the lack of drainage systems, limited soil management practices, etc. Thus, it is reasonable to suggest that bounce and roll distance is more consistent now, but prior to 1970s when automatic irrigation systems were not yet the norm, bounce and roll distance was likely farther during a period with minimal rainfall.

3.2 Mowing Height

Across all grass species, the fairway mowing height has the second largest impact on bounce and roll distance. Using the data from all the test events, a model was created to predict how mowing height changes will impact bounce and roll distance. Across all test events and when every other variable remains constant, bounce and roll distance is predicted to decrease by 2.23 yards when the mowing height increases by 0.1 inch. However, on creeping bentgrass a mowing height increase from 0.350 to 0.400 inch did not result in a significant reduction in bounce and roll distance. It is likely that once a mowing height is below a certain point – e.g., 0.350 inch – increasing the height by 0.05 or 0.1 inch will not impact on bounce and roll distance. Ultimately, turf density (discussed below) is a factor that likely impacts these predictions as well.

There are other impacts of increasing the fairway mowing height besides observing a decrease in bounce and roll distance. Raising the fairway mowing height promotes more sustainable turf. As the mowing height increases, the turf root system will grow deeper and perform well at lower soil moisture levels compared to a fairway mown at lower heights. Additionally, as mowing height increases, the turf becomes less vulnerable to decline from various diseases and insects.

While a higher mowing height may decrease bounce and roll distance, the presence of healthier turf may allow for increases in bounce and roll distance. For instance, a mowing height greater than 0.400 inch may allow a superintendent to maintain the turf at a lower soil moisture level, likely resulting in an increase in bounce and roll distance. From a sustainability perspective, management practices that allow superintendents to use less water are far more important than any ancillary effects to bounce and roll distance.

3.3 Turf Density

Although not measured, the density of fairway turf likely impacts bounce and roll distance. At several test sites, a USGA Stimpmeter was used to measure ball roll distance on the fairway prior to testing for bounce and roll distance (data not shown). The density of the turf significantly impacted ball roll distance in all the measurements. For instance, a very dense creeping bentgrass teeing ground maintained at 0.300 inch had a ball roll distance of 3 feet 4 inches. Stimpmeter measurements taken on an adjacent creeping bentgrass fairway with a lower density, yet maintained at 0.400 inch, had a ball roll distance of 5 feet 8 inches. These results indicate that while mowing height impacts bounce and roll distance, turf density is also a factor. For grasses with low density, such as fine fescue, bounce and roll distance is probably even less impacted by mowing height than high-density grasses like creeping bentgrass and bermudagrass.

Over time, turf density has increased on fairways as a result of the gradual reduction in mowing heights and turf breeding efforts. As the mowing height is lowered, the turf density increases for most grasses used for fairways. Turfgrass breeders also focused on increasing the density of various grass species so they would persist under lower mowing heights (Mike Kenna, Director, USGA Turfgrass and Environmental Research Program, personal communication). Increased use of creeping bentgrass in cool-humid regions also resulted in fairways with greater density compared to previously used grasses – e.g., Kentucky bluegrass, fine fescue. Thus, it is reasonable to suggest that bounce and roll distance is more impacted by the density of the turf now than in the past when fairway turf had a lower density.

3.4 Mowing Direction

Mowing direction had an impact on overall bounce and roll distance, but the effects vary by grass species. On zoysiagrass, a species with a very stiff leaf blade, a 10.9-yard decrease in bounce and roll distance was observed on the against-grain mowing direction compared to the down-grain mowing direction. The large difference in bounce and roll distance on the zoysiagrass fairway test site is in part because the mowing pattern was burned in for the entire year, resulting in significant grain.

Testing conducted on creeping bentgrass with moderate grain exhibited a 2.9-yard increase in bounce and roll distance on a down-grain mowing direction compared to the against-grain mowing direction. Meanwhile, testing conducted on *Poa annua*/perennial ryegrass fairways revealed that bounce and roll distance was not impacted by mowing direction – i.e., down grain vs. against the grain.

Grasses that grow laterally – e.g., creeping bentgrass, bermudagrass and zoysiagrass – are more susceptible to developing grain than grasses that grow more upright – e.g., fine fescue, *Poa annua* and perennial ryegrass. Superintendents utilize various management practices to minimize the development of grain because it creates a poor quality of cut. This research suggests that where moderate levels of grain are present, bounce and roll distance was only slightly impacted by mowing direction.

Figure 5 Image 1

Figure 5. Tee shots landing on the down grain side (light green turf) of this fairway will not have a longer bounce and roll distance compared to tee shots landing on the against grain side (dark green turf) as long as severe grain issues are prevented through appropriate management practices.

Prior to the 1980s, a half-and-half mowing pattern was primarily used on fairways because large mowers had limited maneuverability. As smaller, lightweight and easy-to-maneuver mowers became available, intricate striping patterns became commonplace on fairways (Dana Lonn, Consultant for the Toro Company, personal communication). Since the economic recession, many courses have gone back to a half-and-half mowing pattern because it is more efficient – i.e., saves labour, fuel and increases the lifespan of equipment. Controlling grain and rotating the mowing pattern should prevent any impact on overall bounce and roll distance.

3.5 Organic Matter Content

The bounce and roll testing on the bermudagrass fairway, which had a higher amount of organic matter than the adjacent creeping bentgrass fairway, indicates that organic matter levels also impact bounce and roll distance. Both the creeping bentgrass and bermudagrass fairways at this course were maintained at the same mowing height. The bermudagrass fairway actually had lower soil moisture content than the creeping bentgrass fairway. However, bounce and roll distance was 17.4 yards shorter on the bermudagrass fairway because the turf had an excessive amount of organic matter. These results are not surprising given how excessive levels of organic matter contribute to soft playing conditions.

Similar to higher-than-optimal soil moisture levels, excessive organic matter contributes to numerous agronomic problems. Superintendents perform a variety of maintenance practices to keep organic matter to a minimum, so it does not create soft conditions.

From a historical perspective, it is difficult to determine how organic matter levels have changed over time. As turf density increases, plant biomass from roots and stems also increase, resulting in higher organic matter accumulation. Modern varieties of creeping bentgrass and bermudagrass also produce

higher levels of organic matter compared to older varieties. Therefore, it is reasonable to suggest that modern fairways have greater levels of organic matter than typical fairways pre-1980. However, advances in aeration equipment and topdressing practices have resulted in better control of organic matter accumulations compared to years ago.

Although fairway topdressing helps control organic matter, it is a very expensive program and limited to courses with adequate resources. A GCSAA cultivation survey reported that only 15 percent of the respondents topdressed fairways regularly (GCSAA Cultivation Survey, 2013). Conversely, Cale Roth, former PGA TOUR Senior Vice-President of Agronomy reported that fairway topdressing is fairly common at courses hosting PGA TOUR events, and that practice certainly has helped improve fairway firmness (Cal Roth, former PGA TOUR Senior Vice-President of Agronomy, personal communication). Thus, organic matter levels are likely to be better managed on golf courses hosting PGA TOUR events compared to recreational play. As a result, it is reasonable to assume that bounce and roll distance is higher at PGA TOUR events compared to courses the only host recreational play given the increased emphasis on topdressing.

4. Concluding Remarks

Our bounce and roll distance research confirms that various agronomic practices impact distance. However, it appears that agronomic variables only contribute a small amount to overall distance. The USGA study examining ShotLink and TrackMan data from 19 venues during the 2007 PGA TOUR season had a total bounce and roll of 30.1 yards ± 3.5 yards. The bounce and roll data from pre-irrigation creeping bentgrass, *Poa annua*/perennial ryegrass, bermudagrass and zoysiagrass fairways serve as a representative sample of courses with high quality playing conditions. The combined average bounce and roll distance from these tests was 17.8 yards ± 13.3 yards. The difference between our bounce and roll distance test results and the 2007 PGA TOUR data highlight how golf courses hosting PGA TOUR events are maintained more intensively with the goal of producing firm playing conditions and a high level of consistency, as evidenced by the minimal variability.

Ultimately, it is difficult to compare modern bounce and roll distances with what occurred in the past. Fairway playing conditions are far superior now with respect to overall turf quality and reliability. The evolution of agronomic practices, equipment, grasses, etc. have resulted in more consistent playing conditions for golfers, but these factors do not necessarily correlate with increases in bounce and roll distance across all facility types.

Soil moisture is the primary factor that influences bounce and roll distance. Modern irrigation practices are extremely precise, but it can be debated on whether fairway conditions are maintained drier now than in the past. At some courses it is likely that their fairways play firmer and faster now. At other courses, the opposite is probably true. Ultimately, irrigation decisions drive soil moisture, which has the most significant impact on bounce and roll distance. The basic factors that influence the development of a course-specific irrigation regime include:

- The drought tolerance level of grasses present
- The amount of cart traffic experienced
- Soil conditions
- Golfer expectations for aesthetics
- Golfer expectations for high-quality playing conditions

Golf courses that have drought-intolerant grasses will need to irrigate fairways more than a course with drought-tolerant grasses. If a course has a lot golf cart traffic, it becomes more difficult to dry the turf much because it can be damaged quickly from carts driving through wilted turf. Thus, irrigation decisions are one of the most challenging aspects of maintaining the fairways.

At many courses, irrigation decisions are largely influenced by golfer expectations for lush, green fairways. While this is not the case for every golf course, the reality is that aesthetics do influence golfers perceptions on the quality of the course. In 2002, Labbance and Witteveen wrote that "advanced irrigation, when over-used by zealous applications has led to the green grass syndrome, and courses once maintained lean and mean to promote the ground game now became lush retreats of wall-to-wall turf coverage." More recently, Jeff Brauer, golf course architect and past president of the American Society of Golf Course Architects suggested that automatic irrigation has actually reduced rollout of the golf ball following drives. As mentioned earlier, maintaining soil moisture levels about course-specific thresholds has several consequences. However, many golfers question the quality and health of fairways if they are not lush and green, as described in the 1977 article Green is Not Great, written by former National Director of the USGA Green Section Al Radko (Radko, 1977). Golf courses that implement an irrigation regime that focuses on aesthetics more so than playability will likely not have an increased bounce and roll distance now compared to the past.

At tournament golf events, playability is the primary driver with respect to irrigation decisions; not aesthetics. As a result, it is very likely that agronomic practices impact bounce and roll distance and overall distance more so for tournament golf events than courses hosting recreational play. At recreational facilities, it appears unlikely that agronomic conditions are a major factor in overall driving distance. Certainly, some recreational courses are being maintained firmer and faster than years ago, but the majority are probably just providing more consistent conditions, which does not necessarily translate into increased bounce and roll distance.

5. References

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Appendix A – List of Figures