Measuring crop circles

from the Esri GeoInquiries™ collection for Mathematics

MATH

Target audience – Geometry learners	Time required – 15 minutes

Activity	Use remotely sensed data to estimate and measure the area of (center-pivot irrigation) crop circles.
Math Standards	**CCSS: MATH.CONTENT.HSG.MG.A.1.** Use geometric shapes, their measures, and their properties to describe objects. **CCSS: MATH.CONTENT.HSG.GMD.A.1**. Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone.
Learning Outcomes	• Students will measure the area of a circle. • Students will apply their understanding of circles to determine the areas of various circle-based shapes.

Map URL: http://esriurl.com/mathGeoInquiry10

⚙️ Engage

What are you seeing?

→ Click the link above to launch the map.
? What is visible on the map? *[Farmland, circular irrigation patterns, and color and size variation, etc.]*
→ Read aloud: "Circular shapes in the fields are caused by a single water source, piped to the middle of the field with an arm spraying water as it rotates around the centerpoint."
? How could we use geometry to measure these circles? *[Use measuring tools and formulas to investigate the areas being irrigated.]*

🔍 Explore

How large are the circles?

→ Identify the largest crop circle in the map view. *[It is about four times the size of others.]*
→ Click the button, Measure. Select the Distance tool and set the units to feet.
→ Click in the center of the circle, draw a line to the circle's edge, and double click. *[The radius will appear in the Measure window.]*
? What is the radius in feet? *[r ~2,640 feet]*
→ Calculate the irrigated area. (Area = pi x r^2) *[~22 million square feet]*
? How does the area of the circle compare with other circles in the map view? *[It is about four times larger.]*

💬 Explain

How does area vary when only fractions of a circle are irrigated?

? How would you measure the irrigation area if only part of the circle is being irrigated? *[Calculate the total circle area and multiply by the estimated fraction of the irrigated area.]*
? What would be the formula if only half the circle was green? *[(pi x r^2)/2]*

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Elaborate

Do multiple smaller circles have greater area?

→ Click Bookmarks and choose 4 Circles Challenge.
→ Read aloud: "There are four smaller circles adjacent to one larger one."
? Which of the two areas irrigates a larger area? *[They irrigate the same area. If you assume that the smaller circle has a radius of 1, the area of each is pi, giving 4 pi all together. The larger circle has a radius of 2, giving the larger circle an area of 4 pi. Actual measurements will vary slightly.]*

Evaluate

How does the accuracy of the Area tool compare?

→ Click Measure, select the Area tool, and set units to square feet.
→ Click the outline of a big circle (r = 4) by repeatedly clicking around the circle's edge to approximate the circular area.
→ Note the area in square feet of the traced circle.
→ Compare the linear distance calculation for the circle to the traced area.
? Which method of area measurement is more accurate? Why? *[The area calculated from a radius measurement should be more accurate. Fewer measurements are required, and fewer areas are missed by approximating (tracing) the edge.]*
? How can the traced-edge method result be improved? *[Zoom in closer to the circle to better see the edge. Create more measuring points along the edge to reduce missed areas.]*

USE THE MEASURE TOOL

- Click Measure, select the Distance button, and from the drop-down list, choose a unit of measurement.
- On the map, click once to start the measurement, click again to change direction, and double-click to stop measuring.
- Hint: Position the area of interest on the map so that it is not obscured by the Measure window.

ZOOM TO A BOOKMARK

- Click Bookmarks.
- Click a bookmark name to zoom to a map location and scale.

Next Steps

DID YOU KNOW? ArcGIS Online is a mapping platform freely available to public, private, and home schools. A school subscription provides additional security, privacy, and content features. Learn more about ArcGIS Online and how to get a school subscription at http://www.esri.com/schools.

THEN TRY THIS...

• Learn more about a variety of measurement issues involved with center-pivot irrigation at http://esriurl.com/Geo17472.

TEXT REFERENCES

This GIS map has been cross-referenced to material in sections of chapters from these high school texts.

- *Geometry by Holt, Rinehart and Winston — Chapter 11*
- *Geometry by Moise and Downs — Chapter 16*
- *Geometry by Houghton Mifflin — Chapter 9*