In much of the southern Great Plains, where conditions allow winter grazing, wheat is managed as a forage and grain crop. A combination of favorable temperatures for wheat growth during winter months and few snow-covered days allows wheat to be used as forage when other forages are limited. Winter wheat offers high-quality forage during the winter in addition to grain at the end of the growing season. The dual-purpose system includes about half of the wheat acreage in Oklahoma and a significant portion of wheat grown in northern Texas and southern Kansas.

In dual-purpose wheat systems, management recommendations for cattle-stocking density are based on the amount of forage needed to sustain cattle weight gains. Fall and winter stocking rates often range from 1 to 2 acres per stocker, depending on weight, while spring stocking rates usually range from 0.75 to 1.3 acres per stocker. Despite being the recommended practice, managing stocking density based on the forage supply and animal weight does not consider the amount of wheat defoliation allowable at the end of grazing to maintain optimum grain yield. Overgrazing wheat pastures increases the risk of reduced grain yield.

The percentage of remaining green canopy cover can be used to help decide when to end in-season grazing. This variable complements forage supply and animal weight while minimizing the risk of overgrazing. The percentage of green canopy cover is simply the proportion of a given ground area covered by green, live vegetation. Green canopy cover affects light interception and the plant’s ability to produce carbohydrates. The more leaf area that is present at grazing termination, the greater the opportunity for the wheat crop to recover from grazing.

A recent study (Butchee and Edwards, 2013) shows that producers can use the percentage of green canopy cover to monitor wheat pastures from the end of fall growth to grazing termination in late winter (late February or early March) to make in-season adjustments to cattle stocking density to prevent overgrazing. The study compared two winter wheat varieties (Overley and Fuller) subjected to three different simulated grazing intensities and a nongrazed control treatment (Figure 1). The study was conducted during three growing seasons in two locations in north central Oklahoma and had an intensive, an average, and a low grazing intensity treatment. Simulated

**Figure 1.** Winter wheat varieties Fuller (left) and Overley (right) following simulated grazing at 1¼, 3, or 4¼ inches mowing height at Lahoma, OK. Photo courtesy of Dillon Butchee, former M.S. student with Oklahoma State University.
grazing was performed when regrowth achieved approximately 2 inches and was terminated at first hollow stem in all site-years.

The results of the study show that yield losses associated with overgrazing can be minimized if the percent of green canopy cover is maintained above 53 percent at the end of the fall, before winter dormancy (Figure 2). It also revealed that a minimum of 62 percent green canopy cover was necessary at grazing termination to maintain 95 percent of the potential grain yield (Figure 2). The research highlights the importance of periodically monitoring green canopy cover during the fall and spring to ensure that the levels of green canopy cover are maintained above the critical thresholds, thus avoiding yield penalties relative to a grain-only wheat system.

ESTIMATING GREEN COVER USING THE CANOPEO SMARTPHONE APPLICATION

Canopeo is a rapid and accurate green canopy cover measurement tool developed at Oklahoma State University. Canopeo is available as an application for both Android and iOS devices and enables the user to measure the percentage of green canopy cover in real time. This allows users to make informed management decisions while in the field.

STEPS TO USE THE CANOPEO APP:

- Search for and download the Canopeo app from either the App Store or GooglePlay store. For more information, visit the official website at www.canopeoapp.com.

Figure 2. The minimum percentage of green canopy cover of 53 percent before winter dormancy (upper panel) and 62 percent at grazing termination or first hollow stem (lower panel) was needed to ensure maximum wheat grain yield relative to an ungrazed control. Figure adapted from Butchee and Edwards, 2013.

Figure 3. User of the Canopeo mobile app measuring percentage of green canopy cover of winter wheat at the Oklahoma State University Research Station near Marshall, OK. Arms should be extended to the side to avoid including shoes in the photo, and the camera should be held parallel to the ground at least 2 feet (60 cm) above the crop canopy. Photo by Todd Johnson.
two grazed wheat pastures, one where grazing was well managed and another with intensive grazing. Average percentages of green cover in the fields were 61 percent and 15 percent, and canopy cover variability was 14 and 73 percent coefficient of variation, respectively. The minimum number of images included in the mean calculation to achieve an acceptable estimation of the wheat field’s green canopy cover with error lower than 5 percent was 6 images for the well-managed field and 12 images for the intensively grazed field (Figure 5). Because the Canopeo app gives the percent of green canopy cover in real time, several measurements can be made quickly.

WHAT INFORMATION FROM THE APP IS NEEDED TO MAKE INFORMED DECISIONS?

The percentage of green canopy cover is a valuable piece of information to make in-season grazing management decisions based on knowledge from Figure 2. The expected effect of different ranges of green canopy cover on wheat grain yield differs depending on the growing season stage, and are as follows:

**LATE FALL, BEFORE WINTER DORMANCY:**

- **60-100% Optimal** Low risk of grazing affecting grain yield.
- **40-60% Caution** Moderate risk of grazing affecting grain yield.
- **0-40% Danger** High risk of grazing affecting grain yield.

**LATE WINTER, AT FIRST HOLLOW STEM:**

- **70-100% Optimal** Low risk of grazing affecting grain yield.
- **50-70% Caution** Moderate risk of grazing affecting grain yield.
- **0-50% Danger** High risk of grazing affecting grain yield.

HOW MANY IMAGES ARE NEEDED IN EACH FIELD OR MANAGEMENT Zone?

The number of images needed for accurate calculation of green canopy cover of a given wheat field depends on the spatial variability of green canopy cover in that particular field (Figure 5). In a case study near Stillwater, Oklahoma, several pictures were taken randomly from

KEY POINTS

- Managing cattle-stocking density based on green canopy cover using the Canopeo app can decrease the risks of wheat grain yield losses associated with overgrazing.
- A minimum green canopy cover of about 53 percent should be maintained before winter dormancy (mid-December) and about 62 percent should be maintained at grazing termination (first hollow stem, late February through March) to minimize grain yield reductions.
- A minimum of six to 12 pictures should be used to determine the average green cover of a given field, depending on field uniformity.

Figure 4. Evaluation of the percentage of green canopy cover before (top, Dec. 2014) and after (bottom, Jan. 2015) cattle grazing at Marshall, OK, using the Canopeo app. The top image presents some freeze damage (see some necrotic leaves) and several dark spots usually ignored on traditional visual quantifications. The bottom image shows excessive defoliation, indicating high risk of affecting grain yield. Notice the green cover is greater than 18 percent, but many leaves are necrotic. Photo courtesy of Andres Patrignani, Assistant Professor, Kansas State University.
REFERENCES


Figure 5. The minimum number of canopy cover pictures included in the estimation of green canopy cover to represent a wheat field with less than 5 percent relative mean error is about 6 for a uniform canopy and 12 for a non-uniform canopy. Relative mean error is the absolute difference between the estimated green canopy cover using the number of images indicated in the x-axis and the overall field mean canopy cover, divided by the actual field mean canopy cover. CV stands for coefficient of variation.

AUTHORS

Romulo P. Lollato, Assistant Professor, Kansas State University
Andres Patrignani, Assistant Professor, Kansas State University
Tyson Ochsner, Associate Professor, Oklahoma State University
Alexandre Rocateli, Assistant Professor, Oklahoma State University
Peter Tomlinson, Assistant Professor, Kansas State University
Jeff Edwards, Professor, Oklahoma State University

The authors gratefully acknowledge Joseph Moyer and Johnathan Holman for their work in reviewing this publication.

THESE RESOURCES AND OTHERS CAN BE FOUND AT:

bookstore.ksre.ksu.edu
pods.dasnr.okstate.edu
canopeoapp.com

THIS MATERIAL IS BASED UPON WORK SUPPORTED BY:

U.S. Department of Agriculture, Project Nos. 2013-69002-23146 through the National Institute for Food and Agriculture’s Agriculture and Food Research Initiative, Regional Approaches for Adaptation to and Mitigation of Climate Variability and Change. Great Plains Grazing is a group of research scientists, Extension specialists, and consumer experts from Kansas State University, Oklahoma State University, University of Oklahoma, Tarleton State University, Samuel Roberts Noble Foundation, and the USDA’s Agricultural Research Service working together to improve and promote regional beef production while mitigating its environmental footprint.

Oklahoma State University Agricultural Experiment Station and Cooperative Extension Service, Oklahoma State University, in compliance with Title VI and VII of the Civil Rights Act of 1964, Executive Order 11246 as amended, Title IX of the Education Amendments of 1972, Americans with Disabilities Act of 1990, and other federal laws and regulations, does not discriminate on the basis of race, color, national origin, gender, age, religion, disability, or status as a veteran in any of its policies, practices or procedures. This includes but is not limited to admissions, employment, financial aid, and educational services.

Publications from Kansas State University are available at: www.ksre.ksu.edu

Publications are reviewed or revised annually by appropriate faculty to reflect current research and practice. Date shown is that of publication or last revision. Contents of this publication may be freely reproduced for educational purposes. All other rights reserved. In case of publication by or on behalf of Kansas State University, or by an agent or employee with authority to act for Kansas State University, nothing is to be construed as constituting an endorsement of any private enterprise or as a warranty or guarantee as to the quality or worth of the product or service advertised.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, as amended. Kansas State University, County Extension Councils, Extension Districts, and United States Department of Agriculture Cooperating. John D. Floros, Director.

K-State Research and Extension

MF3304 July 2016