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Advancing Precision Agriculture in Southern California, Number 2

SAMZ-Desert—A Web Tool for Delineating Management Zones

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Introduction

Farmers in Southern California are under increasing pressure to grow more food while using less water, fertilizer, and other inputs. One of the challenges of this task is that different parts of a field often behave differently. Changes in soil type, crop vigor, or past management can cause some areas to need more, or less, water and nutrients than others. Because of this variability, treating the whole field the same may waste inputs and reduce yields. A better approach is to apply water and fertilizer only where they are needed. This is called site-specific, variable rate application, and it can improve both productivity and resource use (Stafford 2018).

SAMZ-Desert is a zoning tool designed to help growers identify these differences across their fields. It uses satellite images to show how crop performance varies within a field and then groups similar areas into management zones (Garg et al. 2022). Unlike older tools that require many user inputs or technical expertise, SAMZ-Desert provides easy-to-read maps and interpretive messages designed to help growers assess field variability in the desert region of Imperial County.

This publication is the second in a series on *Advancing Precision Agriculture in Southern California*. It explains key terms related to management zones, describes how the SAMZ-Desert tool works, and

provides guidance on how to interpret the maps and information it produces.

Common terms and definitions

Remote sensing: Remote sensing is the use of images from satellites, airplanes, or, more recently, drones to collect information about fields without being on the ground. SAMZ-Desert uses free satellite data from Landsat 8, which captures images at several wavelengths every 16 days. SAMZ-Desert was developed using Landsat 8 images from April 27, 2018, which was selected because it captured widespread active crop growth and relatively few fallow fields across the region.

Normalized Difference Vegetation Index (NDVI): NDVI is a commonly used satellite-based index that indicates how healthy and dense vegetation is in a field. It is calculated from two types of light captured by the satellite: red light, which plants absorb, and near-infrared light, which plants reflect. NDVI values range from -1 to 1 . High values indicate denser and greener vegetation, values near zero represent bare soil, and negative values typically indicate water. By examining how NDVI varies within a field, growers can identify areas with different crop vigor that may require different management.

Management zones: Management zones are groups of areas within a field that behave similarly. These areas may have similar soil properties, crop growth patterns, or responses to water and fertilizer. Dividing a field into management zones helps growers apply inputs more efficiently rather than treating the entire field the same.

Remote sensing and management zone delineation

Satellites enable us to view our fields from above and detect features that are hard to see from the ground. These images are widely used in precision agriculture because they help identify variations in crop growth and soil conditions across the field.

Satellite imagery also reduces the time, cost, and labor needed to collect field data. Landsat 8—one of the most commonly used satellites—captures images in several wavelengths of light (fig. 1). These measurements reveal patterns in crop performance that the human eye cannot detect.

SAMZ-Desert uses NDVI (fig. 2). NDVI provides information about differences in crop vigor across a field. These differences may be associated with soil



Figure 1. Illustration of the Landsat 8 satellite over North America. Source: EROS CalVal Center of Excellence (ECCOE).

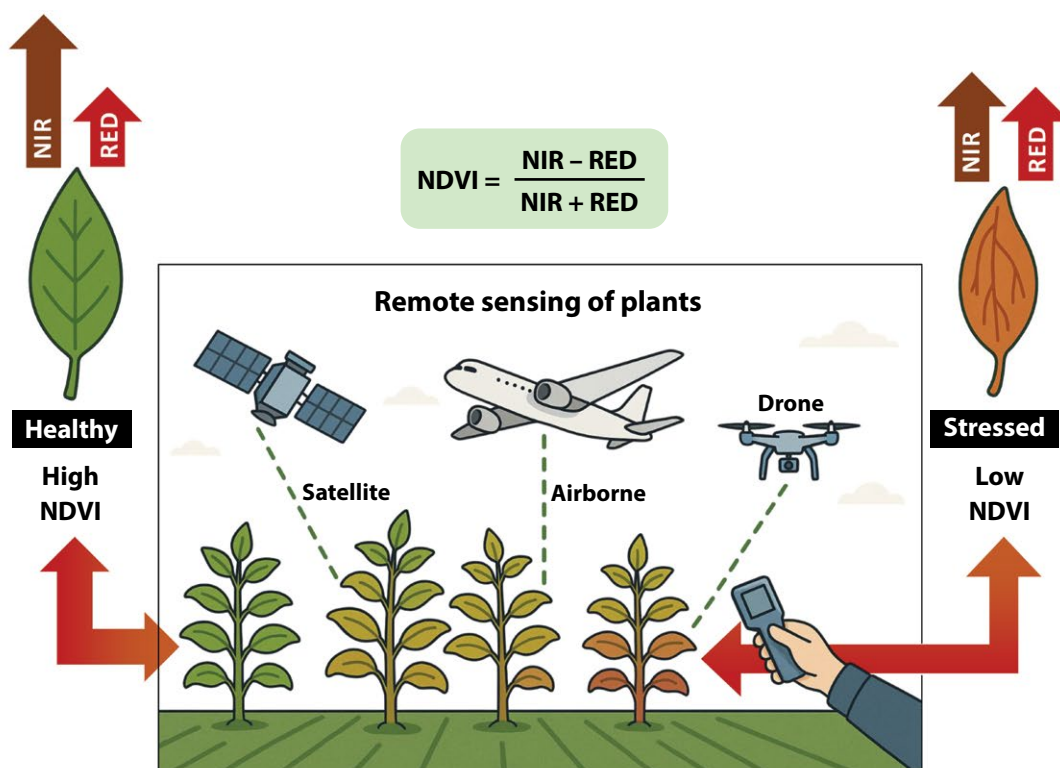


Figure 2. Example of NDVI calculation for healthy and unhealthy plants. Differences in visible and near-infrared (NIR) absorption and reflectance result in high NDVI values for healthy plants and lower NDVI values for unhealthy plants.

properties, salinity, irrigation, nutrients, pests, disease, or other factors. Using NDVI maps, the tool divides the field into management zones using statistical clustering methods.

With SAMZ-Desert, growers can quickly identify how many zones their fields need and where each zone is located. This helps guide decisions about variable rate irrigation (VRI), fertilizer application, and other management practices, saving time and improving efficiency.

Approach and elements of SAMZ-Desert

SAMZ-Desert tests several possible ways to divide a field, ranging from one to ten management zones. As more zones are added, the tool can capture more of the differences within the field. However, too many zones can make the map confusing or difficult for growers to use. To avoid this, the tool identifies the best number of zones by looking at how much variability is reduced each time a new zone is added. A zone number is considered optimum when at least half of the variability has been explained and when adding another zone would reduce the remaining variability by less than 10 percent. This ensures that the recommended number of zones is useful without being unnecessarily complicated.

To draw the zones, SAMZ-Desert uses a statistical method called K-means clustering. This method groups areas of the field that behave similarly based on their NDVI values. Areas with similar crop conditions end up in the same zone, while areas that behave differently are placed in different zones. Because this method looks for natural patterns in the satellite data, it does not require any training information and produces clear, easy-to-understand zone maps.

The SAMZ-Desert interface contains several panels that guide the grower through viewing results. The Google Earth imagery panel shows all agricultural fields, with fields of interest highlighted in yellow, and allows growers to zoom and navigate to find their field (fig. 3A). The NDVI panel displays the minimum, maximum, and average NDVI values (fig. 3B), helping growers see whether the field shows meaningful variability. The details panel (fig. 3C) provides basic information such as the field's location and the crop being grown. The performance graph (fig. 3D) shows how much variability is captured as the number of zones increases, helping determine the optimum number. The optimum zones panel (fig. 3E) reports the recommended number of zones for variable rate applications, and the zone map (fig. 3F) displays the field divided into those zones, with each zone shown in a different color. The message panel (fig. 3G) provides simple messages that

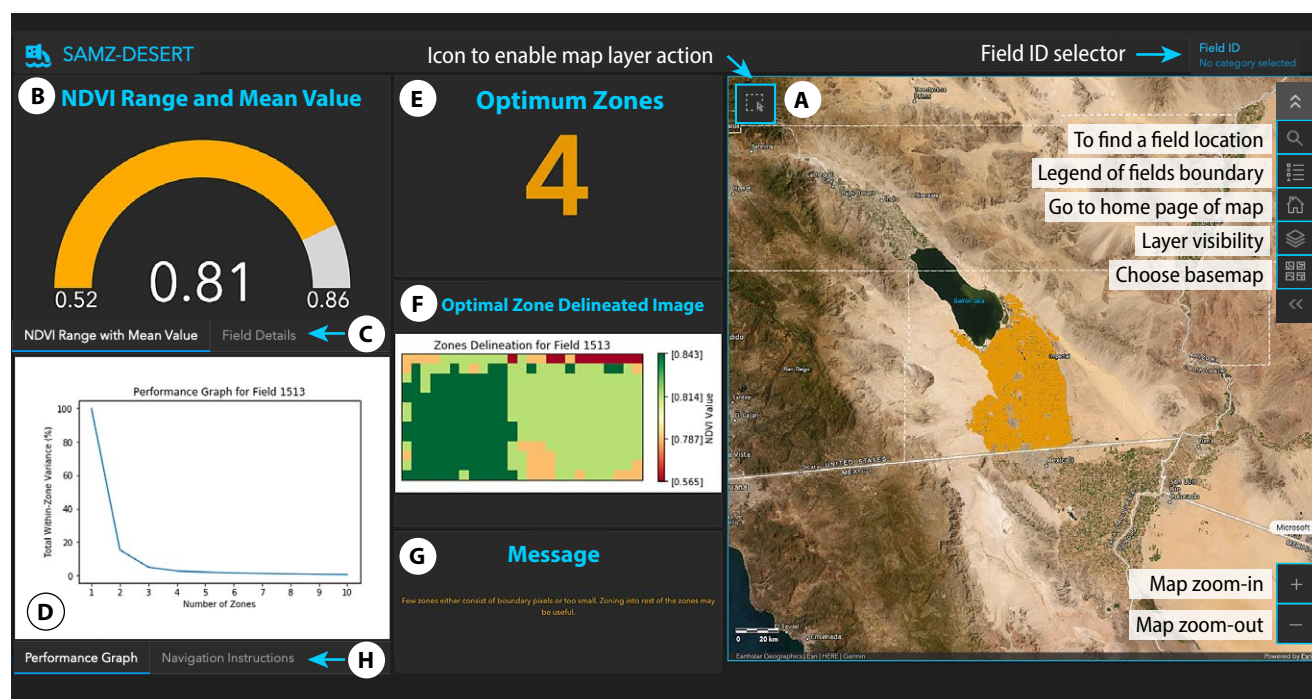


Figure 3. Snapshot of the SAMZ-Desert interface showing its panel elements. A link to the tool is available on the [Verdi Water Management Group website](#).

help growers interpret the results, such as whether zoning is useful, unnecessary, or limited by field size. Navigation instructions are included to help new users operate the tool (fig. 3H).

Growers can select a field either by turning on the map layer and clicking directly on the field or by entering the Field ID in the Field ID selector. Once a field is selected, the map zooms in automatically and all panels update with the information for that field.

For example, when Field ID 4661 is selected (fig. 4), the tool highlights the field and shows that NDVI ranges from 0.41 to 0.79, with an average value of 0.66. This range of about 0.4 indicates strong variability within the field, so the message panel recommends zoning. Based on the performance graph, the optimum number of management zones for this field is four. The final output displays the field divided into four color-coded zones—red, yellow, light green, and dark green—each representing an area with similar crop vigor or field conditions.

After SAMZ-Desert generates a zone map, growers should use the map as a starting point for field checking. The suggested zones can be compared with the grower's own knowledge of the field, soil samples collected from each zone, soil salinity or apparent electrical conductivity maps, drone imagery, yield

maps, or visual observations of crop growth. If the same areas continue to show different crop conditions or yield over time, growers may want to investigate the cause, such as differences in soil texture, salinity, irrigation uniformity, pest pressure, or disease. In this way, SAMZ-Desert helps identify areas that may need closer attention before growers make VRI, fertilizer, or other management decisions.

Field-level variability in Imperial Valley

Irrigation is the driving force behind crop production in the Southern California desert. Because fields in this region often contain areas with different soil and crop conditions, applying the same amount of water for crop growth and leaching of salts everywhere may not be efficient (Sapkota et al. 2024). VRI can help, but growers need tools that clearly show where these differences occur.

To understand how common this variability is, we analyzed close to 7,000 fields throughout Imperial County. Nearly half of all fields (48%) showed noticeable differences within the field based on NDVI. A single satellite image, however, may show field differences that do not persist over time. When images from 2018 to 2020 were compared, about 13 percent of fields consistently showed within-field variability and



Figure 4. Snapshot of SAMZ-Desert displaying the results for a field with Field ID 4661.

were the best candidates for variable-rate management. The study also found that only about 25 percent of fields with strong variability had management zones that remained fairly stable over time. This means growers should update zone maps periodically rather than rely on a single map for several years.

Most variable fields needed four management zones, which was the optimum number for about 37 percent of all fields. About 11 percent of fields were best divided into three zones, and only about 1 percent required five zones. These zone numbers were able to explain most of the variability inside each field—between 88 percent and 95 percent depending on how many zones were used.

These results show that many fields in Imperial County have substantial variability that may benefit from VRI or other precision management practices. More technical details can be found in Garg et al. 2022.

Summary and concluding remarks

The SAMZ-Desert tool gives growers a quick and simple way to look at how conditions vary within their fields. It helps visualize potential management zones and provides useful information for early decision making. The tool is free, interactive, and easy to use, making it a good starting point for anyone interested in moving toward precision agriculture in Southern California.

Because SAMZ-Desert is based on satellite imagery, its results should be viewed as an initial indication of variability. Growers should always check these findings in the field and use standard practices such as soil sampling, soil electrical conductivity mapping, and collecting site-specific information to get a clearer picture of their field conditions. Combining this ground-truth information with their own knowledge and experience will help growers make confident decisions before switching to variable rate applications of water, fertilizer, or other inputs.

SAMZ-Desert is intended to increase awareness of field variability and help identify areas that may benefit from different management approaches. The tool will continue to expand to more fields in Southern California, and improvements will be made as new research becomes available. Feedback from growers and agricultural professionals is welcome and will help make the tool more accurate and more

useful over time. Please contact Dr. Amir Verdi at amir.verdi@ucr.edu to share your feedback.

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