No. 141, Original

IN THE
SUPREME COURT OF THE UNITED STATES

♦

STATE OF TEXAS,
Plaintiff
v.

STATE OF NEW MEXICO and
STATE OF COLORADO,
Defendants

♦

OFFICE OF THE SPECIAL MASTER

♦

STATE OF NEW MEXICO'S *DAUBERT* MOTION *IN LIMINE* TO EXCLUDE OPINIONS OFFERED BY DR. JOEL KIMMELSHUE AND MICA HEILMANN

♦

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July 20, 2021

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Cases

Statutes

COMES NOW the State of New Mexico ("New Mexico") and respectfully moves *in limine* to exclude a portion of the testimony of Texas's experts, Dr. Joel Kimmelshue and Mica Heilmann, both of Land IQ, under Rule 702 of the Federal Rules of Evidence and *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993) and its progeny.

BACKGROUND

1. On May 31, 2019, Texas disclosed the *Expert Report of Joel E. Kimmelshue, Ph.D.* ("Land IQ Report"), attached hereto as Exhibit A (cover, table of contents, and excerpts only). No co-authors were listed on the report. The Land IQ Report stated, in very general terms, that Land IQ used what is called a "random forest statistical classification algorithm" that assigns a crop type to each field based on the field's statistical similarity to data used to "train" the algorithm on the appearance of various crops in satellite imagery ("Land IQ Methodology"). Land IQ Report at 14. The Land IQ Report did not provide detailed information on how Land IQ developed and employed the Land IQ Methodology.

2. New Mexico deposed Dr. Kimmelshue on September 19 and 20, 2019. At Dr. Kimmelshue's deposition, counsel for New Mexico questioned Dr. Kimmelshue regarding the Land IQ Methodology. Dr. Kimmelshue initially declined to answer questions regarding the Land IQ Methodology except in a very general sense, asserting Land IQ's position that the methodology is a proprietary trade secret:

   Q: . . . Will you explain to me what you mean specifically about what you did with the Landsat imagery to decide how to pick training versus validations fields?"

   A: Yeah, I'm going to not answer that. Sorry.

   . . .

Q: . . . Would you explain what you mean by the mean value and how you extracted it?

A: I - - I'm not - - I'm not going to answer that either. Sorry.

. . .

Q: . . . Would you explain how you determine the field's statistical similarity to the training data?

A: Trade secret. Sorry.

Exhibit B, *Deposition of Joel Kimmelshue,* at 128:1-25, 129:1-3 (Sept. 19, 2019) (excerpts) ("*Kimmelshue Depo. Tr. Day 1*"). Dr. Kimmelshue later answered some questions about the Land IQ Methodology, but did not provide detailed information.

3. Dr. Kimmelshue testified that Land IQ had developed a computer program into which Land IQ had input the proprietary algorithms supporting the Land IQ methodology. *Id*. at 162:9-21 ("Q: And is there a particular computer program that these algorithms are already loaded in that you use every time you do the random forest method? A: Yes."). New Mexico requested a copy of this software, but Dr. Kimmelshue declined. *Id*. at 162:22-25. Dr. Kimmelshue then said he would discuss with Land IQ counsel whether Land IQ could disclose this software under a confidentiality agreement. *Id*. at 163:13-18.

4. On October 9, 2019, the Special Master approved a Stipulated Protective Order ("Protective Order") negotiated by the parties that governed the disclosure of confidential materials related to the Land IQ Methodology.

5. On October 31, 2019, New Mexico disclosed its initial expert reports. The Report of New Mexico expert David Jordan raised several questions and criticisms of the Land IQ Methodology, chief among them that Land IQ provided insufficient information for

Mr. Jordan to understand the Land IQ Methodology or reproduce its results. Exhibit C, *Expert Report of David Jordan* at 42 (Oct. 31, 2010) (cover and table of contents) ("INTERA Report"). Additionally, Mr. Jordan noted that Land IQ's data for 2006 only had a 77% match with field survey data INTERA collected in 2006 for the Mesilla Valley for a different project, suggesting a much lower accuracy for the Land IQ Methodology than reported by Land IQ. *Id*. at 46

6. Pursuant to the Protective Order, on December 30, 2019, counsel for New Mexico finally received thumb drives containing additional information regarding the Land IQ Methodology. These thumb drives did not contain the software Dr. Kimmelshue referred to during his deposition or a detailed explanation of how the Land IQ Methodology was developed or is employed, only a general, high-level description of the Land IQ Methodology ("Land IQ Process Description"), attached as Exhibit D; *see also* Exhibit E, Deposition of Mica Heilmann (Confidential Portion) at 27:22-24 (June 6, 2020) ("Heilmann Confidential Dep. Tr.") ("Q: This document mentions that it's a high level procedures summary. Would you agree with that? A: Yes.").
7. On December 31, 2019, Texas disclosed a rebuttal expert report authored by Dr. Kimmelshue and several other Land IQ employees, including Mica Heilmann. Exhibit F, *Rebuttal Report of Land IQ* (Dec. 31, 2019) (cover and table of contents) ("*Land IQ Rebuttal*"). In the Land IQ Rebuttal, Land IQ asserted that the Land IQ Process Description should be used to evaluate the Land IQ Methodology. *E.g.,* Land IQ Rebuttal at 2.
8. On June 5, 2020, New Mexico deposed Dr. Kimmelshue on the contents of the Land IQ Rebuttal. During this deposition, Dr. Kimmelshue identified Ms. Heilmann as an

expert in the Land IQ Methodology. Exhibit G, Deposition of Joel Kimmelshue at 150:5-13 (June 5, 2020) ("Kimmelshue Depo. Tr. Day 3"). Dr. Kimmelshue also acknowledged that the Land IQ Methodology had not been subject to peer review, except in the sense of the State of California's Department of Water Resources reviewing results from the Land IQ Methodology, but not the methodology itself. Exhibit H, Deposition of Joel Kimmelshue (Confidential Portion) at 172:11-25, 173:1-11 (June 5, 2020) ("A: It has not been published in a peer-reviewed article because it's our proprietary method, and I'm not quite frankly interested in doing that . . .").

9. On June 6, 2020, New Mexico deposed Ms. Heilmann. During her deposition, Ms. Heilmann agreed that "because of the individual expertise woven throughout the analytical process, it is likely impossible to ever exactly replicate the results" of the Land IQ Methodology. Heilmann Confidential Depo. Tr. at 29:8-24.

10. On June 15, 2020, New Mexico Expert David Jordan disclosed his rebuttal report. Exhibit I, *Rebuttal Expert Report of David Jordan* (June 15, 2020) (excerpts) ("INTERA Rebuttal"). Mr. Jordan noted that Land IQ had not directly addressed any of the criticisms of the Land IQ methodology raised in the INTERA Report, and that the "general description" provided in the Land IQ Process Description was insufficient to allow Mr. Jordan to evaluate the Land IQ Methodology. *Id*. at 1. In fact, the Land IQ process description confirmed the Land IQ Methodology differs "for every image, every crop, every date, and every area analyzed and is never exactly the same," making it impossible to reproduce any of the results generated using the Land IQ Methodology. *Id*. at 9.

LEGAL STANDARD

Under Rule 702 of the Federal Rules of Evidence, "the trial judge acts as a 'gatekeeper' screening evidence for relevance and reliability." *Polski v. Quigley Corp.*, 538 F.3d 836, 838 (8th Cir. 2008) (citing *Daubert v. Merrell Dow Pharm., Inc.*, 509 U.S. 579, 589 (1993)). This gatekeeping role under Rule 702 applies regardless of "whether the trier of fact is a judge or a jury." *UGI Sunbury LLC v. A Permanent Easement for 1.7575 Acres*, 949 F.3d 825, 832 (3d Cir. 2020). The party offering the evidence has the burden to show, among other things, that (1) the purported expert is qualified to render the opinions offered, (2) the testimony is the product of reliable principles and methods, and (3) the witness reliably applies the principles and methods to the facts of the case. Fed. R. Evid. 702.

The importance of the trial court's "gatekeeping" responsibility under Rule 702 and *Daubert* cannot be overstated. As the Supreme Court has characterized it, "[T]he objective of that requirement is to ensure the reliability and relevancy of expert testimony. It is to make certain that an expert, whether basing testimony upon professional studies or personal experience, employs in the courtroom the same level of intellectual rigor that characterizes the practice of an expert in the relevant field." *Kumho Tire Co. v. Carmichael*, 526 U.S. 137, 152 (1999). The question of whether an expert's testimony is reliable depends on the facts and circumstances of the particular case. *Id.* at 158. The party offering expert testimony has the burden of proving its admissibility by a preponderance of the evidence. *Daubert*, 509 U.S. at 593 n.10.

Expert testimony is admissible only if a witness uses a reliable methodology and applies that methodology reliably to the facts of the case. Fed. R. Evid. 702(c), (d). Factors bearing on the reliability of an expert's methodology include (1) whether the methodology can be and has been tested, (2) whether it has been subjected to peer review and publication, (3) the known or potential error rate of the methodology, and (4) the general acceptance of the methodology in the relevant scientific community. *Daubert*, 590 U.S. at 593-94. No single one of these factors is dispositive, *id*., but a methodology's failure to meet one or more of these factors can indicate it lacks reliability and that opinions based on that methodology should be excluded. *E.g., United States v. Birdsbill*, 97 Fed. Appx. 721 (9th Cir. 2004) (affirming exclusion of expert's testimony where (1) expert's methodology had a high error rate, (2) the expert's methodology was proprietary and had not been peer-reviewed or published, (3) the expert failed to produce any evidence showing the methodology was generally accepted in the scientific community).

Even if the expert employs principles and methods that are generally reliable, the court may still exclude evidence developed using those principles and methods if their specific application to the facts of the case is suspect. *Gen'l Elec. Co. v. Joiner*, 522 U.S. 136, 146 (1997). ("[N]othing in either *Daubert* or the Federal Rules of Evidence requires a district court to admit opinion evidence that is connected to existing data only by the ipse dixit of the expert. A court may conclude that there is simply too great an analytical gap between the data and the opinion proffered.") Under Rule 702, courts should consider, among other factors, whether "the expert has unjustifiably extrapolated from an accepted premise to an unfounded conclusion" and whether "the expert has adequately accounted for obvious alternative explanations" in reaching the expert's conclusion. *See* Fed. R. Evid. 702, Advisory Committee Notes, 2000 Amendment (citing *Claar v. Burlington N.R.R.*, 29 F.3d 499 (9th Cir. 1994)).

Courts have been willing to exclude expert testimony as unreliable when the expert fails to explain how he or she applied the methodology or failed to adequately explain the link between the accepted scientific premise and the conclusion reached. In *United States v. Valencia-Lopez*, the court upheld the exclusion of an expert's opinion, despite the expert's extensive qualifications, because he "failed to explain in any detail the knowledge, investigatory facts and evidence he was drawing from" and "failed to link his general expertise with his . . . conclusion." 971 F.3d 891, 900 (9th Cir. 2020).

Similarly, in a law firm's defamation suit alleging that an adversary posted on an electronic bulletin board claiming to be an unhappy client, the firm's proffered expert claimed that the post originated from an IP address registered to the adversary. *Wendler & Ezra, P.C. v. American Intern. Group, Inc.*, 521 F.3d 790, 791 (7th Cir. 2008). The court excluded the testimony, however, because the expert did not explain what software the expert used, what data he fed it, what results it produced, or how alternative explanations were ruled out. *Id.*

ARGUMENT

I. The Land IQ Methodology Is Not Reliable.

The Land IQ Methodology violates all four of the *Daubert* factors for evaluating the reliability of an expert's method. Most obviously, the Land IQ Methodology is proprietary and, as a result, has not been peer reviewed or published in a peer-reviewed publication. Kimmelshue Confidential Depo. Tr. at 172:11-25, 173:1-11 (June 5, 2020). The only review of the Land IQ Methodology Dr. Kimmelshue could cite in deposition was review by California's Division of Water Resources of results from the methodology, but not the methodology itself. Also, because the Land IQ Methodology is proprietary and not accessible to members of the relevant scientific community outside Land IQ, it almost by definition has not been generally accepted in that community because no member of that community not employed at Land IQ may know what the Land IQ Methodology entails or use it.

It is also impossible to test the Land IQ Methodology because Land IQ and Texas failed to provide sufficient information to enable New Mexico's experts to understand and reproduce the

Land IQ results.[1] *See City of Pomona v. SQM North America Corp.*, 750 F.3d 1036, 1047 (9th Cir. 2014) (a primary requirement of *Daubert's* testability factor is that someone else "using the same data and methods . . . be able to replicate the results" (quotation omitted)). Even if Land IQ had provided additional information about the Land IQ Methodology, it is not clear whether anyone other than Land IQ could generate the same results with the same data and methods given that the Land IQ Methodology, by Land IQ's own description, is never "exactly the same." Land IQ Process Description at 1; Heilmann Confidential Depo. Tr. at 29:8-24.

Finally, it is impossible to understand the Land IQ Methodology's potential error rate without understanding the methodology itself. While Land IQ purported to provide an error rate analysis, its analysis is suspect. INTERA's independent evaluation of the Land IQ Methodology's error rate for 2006 suggests it is considerably higher than Land IQ reports. INTERA Rep. at 46.

On the evidence Land IQ has provided, it is impossible to determine whether the Land IQ Methodology amounts to anything more than guesswork. Because Texas failed to establish the reliability of the Land IQ Methodology, Dr. Kimmelshue's and Ms. Heilmann's opinions on crop classification information derived using the Land IQ Methodology should be excluded from presentation at trial.

II. The Land IQ Methodology Was Not Reliably Applied.

For similar reasons, the Land IQ Methodology was not reliably applied. By failing to explain in detail how the Land IQ Methodology works and how it was applied to the facts of this case, Land IQ "failed to explain in any detail the knowledge, investigatory facts and evidence [they were] drawing from." *Valencia-Lopez*, 970 P.3d at 900. This is a classic example of an expert's opinions being related to a supposedly sound methodology solely by the "*ipse dixit* of the expert."

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[1] This failure also violates Rule 26(a)(2)'s requirement that a party disclose "a *complete* statement of all opinions the witness will express and the *basis and reasons for them*." Fed. R. Civ. P. 26(a)(2) (emphasis added).

Joiner, 522 U.S. at 146. Because there is "too great an analytical gap," *id*., between the existence of the supposedly science-based Land IQ Methodology and its results, opinions derived from the Land IQ Methodology should be excluded from trial.

CONCLUSION

For the foregoing reasons, New Mexico respectfully requests that the Special Master exclude from trial Dr. Kimmelshue's and Ms. Heilmann's opinions on crop classification information derived using the Land IQ Methodology.

Respectfully submitted,

/s/ *Jeffrey J. Wechsler*

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STATE OF TEXAS,

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OFFICE OF THE SPECIAL MASTER

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STATE OF NEW MEXICO'S CERTIFICATE OF SERVICE

♦

This is to certify that on July 28, 2021, I caused a true and correct copy of the **State of New Mexico's *Daubert* Motion *in Limine* to Exclude Opinions Offered by Dr. Joel Kimmelshue and Mica Heilmann** to be served by e-mail and U.S. Mail upon the Special Master and by e-mail upon all counsel of record and interested parties on the Service List, attached hereto.

Respectfully submitted this 28th day of July, 2021.

/s/ Michael A. Kopp

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EXHIBIT A

May 31, 2019

EXPERT REPORT OF:
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Land Use Classification and Consumptive Use Estimates for the Rincon, Mesilla, and El Paso Valleys from 1936 through 2018

In the matter of:

No. 141, Original
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State of Texas v. State of New Mexico and State of Colorado

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Contents

Annual Land Use Analyses

For each year of spatial analysis, the specific imagery resources, dates, resolution, quality, and other attributes are summarized below. For each year, two or more mapping exhibits are provided (Exhibits 4-32). These exhibits are also provided in larger map size by valley in Appendix 2. The most recent years are listed first.

2018 Analysis

Data Sources

- **Imagery** - Images used for this analytical year are summarized below.

	Imagery	Date	Resolution	Color
Rincon	Planet Labs Landsat 8 Google Earth	Multiple dates Multiple dates Multiple dates	5 m 30 m Various	Natural Color Multispectral Natural Color
Mesilla	Planet Labs Landsat 8 Google Earth	Multiple dates Multiple dates Multiple dates	5 m 30 m Various	Natural Color Multispectral Natural Color

- **Field Data** – Ground truth data collection for summer crops in all three valleys was performed in August 2018 and used as a basis of classification for 2018. Ground truthing efforts were used as training data for classification efforts.

- **Ancillary Data** - Ancillary data used to validate and assist the development of the 2018 crop map included the 2016 classification efforts, and the closest available dates of the Elephant Butte Irrigation District (EBID) crop report (2013) and the El Paso County Water Improvement District #1 (EPCWID) crop report (2012). These data served to inform the analysts as to the likely dominant crop types and their relative percentages in the years immediately preceding the analysis date, but were not used for spatial analysis.

Mapping Methodology

Planet Labs, Google Earth and multiple dates of Landsat 8 imagery (30 m) from across the growing season were used as the image base. An object-based (i.e. field-based) image classification was performed to map the crop types for Rincon and Mesilla Valleys with the 2018 imagery. Field data were stratified by crop type and divided into training and validation data. Mean values of the different image types were extracted from each date of imagery. The mean image values and training data were input to a random forest statistical classification algorithm which assigns a crop type to each field based on the field's statistical similarity to training data.

IN THE SUPREME COURT OF THE UNITED STATES
BEFORE THE OFFICE OF THE SPECIAL MASTER
HON. MICHAEL J. MELLOY

STATE OF TEXAS Plaintiff, VS. STATE OF NEW MEXICO, and STATE OF COLORADO, Defendants.	))))))))))	Original Action Case No. 220141 (Original 141)

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ORAL DEPOSITION OF
JOEL KIMMELSHUE, PhD, CPSS
SEPTEMBER 19, 2019
VOLUME 1

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ORAL DEPOSITION of JOEL KIMMELSHUE, PhD, CPSS, produced as a witness at the instance of the Defendant State of New Mexico, and duly sworn, was taken in the above-styled and numbered cause on September 19, 2019, from 9:10 a.m. to 4:56 p.m., before Heather L. Garza, CSR, RPR, in and for the State of Texas, recorded by machine shorthand, at the offices of SOMACH SIMMONS & DUNN, 500 Capitol Mall, Suite 1000, Sacramento, California, pursuant to the Federal Rules of Civil Procedure and the provisions stated on the record or attached hereto; that the deposition shall be read and signed.

need to assert confidentiality or trade secret on these, please let me know. On Page 14, you say, quote, "Field data was stratified by crop type and divided into training and validation data." Will you explain to me what you mean specifically about what you did with the Landsat imagery to decide how to pick training versus validation fields?

A. Yeah, I'm going to not answer that. Sorry.

Q. So that determination is -- is part of the trade secrets?

A. Yes.

Q. And then you also state on the same page that the mean values of the different image types were extracted from each date of the imagery. Would you explain what you mean by the mean value and how you extracted it?

A. I -- I'm not -- I'm not going to answer that either. Sorry.

Q. Is that because it's a trade secret?

A. Yes.

Q. Okay. And then on the same page again, "The mean image values and training data were input to a random forest statistical classification algorithm, which assigns a crop type to each field based on the field's statistical similarity to training data."

Would you explain how you determine the field's statistical similarity to the training data?

A. Trade secret. Sorry.

Q. And then on Page 15, after the random forest classification was completed, an accuracy assessment was performed with the independent validation sites, and the question I have is how do you -- how did -- how do you compare the independent validation sites to your classification?

A. I can talk about that. That's an industry standard accuracy assessment where when we perform our ground truthing, we collect as many fields as we can on public roads as we're driving by with a driver and two iPads and people who are skilled at identifying the difference between corn and peppers and pecans. A portion -- and other crops. A portion of those data are used as calibration or training data, and a portion of those data are held back for validation. We then use our algorithms to classify all fields that we didn't drive by, including the ones that we held back that we did drive by, and then we can use our results after some other approaches, after algorithms are applied to compare what we saw in the field and how we classified it. So it's kind of a classic observed versus predicted relationship. And the and many times they match nearly all the time, as well, and on down. So we'll choose a level in which we believe that our algorithm is not achieving at least a 95 percent accuracy, and then all of those fields that fall below that -- that level, whether it's .7 or .8 or .85 or .6, whatever it ends up being, is where we begin the photo interpretation support task.

Q. So overall, describe for me which parts of the random forest method is trade secret or proprietary. Is it just the algorithms themselves?

A. It is for all intents and purposes, just the algorithms themselves. The process, the steps that we go through are common -- are fairly common steps.

Q. And is there a particular computer program that these algorithms are already loaded in that you use every time you do the random forest method?

A. Yes.

Q. And what's the name of that software?

A. Doesn't have a -- it's ours. We developed it. We don't name things.

Q. And I'll have to ask these just for the record, but can we get a copy of that software with the algorithms?

A. No.

Q. And that's because it's trade secret, correct?
A. Yes.
Q. Okay.
A. I can describe all the steps for you. I can describe a lot of the questions you're answering, but I hope you can understand that we have a research and development arm to our company, and we've spent literally hundreds of thousands of dollars in developing this methodology and although I fully respect all the people in this room, there's some here that would like to know it.
Q. Have you ever provided the software or the algorithms under a confidentiality agreement?
A. No.
Q. Would you ever?
A. I don't know. We'd have to -- I'd have to discuss it with our counsel.
Q. Sure. I may come back to some of that tomorrow, but for now, we'll -- we'll move off of the random forest method. Okay?
A. Uh-huh.
Q. And I'm going to move on then to your pecan acreage assessment. Pecan spacing and age analysis.
A. Sure.

EXHIBIT C

Texas v. New Mexico and Colorado
No. 141, Orig., U.S. Supreme Court

Analysis of Irrigated Lands in the Rio Grande Valley from Caballo Reservoir in New Mexico to Fort Quitman, Texas

Expert Report Prepared by

David Jordan, PE

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GEOSCIENCE & ENGINEERING SOLUTIONS

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October 2019

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4. Rebuttal of the Land IQ Analysis

We have reviewed the Land IQ report (Land IQ, 2019) and evaluated it with respect to its quantification of total irrigated acreage in EBID, EP No. 1, and Hudspeth County. Note that the Valle de Juarez in Mexico was not evaluated by Land IQ. In general Land IQ's report lacks detail with respect to algorithms and methods used to estimate irrigated acreages. It also lacks information relative to quantifying the accuracy of the method. The methods are seemingly to be taken on faith, since no information is presented to describe or support their proprietary random forest classification algorithm. The "black box" approach is impossible to evaluate directly. Typical scientific methods usually involve using known, accepted, and peer-reviewed methods of analysis to reach a well-founded conclusion. Land IQ's methodology does not follow this time-tested scientific method.

Land IQ appears to scale irrigated acreages from published crop reports upward, and little information is provided to describe their scaling algorithm nor is any justification for the scaling provided other than a brief discussion of what they refer to as "IOVD", or In/Out Valley Distribution. While this concept is discussed qualitatively, no quantitative detail is provided for how the method was applied.

Note that this rebuttal analysis may be modified or amended if additional information becomes available.

4.1. Land IQ Does Not Provide Enough Information or Detail to Allow Others to Understand or Reproduce the Results of Their Proprietary Random Forest Classification Algorithm

The Land IQ results are presented "as-is" and little or no background information is provided on the proprietary random forest classification algorithm used to develop the results. The reader is left with numerous questions regarding the methodology, which as presented constitutes a "black box":

- What are the algorithms, assumptions, and input parameters?
- Has the method been peer-reviewed by others outside of Land IQ?
- Has the method been tested by others outside of Land IQ?
- Has the method been published in a peer-reviewed journal?

4.2. The Land IQ Proprietary Random Forest Classification "Black Box" Algorithm Was Developed Based on Cropping Practices in California, and May Not Accurately Apply to Cropping Practices in New Mexico and Texas

Based on the resume of Mr. Joel Kimmelshue provided with the Land IQ (2019) report, it appears that the Land IQ random forest classification method has primarily been applied in California, and thus may not be as accurate when applied in New Mexico or Texas. No information has been provided relative to how the method may have been modified to ensure its applicability in New Mexico or Texas. There are significant differences in both crops grown and cropping patterns between California and New Mexico/Texas.

4.4. The 2006 Land IQ Results Do Not Compare Closely with Available Field Data

The Land IQ crop classification for 2006, which is based on visual interpretation of aerial imagery, has a lower accuracy than the classifications developed for years based on field surveys (2016 and 2018). Based on available field data for year 2006, the deterioration in accuracy is close to 20%. INTERA used detailed seasonal field classification (INTERA, 2007) carried out in 2006 to evaluate the Land IQ crop classification for the same year. Note that the survey by INTERA (2007) was not developed to assess crop classification, but to define NDVI thresholds. However, these data are valuable since they are independent from Land IQ ground truth surveys. Field polygon classifications derived during INTERA (2007) were compared against the corresponding field polygons developed by Land IQ for the Mesilla Valley. In 2006, Land IQ provided crop classification in two classes: Summer and a combination of Summer and Fall, while INTERA (2007) developed Spring, Summer, and Fall crop classifications. A total of approximately 3,045 acres were compared. The Land IQ classification for chile, fallow-grain, and onions have no agreement with ground survey results, while the fallow class only agrees with 41% of the field observations. The overall agreement between field data and Land IQ classification was 77%. This number contrasts with higher accuracy values reported by Land IQ for other years.

4.5. Land IQ Double-Counts Acreages in Some Instances, and Thus Over-Estimates Irrigated Acreages

Land IQ double counts some fields in their annual irrigated acreage totals. In their report, irrigated acreage for 19 crop types is added together to produce total irrigated acreage for each year (Figure 29). For many of the years that they performed a remote sensing-based analysis, Land IQ produced crop type classifications for multiple growing seasons. When the classified polygons are examined in GIS, one can see that this method has the possibility of classifying a given field into several different crop types over the year (Figure 29).

Land IQ Crop and Land Use Mapping Process

1 Process Introduction

This document summarizes the processes for land use classification and mapping that Land IQ employs to develop high accuracy crop mapping for purposes of other downstream analyses. The crop mapping classification approach developed by Land IQ involves a series of steps; some of which are automated and some of which are manual. All approaches and efforts are conducted by highly trained individuals with years of experience in this specific type of land and crop use mapping that Land IQ has completed on over 30,000,000 acres over the past decade. Over this time our processes have been and are continually updated.

The information contained below outlines the steps in this process and specifically describes individual protocols. Trained personnel use their best professional judgement to guide and refine the various steps in the process. It is important to note that the higher level procedures outlined here are mostly transferrable, however, every classification situation is different depending on variation in regional characteristics, crop diversity, seasonality, timeframe in which the classification is performed, available imagery data, quality of imagery data, etc. Therefore, the process is refined and customized for every image, every crop, every date, and every area analyzed and is never exactly the same. Several steps within the process are iterative and performed by trained analysts to a point where professional judgement determines an acceptable end point for the specific step being completed. Land IQ does not document every decision point in the interim processes because iterations are continuously performed, and because the ultimate outcome is a crop distribution map that is quantitatively verified against independent data or approaches. Because of the individual expertise woven throughout the analytical process, it is likely impossible to ever exactly replicate the results. However, results should be closely repeatable. The process includes the following components that are discussed in later sections of this document.

- Image Acquisition
- Field Boundary Delineation
- Ground Truth Data Collection
- Remote Sensing
- Photo Interpretation
- Final QA/QC and Accuracy Assessment

It is important to note that this remote sensing aided process was completed on a subset of years. In the remaining years, the process was solely photo interpretive, using trained visual analysts as described in the Field Boundary Delineation and Photo Interpretation sections.

The objective of the remote sensing analysis based steps within the overall process is to generate an efficient initial first cut of land use classification that is then refined manually by trained experts to achieve desired accuracy results. The stopping point of the remotely sensed classification step is an interim product and not the final result.

The ultimate measure of the end product of the entire analysis process is an accuracy assessment approach that can be independently conducted in more than one way.

Therefore, it is suggested that for others to assess these land use classification results, a representative selection of field boundaries provided should be selected without existing classification labels. A trained photo interpretive expert should then be employed to overlay the field boundaries on the appropriate year imagery and visually generate an independent crop classification subset for validation. This independently generated data set can be compared to the Land IQ mapping result to create a completely independent and comprehensive accuracy assessment.

2 IMAGE ACQUISITION

No one single image resource is relied on for all classification efforts. The availability, quality, and timing of the image resources are factors that are considered in the selection of image resources. Typically 1-30 meter resolution, multispectral, favoring higher spatial and spectral resolution imagery is preferred that is timed during specific growing seasons. Therefore, various satellite and aerial image resources can be used and selection of these resources is outlined in detail in the Land IQ expert report.

3 FIELD BOUNDARY DELINEATION

INTRODUCTION

Field boundaries are digitized within ESRI ArcMap software for each homogeneous cultivated area and updated, added, removed, split, joined, and recomposed for each unique mapping event. This provides a boundary for remote sensing and photo interpretation processes, an area to calculate actual cropped or other acreage, and an area to perform multiple forms of spatial analyses. A team of trained GIS technicians initially create and subsequently update field boundaries as necessary from one mapping event to the next.

SUMMARY OF STANDARDS AND SPECIFICATIONS

The basic standards and specifications that are followed include the following:

- Software – ESRI ArcGIS
- Scale – Digitization is generally completed at 1:2500 scale
- Format – Shapefile format
- Polygon Size – Minimum polygon size of sometimes less than 1 acre depending on the project requirements and consistency of the cropped area
- Organization and Tracking – utilize fishnet method to track completed grids
- Nurseries/Greenhouses – Group nurseries/greenhouses as a separate crop category
- Fallow/Idle - If boundary does not change, leave polygons as they are

- Splitting – Rules defined below

MXD SETUP

To begin digitization efforts, an ArcGIS .mxd file is set up according to the following criteria:

- Most recent field boundaries from previous mapping efforts are loaded (if existing)
- Polygon line width is set to 1
- Define fishnet and set line width to 2 and set opacity to 50% (Figure 1)
- Mapping boundary applied as appropriate
- Current year imagery – use imagery as determined by GIS manager and corresponding mapping year

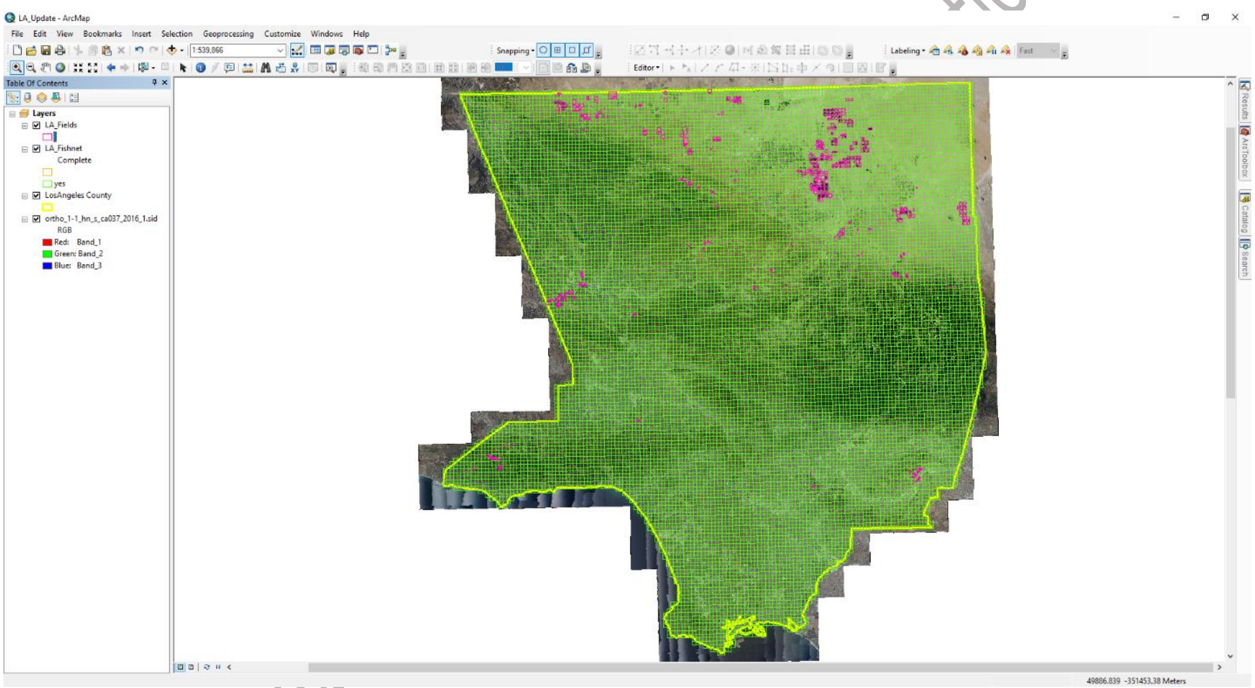

Figure 1. Layer designation and fishnet example

FISHNET

Generation of a fishnet creates a grid so that one grid cell fills the screen to maximize viewing at 1:2,500 scale (Figure 2). The purpose of a fishnet is multifaceted and includes:

- Supports directional and instructional scanning of images
- Aids in organization so that all field boundaries are created or reviewed
- Allows for progress tracking for a certain county or area being updated

Figure 2. Full screen view of one cell of a fishnet.

DIGITIZATION GUIDELINES

The guidelines below are followed when creating or updating field boundaries within the fishnet system:

- Field boundaries are scanned at a scale of 1:2,500 scale utilizing the created fishnet.
- Known area without agriculture (e.g. deserts) can be scanned at a larger scale and marked accordingly.
- Digitization of agricultural fields should exclude other significant features such as navigable roads, larger footprints for irrigation/pumping equipment, and farm shops, homesteads, sheds, etc.
- Farm Roads (generally greater than 10 feet wide) are left outside the field boundary (Figure 3).
- Smaller roads or field divisions (generally less than 10 feet wide) can be included within a polygon (Figure 4).
- The outer boundary is changed if the field completely changes shape.
- Aim to digitize all crop boundaries even if in question as to whether they are an actual cropped field or not. All boundaries are further evaluated in the land use classification steps. Photo interpreters modify or remove boundaries as necessary to accurately represent the classification in a future step of the process.
- Idle fields are not merged or modified if extent has not changed. If there is an old boundary on top of an unplanted field and the extent of the field is the same, do not modify. The field could potentially be planted in the same way.
- If there is an old boundary on top of a field that has been planted and the extent has changed, it is updated accordingly (Figure 5).

- If there are multiple idle fields previously separated by roads, as opposed to a split, merge the fields while maintaining the outer boundary if the roads have now been incorporated into the field (Figure 6).
- Group all Nurseries/greenhouses together by using an approximate <10 feet or >10 feet road rule (Figure 7).

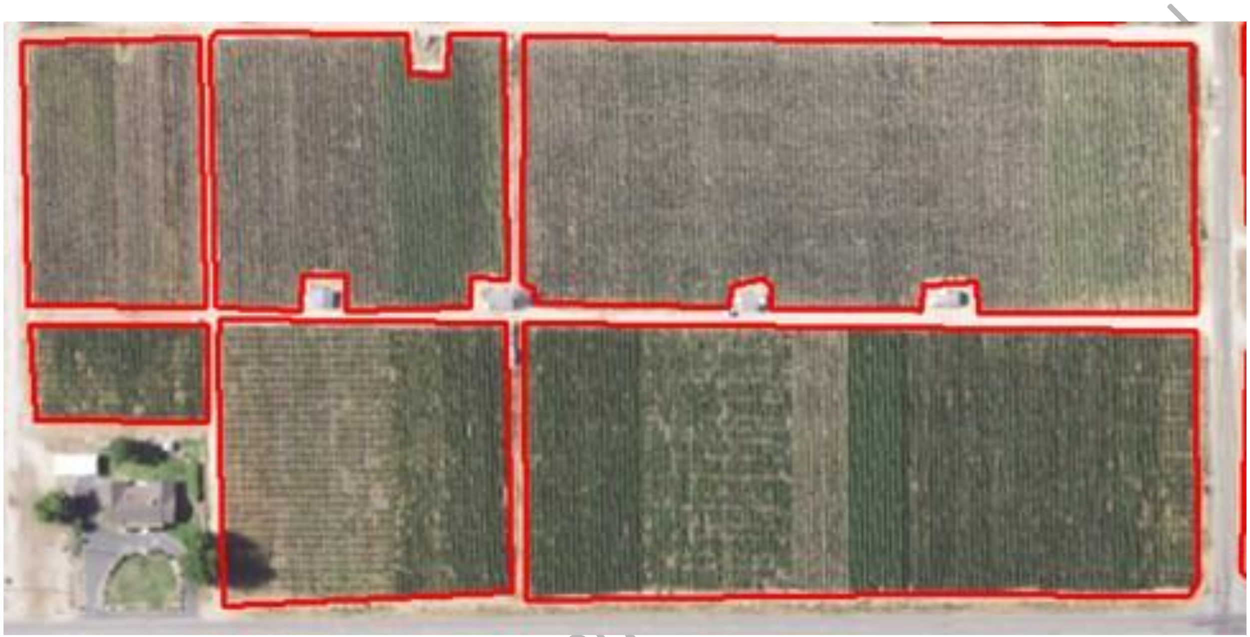

Figure 3. Example of exclusion of roads around fields.

Figure 4. Example of inclusion of narrow roads (<10 feet) within fields.

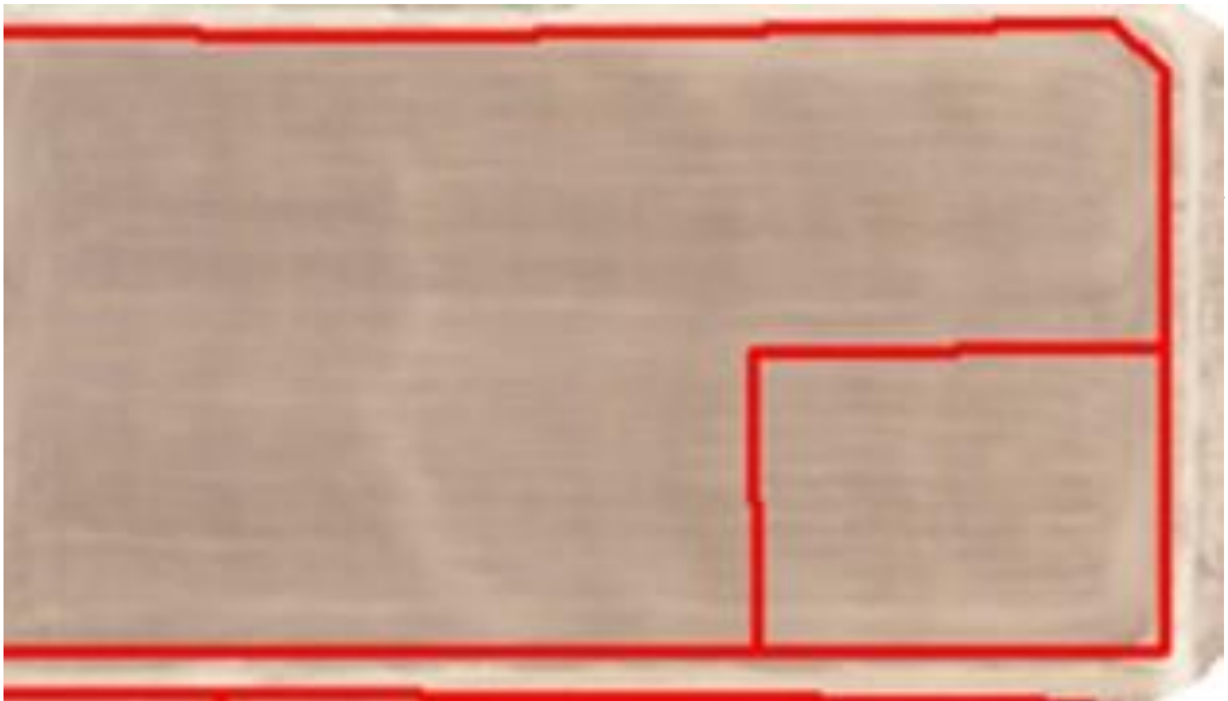

Figure 5. Old boundary on a newly planted field that would be modified.

Figure 6. The highlighted fields will need to be merged while maintaining the former extent.

Figure 7. Example of nursery grouping.

MODIFYING FIELD BOUNDARIES

The guidelines below area provided for the purposes of guiding field boundary modifications and include:

- If an old boundary does not match a new field, first merge old boundaries if they match and then reshape parts that do not represent field appropriately (Figure 8).
- In some circumstances, a single polygon must be split due to permanent changes in the field (Figures 9-10).
- Edits are not made in response to temporary changes that change the appearance of a single field, such as irrigation or harvest (Figures 11-12).
- Use the circle option in the create feature tool window to digitize center pivot fields. (Figure 13). When updating a previously rectangular field to a center pivot field, first digitize the center pivot field in the layer you are updating. Then, select the rectangular field in the layer you are updating, select the split tool then select the trace tool. Trace the circular field you just digitized. This should cuts out the circular field from the rectangular field while retaining the attribute

data from the previous fields. Delete the original circular field you digitized, making sure you are keeping the cut out circular field.

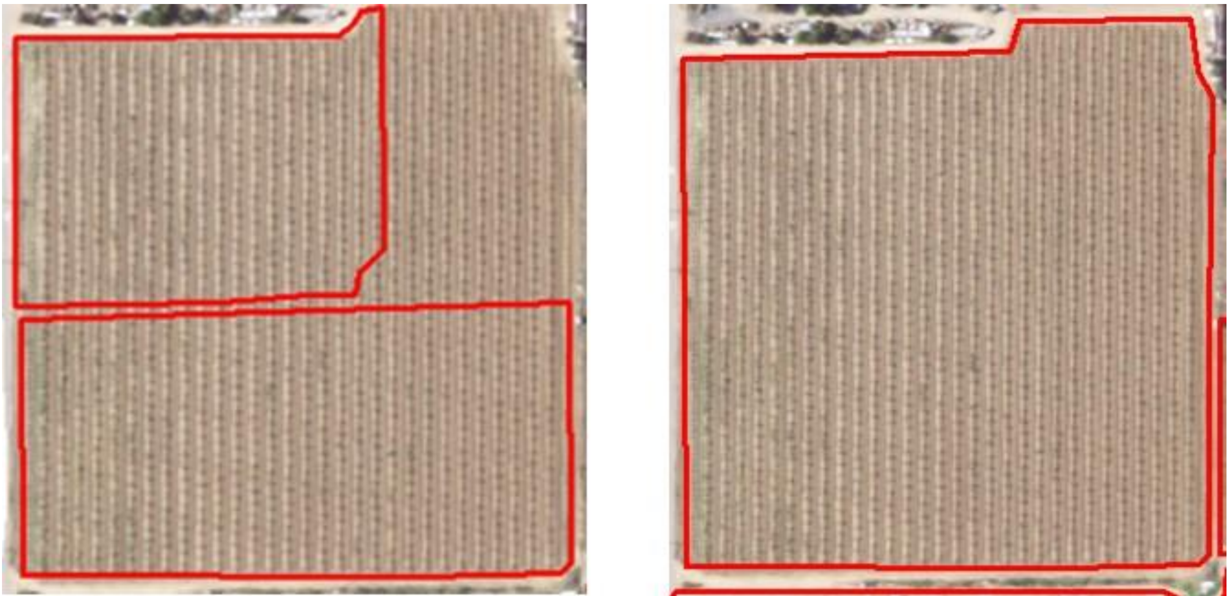

Figure 8. What used to be two fields is combined and then reshaped to reflect the new single, larger field.

Figure 9. Same polygon, different land use – splits are used to delineate each crop change.

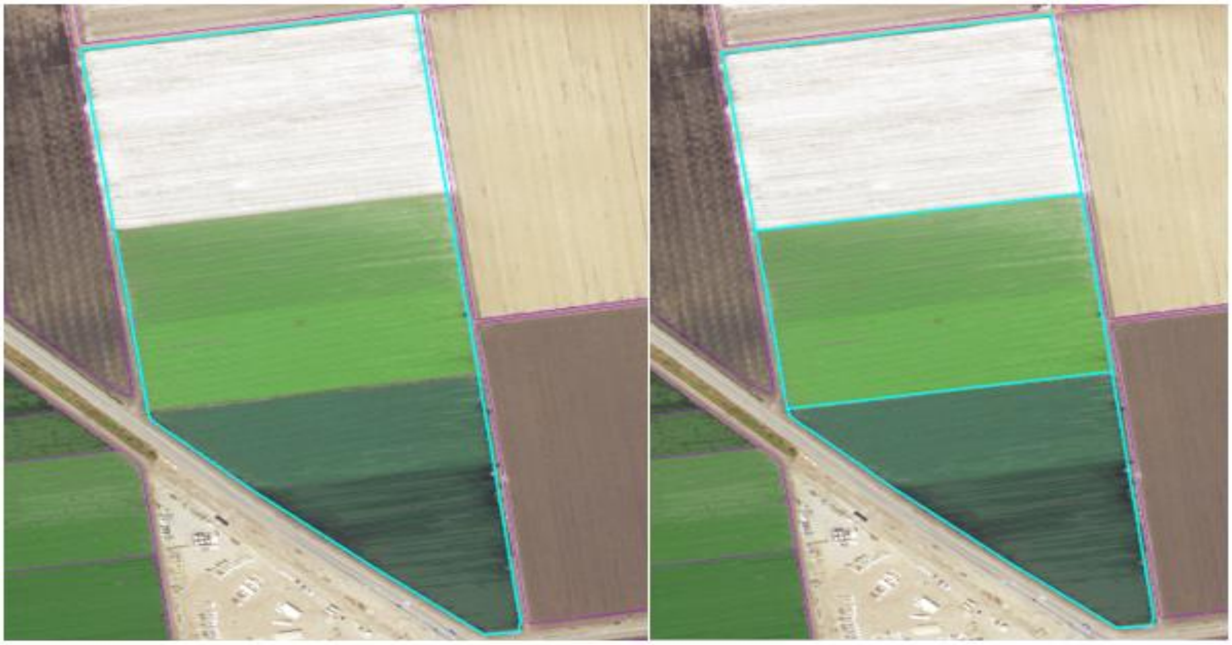

Figure 10. Left: Field with different types of annual crops before splitting. Right: Field after annual crops were split.

Figure 11. Irrigation changes surface appearance but does not require a split. This image was captured in the middle of irrigation.

Figure 12. This image was captured in the middle of harvest. There is no need to split.

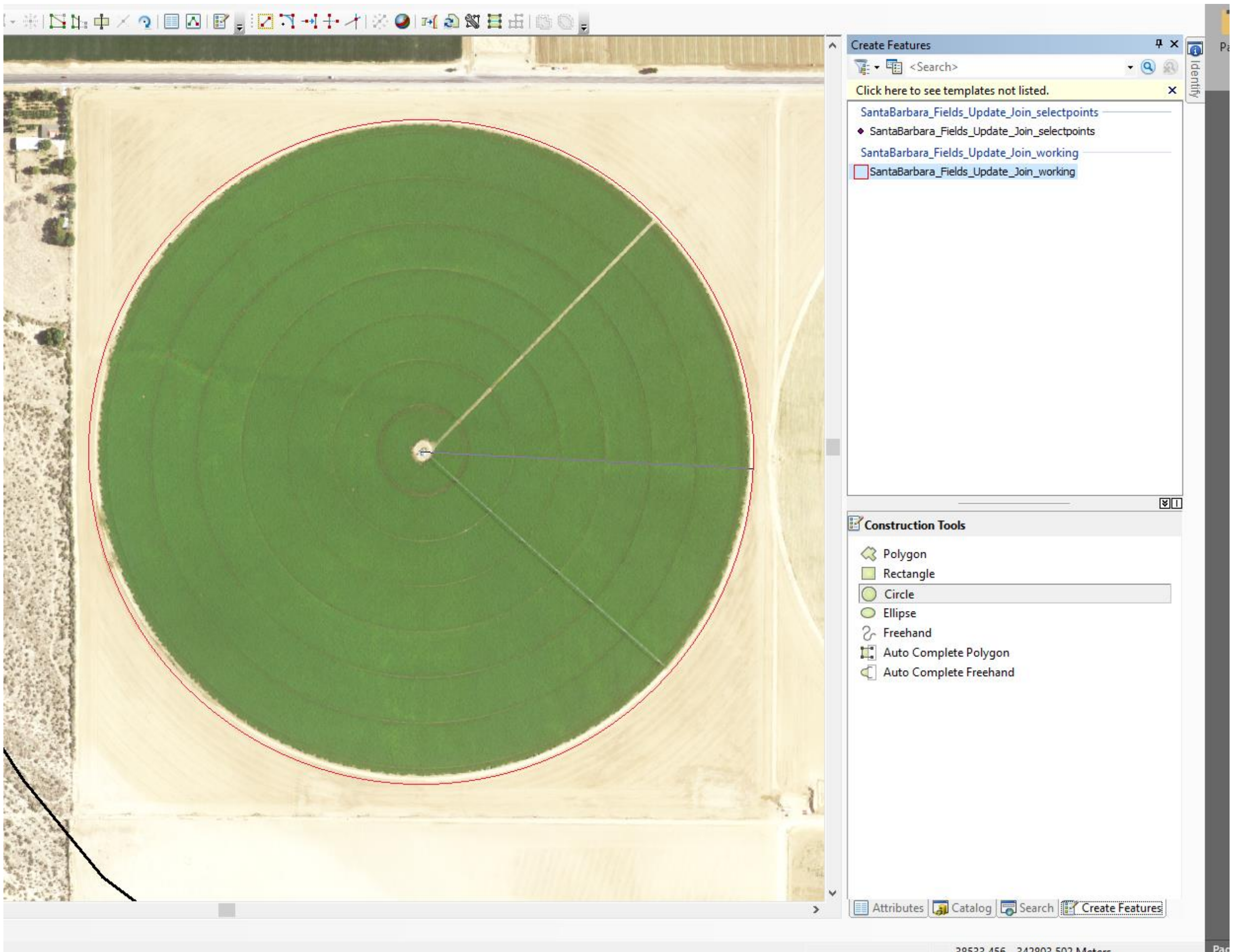

Figure 13. The circle tool used to digitize a center pivot field.

FIELD BOUNDARY FILE TYPE

Initial field boundaries are saved as a shapefile (.shp). Initial boundaries are further modified by analysts through the classification and QA/QC steps as necessary and appropriate.

4 GROUND TRUTHING

The collection of ground truthing data is the starting point in the process of remotely sensed land use mapping. The ground truthing data is used for analysis calibration and validation.

Before a field survey trip is scheduled, a general understanding of the cropping season in the area of interest should be performed including when annual cropping systems may be in production or not. This can be determined through researching publications produced by university extension, county or irrigation district crop reports, analysis of NDVI time series curves via satellite imagery, and anecdotal or personal experience.

The ground truth data collection framework is perfomed within the ESRI ArcGIS environment so that it can be used in field survey software (Collector for ArcGIS), also created by ESRI.

1. A route is created within ArcMap that passes approximately 10-20% of the acreage in the area of interest (Figure 14). Created routes should include the following attributes:
   - Routes are spatially distributed so that production areas are captured as efficiently as possible with minimal overlap/doubling back.
   - If there is a crop of interest, the route density is increased in areas where it is thought to be more prominent.
   - Routes can be saved and used in shapefile format as a simple polyline.
2. Within the geodatabase that will contain the survey dataset, the domains are created (selectable options) to be used with each attribute that will be created in the feature class. Create the survey dataset within an ArcServer Geodatabase that contains all attributes of interest. Create the attribute names (fields) and assign the data type and appropriate domain from the drop-down menu that was previously created.
3. Both the route and survey datasets are made usable in Collector for ArcGIS by right clicking on each data set while in ArcCatalog, then selecting manage and:
   - Enable global IDs
   - Enable archiving
   - Enable editor tracking

Figure 14. Example of ground truthing route.

4. The data are published to the ArcGIS portal so they can be accessed by the field survey software (Collector for ArcGIS). This is done with each feature class in a separate MXD and symbolized as desired in the field. Note that this requires a configured ArcServer System Manager. Within the capabilities tab, appropriate feature access is enabled including Create, Delete, Query, Sync and Update. Ownership-Based Access Control on Features is enabled.
5. Create map tile packages of the desired background imagery to be used on field tablet during data collection for reference. NAIP or other high resolution imagery is generally used as background imagery for crop survey efforts. Once the map tile packages have been created, load them on the iPads via iTunes.

6. Create map documents in ArcGIS Portal that is to be used in the Collector for ArcGIS app on the iPads (Figure 15).
    a. Add in the route and survey datasets that were created in the steps above
    b. Ensure all the permissions are enabled under the share menu so the map document is accessible to the appropriate survey crew.
    c. Download map to the iPads for offline use.

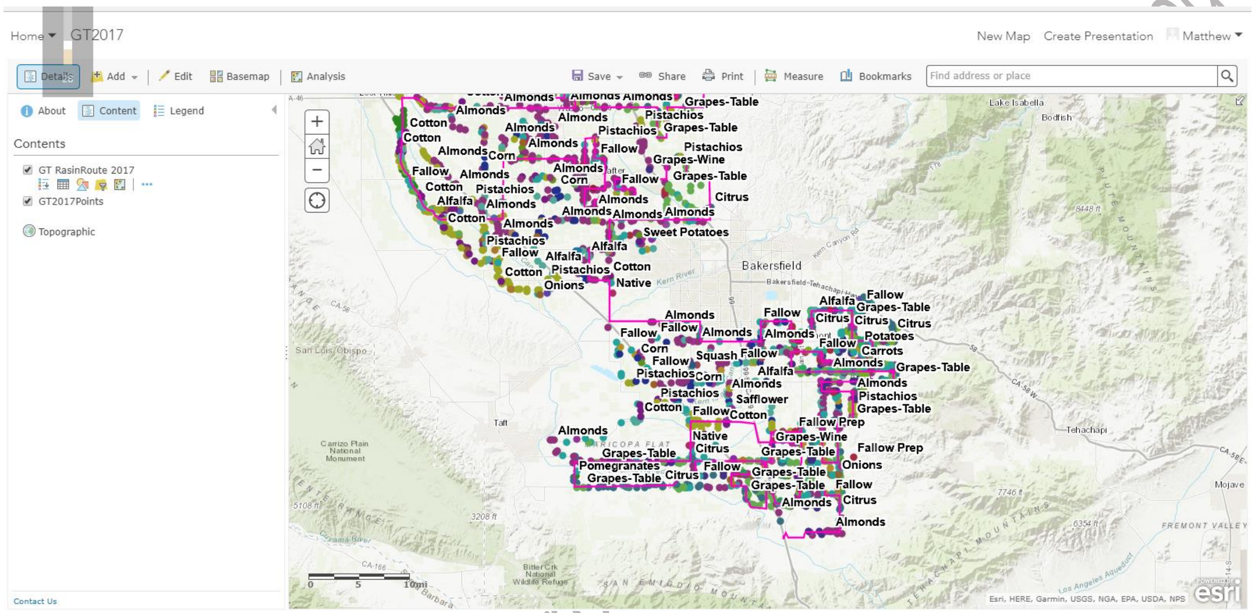

Figure 15. Example of map document creation in ArcGIS Portal.

7. After all the desired datasets have been created and downloaded on to the tablets, field data collection can begin (Figure 16).
    a. The survey crew generally consists of three to four people
        i. One driver and crop type identifier that is experienced with the major crops that will be encountered.
        ii. Two to three loggers; one to log the crop type on each side of the road and one to log other attributes if desired.
    b. The use of an external Bluetooth enabled GPS unit is used to increase the spatial accuracy of the tablets.
    c. The driver calls out the crop types on both sides of the road while traveling on the pre-established route:
        i. Each logger drops a point with the declared crop type on the field in the corresponding image.
            1. The GPS location is displayed on the tablet screen to allow for spatial reference with the surrounding landscape.
            2. Point placement needs to be as close to the estimated center of the field as possible

3. A single point is to be placed on each discreet crop type or discreet field (separated by farm roads, ditches, etc.) so each homogenous block is logged

ii. If a point cannot be dropped on a field or if the analyst is unsure, the field is skipped.

iii. If the crop cannot be positively identified while driving by the field, pull over to investigate further to confirm the identity, if possible.

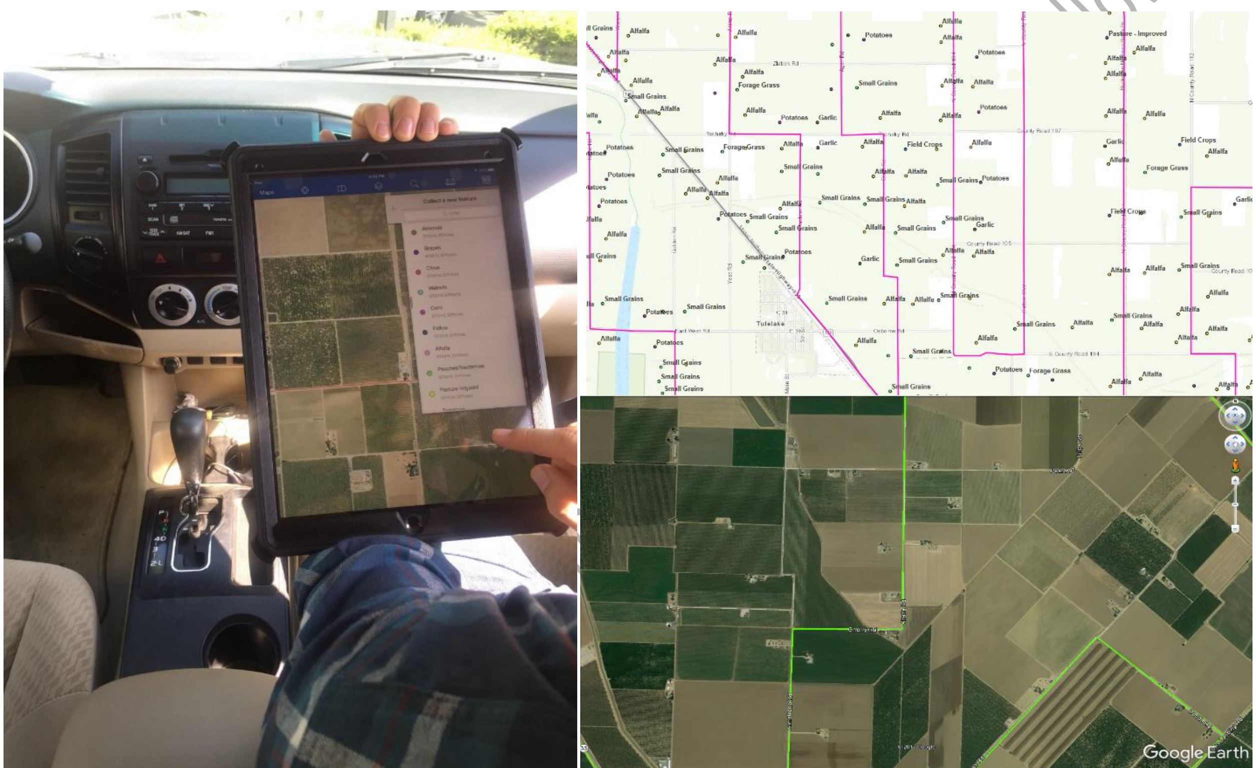

Figure 16. In vehicle example of tablet and ground truth data collection.

8. At the conclusion of survey, data are saved in the shapefile (.shp) format.

5 Remote Sensing

Remote sensing is one of a number of steps in generating the ultimate classification result for crop identification. A random forest classification is the primary approach used to provide a baseline classification of crop type that was then transitioned to manual classification refinement. In some cases a random forest assessment is used alone and in some cases, random forest may be combined with other classification models to classify land use. The steps listed below outline the remotely sensed portion of the process in a multiple model case. In a single model case, just the random forest model was used.

All random forest classifications were supervised with training data. In years where physical ground truth data could not be collected, random forest model results were used to supplement photo interpretation refinement. Model training data were generated by visual photo interpretation. In these years interpreted data were used for training only and not for validation. Table 1 outlines the methods (photointerpretation, remote sensing or both) used for crop classification in the spatial analysis years.

Table 1. Summary of spatially mapped years and approaches used.

Year	Method Used	
	Remote Sensing	Photo/Map Interpretation
2018	x	x
2016	x	x
2014	x	x
2011-12	x	x
2006	x	x
1996	x	x
1986	x	x
1977/1976/1975	-	x
1966	-	x
1955	-	x
1936 *	-	x

x = method used; - = method not used.

* 1936 reported acres used from Joint Investigative Report, however plates for various valleys were also digitized and reviewed

The steps outlined below are an example of the most recent 2018 crop classification. In other remote sensing years, random forest approaches were used similar to those described below for initial classification purposes.

RANDOM FOREST CLASSIFICATION PROCESS

FEATURE DATA PREPARATION

1. Images are downloaded for the analysis year of interest:
   - Source for Landsat imagery is USGS website: https://earthexplorer.usgs.gov/
   - Other aerial and satellite images are selected used where desired and available. The Expert Report outlines images selected for each analysis year.
   - As an example, the following images were downloaded for 2018 analysis:
     - LC08_L1TP_033038_20180908_20180912_01_T1
     - LC08_L1TP_033038_20180823_20180829_01_T1
     - LC08_L1TP_033038_20180807_20180815_01_T1
     - LC08_L1TP_033038_20180722_20180731_01_T1
     - LC08_L1TP_033038_20180706_20180717_01_T1
     - LC08_L1TP_033038_20180620_20180703_01_T1
     - LC08_L1TP_033038_20180604_20180615_01_T1

- LC08_L1TP_033038_20180519_20180605_01_T1
- LC08_L1TP_033038_20180503_20180516_01_T1
- LC08_L1TP_033038_20180417_20180501_01_T1
- LC08_L1TP_033038_20180401_20180416_01_T1
- LC08_L1TP_033038_20180316_20180402_01_T1
- LC08_L1TP_033038_20180228_20180308_01_T1
- LC08_L1TP_033038_20180212_20180222_01_T1
- LC08_L1TP_033038_20180127_20180207_01_T1
- LC08_L1TP_033038_20180111_20180119_01_T1

2. Screen Images for Cloud Cover
   - Images are screened visually for cloud cover or for Landsat images by running the Landsat Quality Assessment Arch GIS tools provided by USGS to create a cloud mask. Source: https://www.usgs.gov/land-resources/nli/landsat/landsat-quality-assessment-arcgis-toolbox
   - The images with cloud coverage < 2% over agricultural field boundaries are retained.

2018 Images	Coverage	Estimation
LC08_L1TP_033038_20180111_20180119_01_T1	0.27%	Cloud-free
LC08_L1TP_033038_20180127_20180207_01_T1	1.71%	Cloud-free
LC08_L1TP_033038_20180212_20180222_01_T1	15.55%	Cloud-cover
LC08_L1TP_033038_20180228_20180308_01_T1	41.65%	Cloud-cover
LC08_L1TP_033038_20180316_20180402_01_T1	37.76%	Cloud-cover
LC08_L1TP_033038_20180401_20180416_01_T1	37.49%	Cloud-cover
LC08_L1TP_033038_20180417_20180501_01_T1	42.22%	Cloud-cover
LC08_L1TP_033038_20180503_20180516_01_T1	0.82%	Cloud-free
LC08_L1TP_033038_20180519_20180605_01_T1	0.11%	Cloud-free
LC08_L1TP_033038_20180604_20180615_01_T1	0.19%	Cloud-free
LC08_L1TP_033038_20180620_20180703_01_T1	0	Cloud-free
LC08_L1TP_033038_20180706_20180717_01_T1	68.30%	Cloud-cover
LC08_L1TP_033038_20180722_20180731_01_T1	0	Cloud-free
LC08_L1TP_033038_20180807_20180815_01_T1	0.07%	Cloud-free
LC08_L1TP_033038_20180823_20180829_01_T1	34.97%	Cloud-cover
LC08_L1TP_033038_20180908_20180912_01_T1	27.49%	Cloud-cover

3. Perform Zonal stats on Field Boundaries
   - Tool used: Arcpy Zonal stats tool
   - Zonal mean values are calculated on the images above, for the selected features based on previous land classification experience. The features used in 2018 are:
     - Band 2 - Blue
     - Band 3 - Green
     - Band 4 - Red
     - Band 5 - Near Infrared (NIR)
     - Band 6 - SWIR 1

  - Band 7 - SWIR 2
  - Normalized Difference Vegetation Index
  - Soil Adjusted Vegetation Index
- NAIP image bands are also added where applicable and other vegetation indices may be calculated and included as defined by the analyst.
- The example result for 2018 is a field boundary shapefile with 8 (number of cloud free images) x 8 (features from each image) = 64 features.
- The total features will vary in other years depending on the number of images and features used.

TARGET VARIABLE PREPARATION

Spatially join field boundary to ground truthing or training dataset (with 64 features in 2018). The result is a field boundary Shapefile with crop types (from ground truthing data) and features (64 features from previous steps)

1. The polygons with ground truthing information are used as training and test data. In the 2018 analysis data were split into 80% training and 20% test data to generate initial prediction accuracy. In other years, Out-of-Bag (OOB) error was generated within the model process to generate initial prediction accuracy. OOB error is a method of measuring the prediction error of random forest models utilizing bootstrap aggregating (bagging) to sub-sample data samples used for training. OOB is the mean prediction error on each training sample x_i, using only the trees that did not have x_i in their bootstrap sample.

MODEL CONSTRUCTION

Up to four different models can be built and include:

1. Random forest based on all images/selected features (used in all years)
2. Random forest built on features that have undergone Principle Component Analysis (used in 2018)
3. Gradient boosting tree model on all images/selected features (used in 2018)
4. Gradient boosting tree model built upon features that have undergone Principle Component Analysis (used in 2018)

Brief descriptions and links to the Random Forest algorithm, Gradient Boosting Tree algorithm, and Principle Component Analysis from the Python Scikit-learn package are provided below.

- Random forest algorithm: A random forest is a meta-estimator that fits a number of decision tree classifiers on various sub-samples of the dataset and uses averaging to improve the predictive accuracy and control over-fitting. The sub-sample size is always the same as the original input sample size but the samples are drawn with replacement if bootstrap=True (default). Link: https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.RandomForestClassifier.html

- Gradient boosting for classification: Gradient Boosting builds an additive model in a forward stage-wise fashion; it allows for the optimization of arbitrary differentiable loss function. Link: https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.GradientBoostingClassifier.html
- Principal component analysis (PCA) (can be applied in combination with the above two models): Linear dimensionality reduction using Singular Value Decomposition of the data to project it to a lower dimensional space. Link: https://scikit-learn.org/stable/modules/generated/sklearn.decomposition.PCA.html

Model steps and parameters for the random forest model are below. The default model parameters are generally used if preliminary results are acceptable.

- Import field boundaries with ground truthing information and features as input data
- If applicable (for 2018) Perform split of fields into 80% training data and 20% test data using sklearn.cross validation, sklearn.model selection, or other similar data splitting function.
- Train the model with the training dataset using default model parameters (note n estimators=100 is the only user defined parameter used in 2018):
  - i. bootstrap=True
  - ii. class_weight=None
  - iii. criterion='gini'
  - iv. max_depth=None
  - v. max_features='auto'
  - vi. max_leaf_nodes=None
  - vii. min_impurity_decrease=0.0
  - viii. min_impurity_split=None
  - ix. min_samples_leaf=1
  - x. min_samples_split=2
  - xi. min_weight_fraction_leaf=0.0
  - xii. n_estimators=100
  - xiii. n_jobs=1
  - xiv. oob_score=False
  - xv. random_state=None
  - xvi. verbose=0
  - xvii. warm_start=False
- During the model parameter tuning process, the analyst examines test accuracy or out-of-bag accuracy to guide the model process. The analysts typically seeks greater than 80% accuracy for the initial classification (for 2018 the preliminary, initial classification accuracy was 85.15%).
- In 2018 using multiple models, the same steps are used for the other 3 models – typically using default parameters.

MODEL PREDICTION

1. The trained model is then run on the full field boundary shapefile (with all of its features) to predict crop type, together with probability for the Random Forest model. The random forest model is used to predict probability information. Changing the predict type to "Prob" will return probability of prediction.
2. The model results are attached to the field boundaries.
   - In the 2018 four-model scenario, the final crop type was preliminarily decided if at least 3 out of 4 models predict the same crop type. All other fields with less than 3 matching results were flagged for manual review by trained analysts using visual photointerpretation.
   - In other years using just Random Forest, the prediction probability is used determine fields for review. The probability results are reviewed manually and a lower probability cutoff is determined by the analyst. This threshold varies, but is typically probabilities less than 75-90%.
3. Preliminary classification results are then passed on for refinement by photointerpretation.

6 PHOTO INTERPRETATION

Photo interpretation is completed by trained analysts familiar with crop production and imagery resources. Photo interpretation occurs 1) on fields where remote sensing efforts were not conclusive, 2) on all fields where remote sensing efforts are not conducted, and 3) separately, as additional final QA/QC across full mapping products. Personnel first familiarize themselves with the predominant crops grown in the area of interest via crop reports, irrigation district reports, etc. They then examine image resources to identify crop type using a number of field characteristics and indicators as appropriate:

If higher resolution imagery is available (i.e. USDA NAIP, aerials from manned aircraft or UAV, Google maps):

1. Examine the textural and tonal characteristics of the image, including:
   a. Row spacing
   b. Canopy Color
   c. Plant height and height consistency
   d. Plant density
   e. Plant morphology
2. Look for management strategies or equipment that is specific to certain crop types.
   a. Irrigation type
   b. Mowing/cutting/multiple harvests
   c. Mechanical harvest/hand harvest
   d. Bales/lugs/other specific container types
   e. Bee hives
   f. Field equipment
3. View other images to understand historic cropping patterns
4. Google street view via Google Earth or Google Maps if available and timely

If lower resolution imagery is available (i.e. Landsat, archived aerials):

1. Examine the tonal characteristics of the image including color
2. Examine the timing and duration of the growing season via Landsat time series.
2. Compare the duration of the growing season to crop calendars for the area of interest

Finally, assign the crop type to the polygon if not already assigned correctly.

7 FINAL QA/QC AND ACCURACY ASSESSMENT

The final QA/QC and accuracy assessment efforts consist of the following:

1. Perform topology error analysis to identify any overlapping boundaries or polygon slivers.
2. Re-scan the entire mapping result using photo interpretive review as a final QA/QC and accuracy effort.
3. Accuracy assessment is conducted using one or both of two methods which include comparison of the map results to set-aside ground truth data or comparison to independently photo interpreted selection of fields.

IN THE SUPREME COURT OF THE UNITED STATES
BEFORE THE OFFICE OF THE SPECIAL MASTER
HON. MICHAEL J. MELLOY

STATE OF TEXAS	)	
	)	
Plaintiff,	)	
	)	Original Action Case
VS.	)	No. 220141
	)	(Original 141)
STATE OF NEW MEXICO,	)	
and STATE OF COLORADO,	)	
	)	
Defendants.	)	

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ATTORNEYS' EYES ONLY
CONFIDENTIAL PORTIONS TO THE
REMOTE ORAL AND VIDEOTAPED DEPOSITION OF
MICA HEILMANN
JUNE 6, 2020
PAGE 26 LINE 13 THROUGH PAGE 52 LINE 20

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okay?

A. Yes. That's fine.

Q. And do you have it there available to you?

A. I do.

Q. Great. Good. So, Ms. Heilmann, for this document here, the title of it is, "Land IQ crop and land use mapping process." Was this document developed specifically for this case to be disclosed to the State of New Mexico or was this document, did it exist prior to this case?

A. Some of the content existed prior to this case, but the document and this compilation was developed just for this purpose.

Q. And who prepared this document?

A. It was prepared by me and Joel Kimmelshue and some of our remote sensing and photo interpretation staff.

Q. Are there other more detailed summaries or analysis of the process that you use for the crop and land use mapping process?

A. No.

Q. This document mentions that it's a high level procedures summary. Would you agree with that?

A. Yes.

Q. It also mentions that the processes are

services group?

A. We -- we have a partnership where we both lead our firm and so I wouldn't say we have a very hard delineation. He also leads our remote sensing folks on specific projects, but on this project, I was specifically the team leader of our group for this project.

Q. There's a statement in the document also that because of the individual expertise woven throughout the analytical process, it is likely impossible to ever exactly replicate the results; is that true?

A. Where is that statement?

Q. It's on the first page near the bottom of the first paragraph.

A. I'm sorry. Did you say the first paragraph on the first page?

Q. I did say that. I apologize. I meant to say the second paragraph.

A. Yes. The expertise and the specific individual decision points in the process do result in -- it -- it would never be exactly replicated because of the individual photo interpretive components of the process, but the process, in general, can be replicated closely.

Q. And how would somebody replicate it?

EXHIBIT F

December 30, 2019

EXPERT REPORT OF:

Joel E. Kimmelshue, PhD, CPSS

Mica Heilmann, BS, CPSS, CPESC

Stephanie Tillman, MS, CPSS, CPAg, CCA

Travis Brooks, PhD Candidate

REBUTTAL REPORT RE:

Land Use Classification and Consumptive Use Estimates for the Rincon, Mesilla, and El Paso Valleys from 1936 through 2018 – PART 1. Response to New Mexico Rebuttal Comments

Consumptive Use of Applied Water in the Rincon, Mesilla, El Paso and Juarez Valleys in the Rio Grande Basin – PART 2. New Mexico Expert Report Rebuttal Comments

In the matter of:

No. 141, Original
In the Supreme Court of the United States
State of Texas v. State of New Mexico and State of Colorado

Prepared for:
Somach Simmons & Dunn
500 Capitol Mall, Suite 1000
Sacramento, CA 95814

Prepared by:
Land IQ
2020 L Street, Suite 210
Sacramento, CA 95811

Land Use Classification and Consumptive Use Estimates for the Rincon, Mesilla, & El Paso Valleys from 1936 through 2018 – PART 1. Response to New Mexico Rebuttal Comments From The October 2019 Report Version

The following provides responses and/or clarifications to the rebuttal comments from Davids Engineering in association with Evapotranspiration Plus (further referred to as the New Mexico experts) to Land IQ expert report. A failure in this Rebuttal Report to respond to every criticism or critique every opinion of the New Mexico experts should not be construed as acceptance of the New Mexico experts' positions. Land IQ reserves the right to further criticize NM experts work at the time of trial if asked to do so by counsel for the State of Texas.

Agricultural Land Use

-Annual Land Use Analyses

Opinion of New Mexico experts:

The Land IQ Report lacks clear and sufficient information necessary to confirm the accuracy of the land use classification procedures, which are central to estimating consumptive use; The level of detail provided in the disclosed report does not allow for replication or evaluation of each step within the procedure:

Rebuttal Response by Texas experts:

All Land IQ procedures are being made available with this rebuttal report upon receipt of a signed confidentiality agreement. Accuracy results have been provided for years with validation data. In the same or other years, independent validation can be conducted by any party performing a separate, photointerpretation by trained professionals on a subset of fields and comparing results.

The New Mexico experts state that specific image dates were not provided. In the sections of the Texas expert report for each mapped spatial year, image sources were provided.

Analysis targeted higher resolution imagery (e.g., NAIP, or other aerial image sources) that were captured during the main growing season for the purposes of field delineations, and land use analysis. These images were provided and in several cases are publicly available, including NAIP imagery dates which can be found at:

https://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/

All Landsat imagery dates and metadata can be found at:

https://www.usgs.gov/land-resources/nli/landsat/landsat-data-access?qt-science_support_page_related_con=0#qt-science_support_page_related_con

All Google Earth image dates can be found on the time slider function on Google Earth.

New Mexico experts should not assume that an image was available "about one every decade between 1936-2018" (New Mexico Expert Report, page 125). Imagery was more available in recent years and less available in historical years. Imagery used for the Texas expert analysis started in 1955 and ended in 2018. All imagery dates used are provided in the Texas expert report for each section

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STATE OF NEW MEXICO,	)	
and STATE OF COLORADO,	)	
	)	
Defendants.	)	

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REMOTE ORAL AND VIDEOTAPED DEPOSITION OF
JOEL KIMMELSHUE
JUNE 5, 2020

****

REMOTE ORAL AND VIDEOTAPED DEPOSITION of JOEL KIMMELSHUE, produced as a witness at the instance of the Defendant State of New Mexico, and duly sworn, was taken in the above-styled and numbered cause on June 5, 2020, from 10:10 a.m. Central time to 5:35 p.m. Central time, before Heather L. Garza, CSR, RPR, in and for the State of Texas, recorded by machine shorthand, at the offices of HEATHER L. GARZA, CSR, RPR, The Woodlands, Texas, pursuant to the Federal Rules of Civil Procedure and the provisions stated on the record or attached hereto; that the deposition shall be read and signed.

the information and glean through the literature and provide the -- the summaries that I instructed her to provide. I wanted a -- a comprehensive literature review on consumptive use, literature by crop type.

Q. Okay. And describe for me in as much detail as possible what Mica Heilmann -- Heilmann's role was?

A. Mica's role more centers on the remote-sensing side of the work that we do, and also senior review on the bulk of this document.

Q. So what do you mean by the remote-sensing side of the work?

A. That would be in our confidential process document.

Q. And then what do you mean by senior review of the bulk of this document?

A. We all review documents before they leave our door as senior reviewers.

Q. Okay. Neither one of those categories, though, relate to Pages 17 to 20.

A. Maybe I missed what you were saying, Ms. Thompson, but all the tables in here are the summaries -- intended to be the summaries of the literature reviews that we did. That's where I mentioned that Stephanie had a significant role in that. She -- she'll speak to those.

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ATTORNEYS' EYES ONLY
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JUNE 5, 2020
PAGE 161 LINE 12 THROUGH PAGE 181 LINE 1

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The process depends on crop type. The process depends on time series analysis of the crops that are grown, when they're planted, when they're harvested. The process depends on complexity of the cropping system. The process depends upon whether it's double or triple cropped, multi-cropped. Those -- some of these things are similar in California than in New Mexico, but some of those things are different so that's why we have to modify it every time we do it. The images are different.

Q. Has the application of this particular method or process ever been peer reviewed?

A. Can you define peer reviewed?

Q. Sure. Has it ever been published in a peer-reviewed article?

A. It has not been published in a peer-reviewed article because it's our proprietary method, and I'm not quite frankly interested in doing that, however, it has been vetted by the State of California, Department of Water Resources Land Use Division multiple times, and if there's anybody that probably is the next that is probably very well skilled in understanding land use and remote sensing and the accuracy of the work that we do, the work that we do here in California is for them and they scrutinize our work heavily, so they -- it's not a peer review -- it is a peer review, but it's not a scientific research article peer review. Those data are made public, so before our data here in California go to the public use, it goes through a rigorous review -- peer-review process through the state of California.

Q. And so when they do their peer-review process, do they have the proprietary code that they can review and check?

A. Again, it -- it's not one single code, just to be clear, and no, they do not.

Q. Do they, when they get the product from you, do they do an evaluation and -- and provide feedback to you?

A. Yes.

Q. And then are there adjustments made?

A. Sometimes. Their evaluation is by actually doing their own independent ground truthing, their own independent crop classification of which they've been doing for years, and their own method, and then they compare those results to ours and provide us feedback.

Q. What type of adjustments then get made?

A. Usually the -- if there was any -- I mean, no. I don't care what remote sensing process you're using, nothing is ever perfect. Our accuracy through

EXHIBIT I

Texas v. New Mexico and Colorado
No. 141, Orig., U.S. Supreme Court

Rebuttal Report to Land IQ Expert Report (December 30, 2019)

Prepared by
David Jordan, PE

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

6000 Uptown Boulevard NE, Suite 220
Albuquerque, New Mexico 87110

June 2020

Table of Contents

1. Introduction

INTERA Incorporated (INTERA) has been asked to provide responses to the Land IQ December 2019 rebuttal report (Land IQ, 2019b) and evaluate any previously presented rebuttal points directed towards the Land IQ May 2019 expert report (Land IQ, 2019a) in the INTERA October 2019 expert report (INTERA, 2019) but uncontested in the Land IQ December 2019 rebuttal report (Land IQ, 2019b). Note that this rebuttal analysis may be modified or amended if additional information becomes available.

2. Uncontested Prior INTERA Opinions

We previously reviewed the Land IQ expert report (Land IQ, 2019a) and evaluated it with respect to its quantification of total irrigated acreage in Elephant Butte Irrigation District (EBID), El Paso County Water Improvement District Number 1 (EP No. 1), and Hudspeth County Conservation and Reclamation District No. 1 (Hudspeth County). In general Land IQ's report lacks detail with respect to algorithms and methods used to estimate irrigated acreages and crop identifications. It also lacks information relative to quantifying the accuracy of the method. Typical scientific studies are expected to use known, accepted, and peer-reviewed methods of analysis to reach a well-founded conclusion. Land IQ's methodology is deficient and does not follow this time-tested scientific method according to expectations.

On December 30, 2019, Land IQ released a 22-page Classification Process Description (confidential proprietary material) on the methods used in their analysis (Land IQ, 2019c). The document describes the general methodology for image acquisition, field boundary delineation, ground-truth data collection, remote sensing, and photo interpretation. Land IQ explains that their process "is never exactly the same" (Land IQ, 2019c, p. 1), and it is generally guided by professional judgement. This is counter to the scientific method, which requires the application of a known approach to reach the same conclusion each time the method is applied, i.e. applying a reproducible method. The Land IQ algorithm is based on partial data collection for the training of a statistical model based on remote-sensing indices averaged by polygon fields. However, in most parcels, and in most years, field data are not available with which to train the Land IQ algorithm. The document provides limited details for the analysis performed for year 2018, as an example, and no information for prior years.

2.1. Land IQ does not provide enough information or detail to allow others to test or reproduce the results of their proprietary random forest classification algorithm

Land IQ has provided some limited information on their proprietary random forest classification algorithm, which we reviewed once we had signed a stipulated protective order. Even after a review of the Land IQ methodology, a number of outstanding issues that we have previously articulated remain:

- The method does not appear to be generally accepted in the scientific community.
- The method has not been tested by others outside of Land IQ.
- The method has not been published in a peer-reviewed journal.
- Land IQ did not provide sufficient data to evaluate the methodology and allow others to test or reproduce the results.
- Land IQ only provided limited information for the 2018 process and no details on any other year.

3. Additional Rebuttal Points

3.1. Land IQ's random forest classification algorithm is highly dependent on ground-truthing

The accuracy of Land IQ's method is heavily based on using ground-truthing data to calibrate the method: "…the work that we do is based on heavy ground truthing… We do that in crop mapping." (Kimmelshue Dep. p242, lines 12-14.). Thus, for years other than 2014 and 2018, which are the only two years for which field ground-truth data are available, the accuracy of the method is likely to be lower, as discussed in Section 2.4 where we observed a 20% decline in the accuracy of the method due to the lack of field data to calibrate the method. In addition, Land IQ arbitrarily removes ground-truthing data when it does not match with their modeled results: "Q. So then you just take these points out? A. …if we discover that they were incorrect ground truthing points, yes we do." (Kimmelshue Dep. p159, lines 6-10.). This practice introduces bias into the accuracy results and is not consistent with application of the scientific method.

Based on information presented in Land IQ's discussion of their proprietary methodology (Land IQ, 2019c), Land IQ uses crops identified via interpreting aerial photography in lieu of actual field data for its analysis of the 2006 growing season, which introduces additional uncertainty into their results. Given that the method is heavily reliant on calibration by field data, using crop-type data interpreted from aerial photography (which are themselves subject to error) will introduce additional error into the methodology. As discussed previously in Section 2.4, the error rate associated with crop-type identification in the absence of actual field data is much higher. Based on field data for the 2006 growing season collected by INTERA, the deterioration in accuracy of the Land IQ algorithm is close to 20%. No attempt was made by Land IQ to evaluate the degree to which this method is prone to error and bias while using historical imagery for training. Interpreted crop data from aerial imagery are not field data and should not be treated as such.

3.2. Land IQ's approach has not been peer reviewed

No evidence of peer review of the Land IQ methodology has been presented in any of the materials provided by Land IQ thus far (Land IQ 2019a, 2019b, 2019c). Joel Kimmelshue confirmed during his June 5, 2020 deposition that the method has not been published in a peer-reviewed journal: "It has not been published in a peer-reviewed article because it's our proprietary method…" (Kimmelshue Dep. Reconvened, p161). The scientific method is expected to involve known, accepted, and peer-reviewed methods of analysis to reach a well-founded conclusion. Land IQ's methodology does not follow this time-tested scientific method. According to Land IQ's classification process document, their approach is different "for every image, every crop, every date, and every area analyzed and is never exactly the same" (Land IQ, 2019c).

Based on our review of the proprietary methodology (Land IQ, 2019c), the exact steps for each year are not documented except for basic details in 2018. No information is provided for any prior years. Land IQ (2019c) also describes the use of photo interpretation in all steps of analysis, from training their random forest classification model to quality assurance and quality control (QA/QC) of preliminary model results to final classification. It is therefore impossible to evaluate how their inputs, assumptions, and analysis criteria affect their historical estimates.