



# SUSTAINABLE BIOECONOMY FOR ARID REGIONS (SBAR)

Summary Report – Quarter 3, 2019

Information submitted by project partners; synthesized by:  
Alix Rogstad, Project Director

## USDA Cover Page

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## ACCOMPLISHMENTS

July 2019 – September 2019

### INTRODUCTION AND PROJECT MANAGEMENT

#### **General Overview: Project Organization**

The Sustainable Bio-economy for Arid Regions (SBAR) Center of Excellence continues to receive project direction and oversight from Dr. Kimberly Ogden, who leads the overall research effort and ensures adequate progress toward meeting project goals. The SBAR Project Director (Alix Rogstad) continues to manage all of the day-to-day project administration and business affairs, as well as coordination, communication, and data sharing among partnering organizations and institutions.

A comprehensive project evaluation plan, approved in July 2018, continues to be effective at capturing detailed progress on the project's defined objectives. As a living document, the evaluation plan will change to reflect revised research questions, project goals and big-picture, overall objectives. The second year comprehensive review for the project was conducted at the 2019 SBAR Retreat in September, and lessons learned and feedback will be incorporated into year three activities. The next scheduled thorough review and update will be in July 2020.

#### **Advisory Board**

No changes were made to the Advisory Board during this quarter (Table 1). Receiving the signed non-disclosure agreements (NDA) to ensure confidentiality of research data, information, and conclusions for the duration of the project is ongoing. To date 7 NDAs have been completed and returned, 4 other Advisory Board members are subject to existing project NDA and confidentiality agreements, and the remaining 4 NDAs are pending.

**Table 1.** SBAR Advisory Board members.

Advisory Board Member	Company/ Representation	Year Joined Board
Chris Cassidy	USDA, Rural Development	2018
Matt Chavez	Independent Grower, NM	2017
Steve Csonka	Commercial Aviation Alternative Fuels Initiative (CAAFI)	2017
Mark DeDecker	Bridgestone Americas, Inc.	2017
Gary Deen	Double D Farms, AZ	2017
William Goldner	USDA, National Institute of Food and Agriculture	2017
John Holladay	Pacific Northwest National Laboratory	2019
Chris Kuzdas	Environmental Defense Fund	2018
Homer Marks	Southwest Indian Agriculture Association, Tohono O'odham Nation	2017
Newt McCarty	NMSU, Extension Educator	2018
Jaroy Moore	Texas A&M Agrilife Research & Extension Center	2017
Alex Muravijov	Guar Resources	2017
Paul "Paco" Ollerton	Tierra Verde Farms, AZ	2019
Matt Payne	West Water Research, Inc.	2018
Bob White	Bridgestone Americas, Inc.	2017

### ***Budget and Financial Management***

On-going budget management activities are working effectively, and all project expenditures are on track. Rogstad continued to develop sub-award agreements and modifications, non-disclosure agreements, and work with partners to ensure grant funds are spent according to the project plan and approved scopes of work.

Sub-awards are fully activated with all project partner institutions: Bridgestone Americas, Inc., New Mexico State University (NMSU), Colorado School of Mines (CSM), Colorado State University (CSU), and the USDA-Agricultural Research Service (USDA-ARS). All sub-awards are progressing appropriately.

To clarify the budget reallocation process and address specific questions that have been raised regarding the use of SBAR project funds, a reference document (Budget Guidelines) was developed by Rogstad and reviewed by the SBAR Leadership Team in September. A final version is expected to be approved in October and shared broadly among the SBAR Team for future reference.

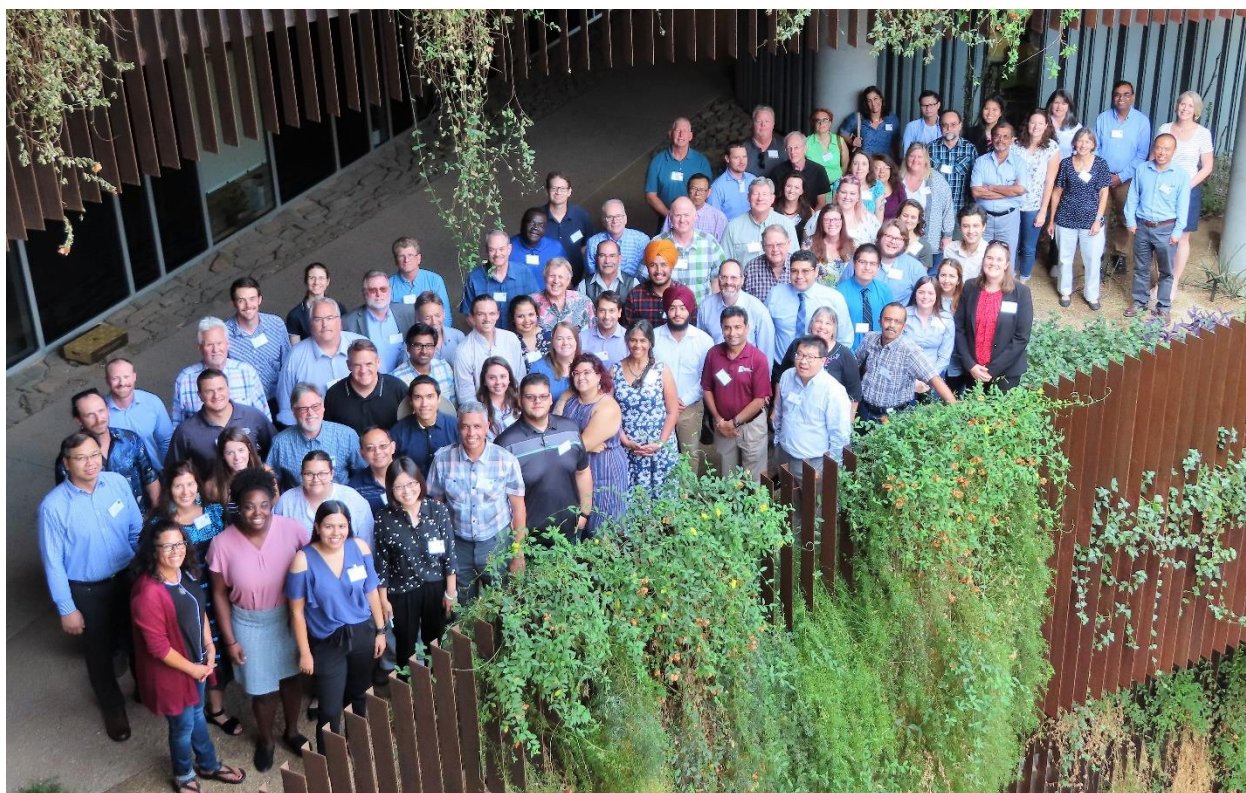
### ***Component Working Group Meetings***

All five SBAR component working groups continued to participate in scheduled online meetings to ensure forward momentum on all project tasks. Smaller focus group meetings were scheduled and facilitated as necessary. During this reporting period, the virtual meeting space (via Zoom) was utilized 21 times for over 24.1 hours. An additional 12 meetings were hosted during the same timeframe that did not require the virtual meeting space. Component working group meetings were also hosted in conjunction with the 2019 SBAR Retreat (see section below), which accounted for an additional 18 hours of face-to-face interaction among team members.

### ***LEADS Team Meetings***

The component leaders and co-leaders (LEADS) continued to meet with Ogden and Rogstad during established twice-monthly meetings held via SBAR's dedicated Zoom online meeting space. The LEADS continue to provide guidance for project decisions, and assist with resolving internal conflicts that are brought for discussion.





**Photo 1.** *SBAR Team at the Annual Retreat at the University of Arizona in Tucson, Arizona, September 2019.*

### **2019 SBAR Annual Retreat**

The 2019 SBAR Annual Retreat was hosted at the University of Arizona in Tucson from 11-13 September, and it was scheduled in collaboration with the Association for the Advancement of Industrial Crops (AAIC). One-hundred-five (105) people affiliated with the SBAR project were in attendance, including Advisory Board members, researchers, key personnel, students, and international visitors. Specialized working group meetings were hosted on Wednesday, where component working teams were able to interact and directly engage with each other to work on identified tasks and define the next year's goals (Appendix 1).

There were multiple opportunities during the Annual Retreat for student engagement, including open networking periods, and the SBAR Interdisciplinary Face-Off – a student challenge competition designed to facilitate teamwork across disciplines. Also like previous annual meetings, a student poster competition was hosted for undergraduate and graduate students. This year's competition was open to *Project Puente* interns who were encouraged to produce and showcase their summer SBAR work via a research poster, even if they were unable to



attend the meeting in-person. In all, over 35 undergraduate and graduate students participated in the Retreat, with over 20 participating in the student poster contest. Posters (and associated Q&A) were scored by a diverse team of judges on a variety of quality and presentation metrics. Cash prizes – generously provided by Bridgestone Americas, Inc. – were awarded to the top-scoring posters in intern, undergraduate, and graduate student categories.



**Photo 2.** Student poster contest winners: Nicolas Soliz, NMSU (Undergrad, 1st Place); Ana Soto, UA (Intern, 2nd Place); April Wright, NMSU (Undergrad, 2nd Place); Hailey Summers, CSU (Graduate, 1st Place); Jagdeep Singh, NMSU (Graduate, 2nd Place).

This year's Annual Retreat also included interdisciplinary breakout sessions to facilitate whole-team engagement across components. The sessions were designed and allowed for input and candid dialogue from all participants, including researchers, key personnel, SBAR Teacher Mentors, as well as Advisory Board members. Key ideas identified were captured and then prioritized for future action.



**Photo 3.** Interdisciplinary breakout session discussion sustainability topics, SBAR Annual Retreat, September 2019.

Synthesized evaluation information captured during and following the 2019 SBAR Annual Retreat is provided in Appendix 2.



**Photo 4.** Prioritization of key ideas identified during breakout discussions, SBAR Annual Retreat, September 2019.

## Communication and Reporting

Reporting schedules for researchers are established and working well. Quarterly reports submitted are synthesized and made available to the research team and Advisory Board members. Summary reports are also posted to the SBAR website for wider dissemination. A Task Tracker Report is provided to the LEADS, which gives a status update for each team member per component. The Task Tracker Report is a proactive management tool that allows the identification of issues before they become risks for overall project completion.

## Website and Social Media

The SBAR-specific website ([www.sbar.arizona.edu](http://www.sbar.arizona.edu)) continues to be regularly updated and maintained, serving as the digital “face” of the SBAR Center. The University of Arizona obtained a contract with a new server company/website provider that houses the website in early July, so the SBAR website had to undergo a complete overhaul. This happened mostly behind the scenes, and resulted in some site functionality changes and improvements.

There were 1,116 unique sessions from July – September 2019. Page views occurred in 25 different countries this quarter (top two: USA and India), including 7 countries that have not visited the website previously. Although this quarter experienced a slight decrease in webpage visits from the USA as compared to last quarter, visits from the USA still made up approximately 90% of site visits overall. The SBAR webpage was visited by people in 24 different states during this reporting period (Table 2). Since inception, the website has been viewed by people in 32 states.

**Table 2.** Web traffic to the SBAR Center webpage from within the United States since inception.

State	Time Period				
	Jul – Sep 2018	Oct – Dec 2018	Jan – Mar 2019	Apr – Jun 2019	Jul – Sep 2019
Arizona	X	X	X	X	X
Arkansas					X
California		X	X	X	X
Colorado	X	X	X	X	X
District of Columbia	X	X	X		X
Florida			X	X	
Georgia					X
Illinois		X	X	X	X
Indiana			X		
Iowa	X	X	X	X	X
Kansas		X		X	
Maryland	X				
Massachusetts				X	X
Michigan			X	X	
Minnesota				X	X
Missouri					X
Montana					X
Nebraska					X

State	Time Period				
	Jul – Sep 2018	Oct – Dec 2018	Jan – Mar 2019	Apr – Jun 2019	Jul – Sep 2019
Nevada					X
New Mexico	X	X	X	X	X
New York	X		X	X	X
North Carolina		X			
Ohio			X	X	X
Oregon				X	X
Pennsylvania			X		
South Carolina	X			X	
Tennessee	X	X	X	X	X
Texas	X		X	X	X
Virginia			X	X	X
Washington		X	X	X	X
Wisconsin			X		X
Wyoming			X	X	X
<b>Total</b>	<b>10</b>	<b>11</b>	<b>19</b>	<b>20</b>	<b>24</b>

There have been 4,435 unique website sessions since July 2018. Since activation, the website has had visitors from 6 continents and 51 different countries around the world (Table 3). The highest visited website pages during this period included those that described SBAR events (SBAR Annual Retreat and 4H biofuel summer camp) and pages that describe our team and project objectives. Other highly visited pages included those that provide the project overview/general description, and accomplishment reports. The website will continue to be updated regularly as the project unfolds.

**Table 3.** International web traffic to the SBAR Center webpage since inception.

Country	Time Period				
	Jul – Sep 2018	Oct – Dec 2018	Jan – Mar 2019	Apr – Jun 2019	Jul – Sep 2019
Argentina					X
Australia		X	X	X	X
Austria	X				X
Bangladesh					X
Brazil			X		X
Canada	X	X	X	X	X
Chile				X	
China		X	X	X	X
Côte d'Ivoire					X
Egypt		X			
Estonia			X		
Ethiopia		X			
France			X	X	
Germany	X	X		X	X
Ghana				X	

Country	Time Period				
	Jul – Sep 2018	Oct – Dec 2018	Jan – Mar 2019	Apr – Jun 2019	Jul – Sep 2019
Hong Kong	X	X		X	X
India	X	X	X	X	X
Indonesia					X
Iran	X		X	X	X
Ireland				X	
Israel			X		
Italy	X	X	X	X	X
Japan	X	X	X	X	X
Kuwait		X	X		
Lebanon				X	
Malaysia			X	X	
Mexico		X	X	X	X
Morocco				X	
Namibia				X	
Nepal		X		X	
Netherlands					X
New Zealand	X				
Pakistan		X		X	X
Philippines	X			X	
Poland			X		
Russia				X	X
Saudi Arabia					X
Singapore					X
South Africa			X		
South Korea				X	
Spain				X	X
Sri Lanka				X	
Sweden				X	
Thailand	X			X	
Turkey		X	X		
Ukraine				X	
United Arab Emirates				X	
United Kingdom	X	X	X	X	X
United States	X	X	X	X	X
Vietnam					X
Zambia			X		
<b>Total</b>	<b>13</b>	<b>17</b>	<b>20</b>	<b>31</b>	<b>25</b>

## FEEDSTOCK DEVELOPMENT & PRODUCTION

Project Coordination: As of July 2019, the two Feedstock Development (FD) working groups decided to begin holding a single joint meeting to enhance their work in guar and guayule. They continue to meet monthly and on an as-needed basis in between monthly meetings. The UA continues to lead monthly meetings, which are leveraged to ensure all team members are on schedule and research work can seamlessly integrate between components. The FD team members also meet during weekly research team meetings (all-hands) hosted at both the UA and New Mexico State University. These weekly briefings provide an opportunity for open communication regarding on-going experiments and results.

### Issues/Risks:

**Angadi:** The year was very unusual. Frequent rainfall during early summer delayed planting and like most farmers in the region, we struggled to complete trial planting. That was followed by a hot and dry period during growth and flowering. Then during pod development we received significant rainfall that was not useful for guar but increased diseases. The way one farmer told me, this was a non-guar season. Guar seed yield may be lower than last year as a result.

**Maier/Neilson:** Quality control analysis continues to raise concerns with the soil chemical data generated by NMSU. Analysis was repeated in the Maier Lab during Q3 for bioavailable phosphorus, an analysis that was replicated in duplicate by NMSU. Different values were obtained for the samples analyzed by the Maier Lab. Maier Lab will perform analysis on pH, EC and organic Carbon as a means of evaluating the Year 1 NMSU soil chemical data. In addition, select year 1 soil samples will be sent to three commercial labs to further evaluate the current data set. Year 2 soils will be sent to a commercial lab which will be selected based on the Year 1 trial samples and the availability of funding.

Jessica Ledesma (undergraduate student) has been trained to complete soil texture analysis on the Year 1 Eloy soils. The analysis is 50% complete.

Kyle Brown has gained expertise in DNA extraction and quantification and is now on track to complete the DNA extractions for the Year 1 soils. The Year 2 SOW includes a revised timeline for microbial analysis of soils for this task.

**McCloskey:** We are just finishing the data analysis on the spring 2019 data. I have a backlog of writing tasks to turn this data (and previous data) into reports for the SLN label submissions and research reports. We are now caught up in the work of conducting the fall 2019 experiments at MAC. Thus, I have postponed writing into Q4. The fall 2019 experiments at MAC are numerous so will be a challenge to get the reports completed but I am committed to the effort.

As an aside the Fall 2019 experiments in the SOW for year 3 were started at MAC with herbicide applications and planting in October. Preemergence herbicides were applied and the fields pre-irrigated in mid-October to start the experiments. The fields were planted on October 17, 2019 and irrigated 10/18, 10/20, 10/22 and 10/25. This was followed by a very windy Friday 10/25 and following weekend. At this point, pre-irrigation does not seem to have solved the problem of the beds cracking down the middle during drying. I am not sure this planting is going to be successful and it is too late to replant. Failure would result in more time for writing.



**McMahan:** Our main issue has been the growth rate of the plants. Leaf discs that were transformed in December 2018/January 2019 are finally developing shoots, but slower than expected. We continue to evaluate changes in the media (sucrose concentration) and process (longer time before calli transfers) to accelerate plant recovery. We anticipate plants from the first 3 constructs will be large enough to test for confirmation of transformation by December 2019.

**Ogden:** A risk is that S. Pradyawong had to return to her home country and we are unsure when she will return. A. Smith is a first-year graduate student and is just learning.

**Waller:** The WINDS model is now running in the server and we can accomplish all basic tasks such as simulating multiple fields, running on the server, saving data to the database, and displaying data from the database. We are also running the nitrogen and salinity algorithms. Everything does not work perfectly, and we are now trouble shooting, back-checking against calibrated models, working on the web page input and output, and adding functionality for the user.

**Objective 1. Improve biomass quantity and quality through genetics and traditional breeding.**

Task #	Description of Task	Deliverable	Target Completion Date
1 Dierig	Evaluate USDA germplasm lines	Ploidy analysis completed  Harvest/Analysis of first growth cycle completed	31 Aug 19  30 Apr 20
2 McMah	Prepare expression vectors for downregulation of SEPATALLA3 and FLOWERING LOCUS T genes in guayule	Complete construct for transformation work on SEPATALLA3  Complete construct for transformation work on FLOWERING LOCUS T	30 Nov 18  31 Mar 19
3 McMah	Perform plant transformations using all 3 constructs (AP1, SEP3, FT, LEAFY)	Confirmed transformation for invitro plants – 6 lines AP1  Confirmed transformation for invitro plants – 6 lines SEP3  Confirmed transformation for invitro plants – 6 lines FT  Confirmed transformation for invitro plants – 6 lines LEAFY	31 Aug 20  31 Aug 20  31 Aug 20  31 Aug 20
4 McMah	Determine effect of transgenes on rubber content by ASE (tissue culture)	% rubber data obtained for each construct line	31 Aug 20
5 McMah	Transfer plants to greenhouse for flowering phenotype	Transfer at least 2 lines to greenhouse	31 Aug 20



6 Ray	Evaluate growth and rubber/resin content in guayule germplasm lines	Rubber/resin content determined in 21 guayule germplasm lines	30 Jun 20
7 Ray	Compare root growth/architecture and water use in direct-seeded and transplant-established guayule	Plantings established	31 Jan 20
		Compare root growth and top growth for direct-seeded and transplant-established plants	31 May 20
		Compare root growth/top growth/water use	31 Mar 20

#### Evaluate Germplasm Lines (Variety Trials):

The first-year harvest and data analysis has been completed. Seed was collected from most lines. The next harvest is scheduled for April 2020, with re-growth planned for a final harvest in 2022.

#### Expression Vectors for Downregulating SEP3 and FT Genes:

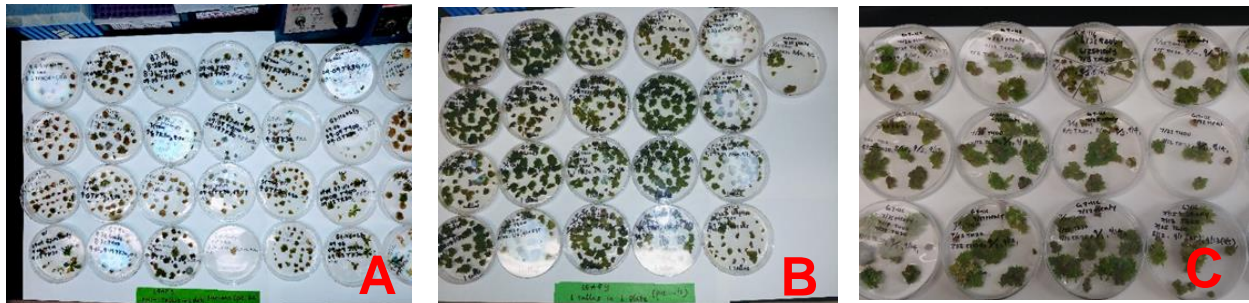
Our project seeks to enhance natural rubber content in guayule by downregulation of flowering. Previously, four target genes, all transcription factors related to flowering, were identified, guayule transformation constructs were completed for all 4 genes.

1. **Downregulation** of *APETALA1* (*AP1*), which promoted flowering in citrus (Pena *et al.* 2001).
2. **Downregulation** of *SEPATTALA* (*SEP*) a class E protein that may have a role in all aspects of flower development (sepal identity, petal identity, ovule identity, stamen identity, and carpal identity), in combination with other transcription factors.
3. **Downregulation** of *FLOWERING LOCUS T* (*FT*). *FT2* downregulation in sugar beet resulted in continued vegetative growth without flowering (Pin *et al.* 2017).
4. **Downregulation** of the *LEAFY* gene. *LEAFY* is a plant-specific transcription factor involved in floral meristem identity. It causes groups of undifferentiated cells to develop into flowers instead of leaves (Weigel *et al.* 1992) and has been downregulated in poplar (Klocko *et al.* 2016).
5. In 3Q19 a fifth construct was prepared, combining two of the above genes ***APETALA1* and *SEPATTALA*** in a single construct, called pND6 – AP1 – SEP3 (pAS).

#### Plant Transformations using AP1, SEP3, and FT Genes:

In 3Q19, an additional 2482 transformations attempts were completed for the *LEAFY* RNAi construct; 1666 of those attempts continue to grow under selection pressure. Others were eliminated due to contamination, indication of false positives, and low concentration of viable calli for potential recovery.

As of October 2019, we have 162 plates with *LEAFY* construct guayule plant calli growing at early stage, middle stage and late stage (Figure 1). We have recovered shoots from putative SEP-transformed plants, now growing in root-induction media (Figure 2).



**Figure 1.** Guayule leaf tissues following transformation with *LEAFY* transcription factor. Shown (A) early, (B) middle, and (C) late stages of development.



**Figure 2.** Shoots recovered from guayule with downregulated *SEPATALLA* transcription factor.

### Our next step includes improvement of the guayule transformation protocols.

Transformations are underway for the pAS construct, using an adjusted procedure. A qualitative process analysis showed that leaf sections with large vasculature (guayule leaf midrib) surface area tended to fail within 2-3 weeks. Therefore, we are now preparing leaf strips by incising the leaf on its vertical axis around the midrib instead of horizontally. Another observation worth noting is that most transformation attempts resulted in calli near the areas of incision. This is likely due to the cell wall breakage and direct cell exposure to the *Agrobacterium* or the incorporation of *Agrobacterium* through tertiary and quaternary veinlets. A quantitative experiment is underway to support these observations.

As we perform transformations using the pAS construct, we will vary the light exposure gradients in order to optimize the transformation efficiency. Our current protocol calls for reduced light during co-cultivation and recovery. Since the plates are stacked 6 or more at a time the amount of light exposure is variable. Thus, calli development will be quantified from higher light exposure (plates on the top) to lower light exposure (plates in the stack). (Figure 3)



**Figure 3.** *Guayule* leaf sections under low light growth chamber conditions: APETALA1 + SEPETALLA2 gene construct.

#### Phenotype Studies:

No data to report.

#### Growth and Rubber/Resin Content in Guayule Germplasm Lines:

Research associated with this task continues as planned; no new data to report.

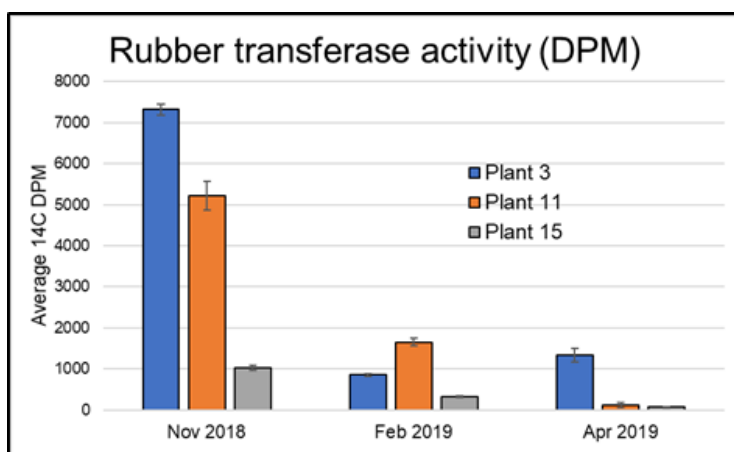
#### Root Growth/Architecture Compared to Water Use in Direct Seed and Transplant-Established:

Research is continuing as planned; measurements were not taken this quarter and there are no new data to report.

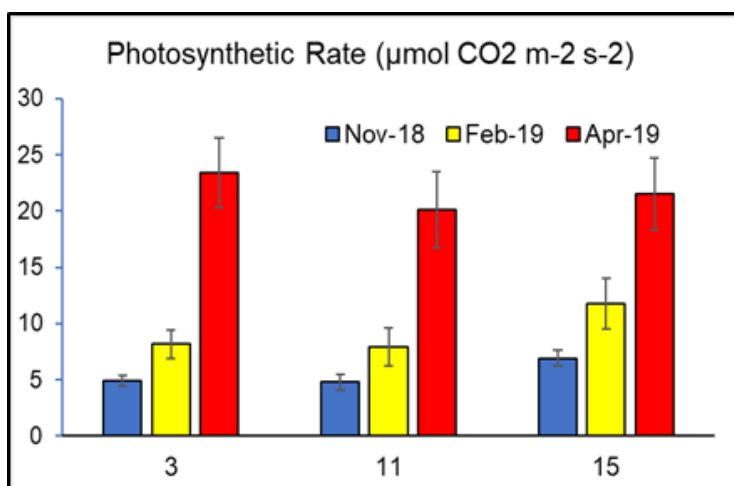
#### Other Tasks:

##### **Dormancy in guayule:**

In our Dormancy collaborative study (with Julie Neilson, Omar Holguin, and Daa El-Shikha/Pete Waller) we continued characterization of plant tissues from irrigation field trials in Maricopa before, during, and after winter dormancy. High molecular weight rubber (1.5M g/mol) was detected in plants at first harvest, after only 7 months of growth. As expected, rubber transferase activity was highest in November (Figure 4). The photosynthetic rate was highest in April (Figure 5). Soil DNA biomass was lower in November for Plot 3 and Plot 15. Soil bacterial abundance was lower in April for Plot 3 only. Differences may be due to fungal or other DNA. These results will be combined with soil chemistry, gene expression, and microbial community characterization studies now underway.



**Figure 4.** Rubber biosynthetic activity in field plants at three time points.



**Figure 5.** Photosynthetic rate from LiCor field measurements.

**Guayule resin fractionation process:** This summer, the USDA-ARS hosted a summer internship for VeeAnder Mealing, a Colorado School of Mines graduate student (Landis lab) and SBAR participant. Research included an environmental assessment of potential process for resin fractionation. Solvent-solvent extractions of purified guayule resin were performed, with a focus on green solvents. Boiling point, not solubility index, best correlated to the extent of solubilization. Longer chain alcohols best solubilized the higher molecular weight components. In some cases, the green solvents fully solubilized the resin under the test conditions used.

**Objective 2. Develop high-throughput phenotyping to support crop expansion using remote-sensing methods to create interactive databases/tools.**

Task #	Description of Task	Deliverable	Target Completion Date
1	Phenotypic characterization - Guayule	Collect and analyze available phenotypic data; plant stand	31 Dec 21

Abdel-H		and establishment, plant height and width, and flowering time  Collect and analyze first set of available high-throughput phenotyping (HTP) parameters: vegetation indices and reflectance  Summary report completed	31 Dec 21   30 Jun 22
2 Abdel-H	Guayule leaf waxes	Protocols established for leaf wax extraction from tissue  Leaf wax extraction from guayule tissue  Wax class determination  Catalog of guayule leaf wax classes and constituents produced under stress/no stress	31 Aug 20  31 Jan 21  31 Dec 21  31 Aug 20
3 Angadi	Guar remote sensing	Seasonal multispectral data from deficit irrigation study	31 Mar 20
4 Dierig	Remote sensing evaluation of USDA germplasm lines	Rate of growth comparison between lines completed	31 Aug 19
5 Dierig	Thermogradient table analysis	Germination data completed	31 Oct 18
6 Dierig	Leaf characterization	Trichome and color analysis of leaves from plants of 10 lines in variety trials	30 Sep 18

### Phenotypic characterization – Guayule:

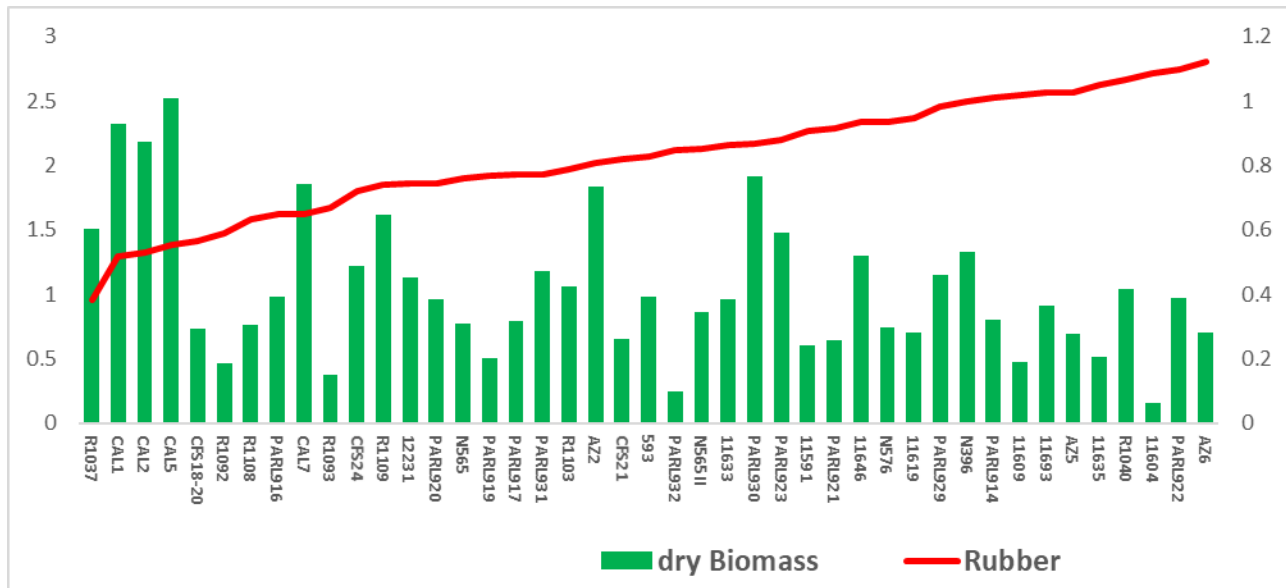
A field trial containing 48 USDA guayule accessions were planted at MAC farm, Maricopa, AZ in randomized completed block Design (RCBD) with four replicates each. Each replicate consists of four rows spaced at 40 inches each and 10 -long plots, within each row plants are spaced at 12 inches. Plots are maintained by hand weeding as needed and surface irrigation at bi-weekly interval based on the weather and plant growth stage.

#### Collect and analyze available field phenotypic data of one-year old plants.

To estimate the rubber and resin contents of one-year guayule genotypes, two plants from each plot were harvested individually, dried, chipped and ground using hummer then Wiley mills. The final ground samples were sent to Eloy station to estimate rubber and resin contents using NIRS modules.

Analysis of variance (ANOVA) showed significant differences among guayule genotypes for plant dry biomass, rubber and resin contents. One-year guayule genotypes have a range from 0.96 to 2.8% of rubber, and 5 – 9.5 % of resin (Figure 6). Improved germplasm tends to be high in rubber with heavy biomass compare to wild genotypes. Variations in rubber and biomass are important traits in final rubber production determination, phenotypic variations in such traits will allow for selecting high rubber content as well as higher rubber production.

Correlation between Rubber and dry biomass is negative, so decisions could be taking for higher rubber % and moderate biomass production.



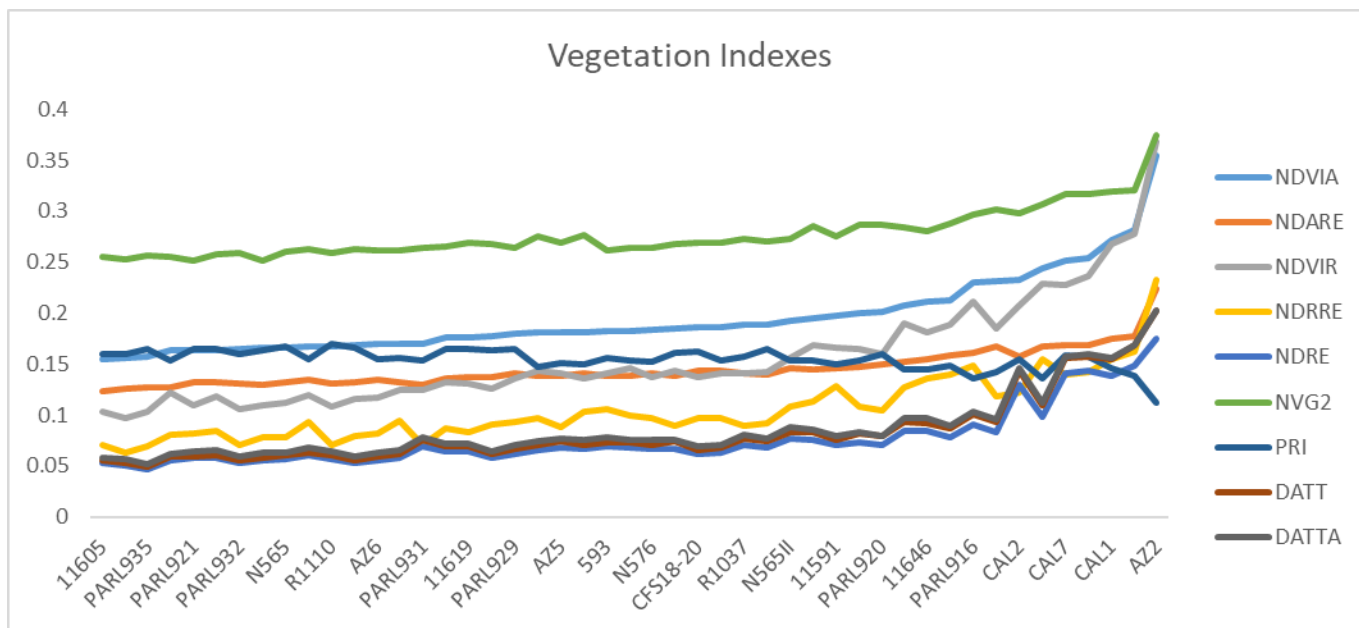
**Figure 6.** Plant dry biomass and rubber per guayule germplasm sampled at the Maricopa Agricultural Center, Arizona.

Collect and analyze high-throughput phenotyping (HTP) parameters for one-year old plants.

A high-clearance tractor equipped with proximal sensors mounted on modified LeeAgra AvengerPro spray rig to collect FB-HT data for guayule and other crops. The HTP platform uses proximal data captured from electronic sensors to measure canopy multi-spectral reflectances to estimate different vegetation and chlorophyll content indexes and canopy temperature. Canopy reflectance is recorded at six wavelengths using Holland Scientific ACS-470 CropCircle sensors, which utilize an active pulse-modulated polychromatic light source.

Canopy temperature is measured by Apogee SI-131 infrared thermometers. The reflectance data were used to construct vegetation indices (VI) including; Normalized difference vegetation index-red (NDVIR), Normalized difference vegetation index-amber (NDVIA), Physiological reflectance index (PRI), Normalized difference vegetation index-red-red edge (NDRRE), Normalized difference vegetation index-amber-red edge (NDARE), Normalized difference red edge index (NDRE), DATT index, and Meris terrestrial chlorophyll index (MTCI). Beside these indexes, we also collected data for canopy temperature. Sixteen runs were collected at regular base weekly, the whole data set is being analyzed and will be reported (Figure 7).





**Figure 7.** Vegetation indices generated for guayule plants at the Maricopa Agricultural Center, Arizona.

#### Remote Sensing Evaluation:

Research is continuing as planned; no measurements were taken this quarter. Due to the size and age of plants, plots are saturated for the indices collected earlier.

#### Thermogradient Table Analysis:

Research is continuing as planned; no new data to report.

#### Leaf Characterization:

Research is continuing as planned; no new data to report.

### **Objective 3. Deploy superior genotypes of guayule and guar to regional growers.**

Task #	Description of Task	Deliverable	Target Completion Date
1 Abdel-H	Identify superior guayule genotypes for second breeding cycle and release	Field planting completed	30 Jun 22
		Seeds collected from superior genotypes	30 Jun 22
2 Angadi	Evaluate guar germplasm in New Mexico high plains environment	Identify guar germplasm suitable for cooler and northern latitudes	30 Apr 20
		Summarize data after harvest; present at field day in Clovis, NM	31 Dec 19
		Assess available guar cultivars at Clovis, NM	31 Dec 19

3 Angadi	Galactomannan assay	Assess irrigation effect on guar gum content	30 Apr 20
4 Grover	Evaluate guar germplasm lines (increase # of seeds)	Obtain seeds from ~30 guar lines for evaluation	31 Aug 19
		Generate report on seed yield and related information learned from multiplication	31 Aug 19
		Collect data on field performance of guar germplasm lines	31 Aug 20
		Generate report on guar germplasm line field performance	31 Aug 20
5 Ray	Evaluate seed from plants surviving root rot inoculation	Screen 42 guayule germplasm lines for root rot fungus tolerance	31 Jan 20
	Determine root rot tolerance per guayule germplasm	New germplasm lines screened for the first time	30 Nov 19
		Seed from surviving plants screened for trait inheritance	31 Dec 21
6 Ray	Guayule salt tolerance trials	7 germplasm line's transplants evaluated for sensitivity under 11 saline treatments	31 Dec 19
		Initial estimate of lines with most tolerance complete	31 Dec 19
		Continue screening germplasm lines	31 Aug 20
		Seed from surviving plants collected and planted for 2 <sup>nd</sup> round evaluation	31 Oct 20
7 Ray	Guar yield trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM	Increase guar seed for yield tests	15 Apr 19
		Yield trial protocols established (3 different for comparison)	1 May 19
		Yield trials planted in 3 locations	30 Jun 20
		Yield trials harvested; yields compared	31 Dec 20
8 Ray	Guar genetic combination trials	Guar seed from crosses of partial male-sterile plants with 2 elite lines collected	31 Dec 19
		Genetic diversity evaluated	31 Jan 21

USDA Guayule Germplasm at Maricopa Agricultural Center (MAC):

No new activity to report.

Guar Germplasm in New Mexico:

Dr. Dennis Ray sent seeds of USDA guar germplasm lines and we have planted the trial for him at Clovis, NM. This work which was planned for last summer, was postponed to 2019 summer season due to lack of sufficient seeds. The trial looked good and lines showed variation in plant architecture, growth and leaf diseases. The trial will be harvested at the end of October 2019 and data will be sent to Dr. Ray.

Guar Alactomannan Assay:

No new activity to report.

Guar Germplasm Line Multiplication:

Guar germplasm seeds have been collected from the previous year's plantings, and evaluation study continues.

Seed Evaluation following Root Inoculation:

No new activity to report.

Root Inoculation per Guayule Germplasm:

Cuttings made from the surviving plants have been completed. Research for this task is proceeding as planned; no new data to report.

Guar Yield Trials in Tucson, AZ; Las Cruces, NM; and Clovis, NM:

Lines evaluated for height (Table 4), branching, pubescence, and lodging.

**Table 4.** Guar heights measured on 29 July and 4 September 2019. Values followed by the same letter are not significantly different. Values are highest to lowest in first column only.

Accession	Mean - July 29		Mean - Sept 4	
PI 542608	50.4	A	139.9	efghi
PI 263698	49.4	Ab	158.5	a
SIRSA 56	47.9	Abc	146.7	bcdefg
TX71-3292	45.0	Abcd	148.7	abcdef
NO 10949	44.0	abcde	133.9	hij
GAWAR	43.4	bcde	151.7	abcd
KINMAN	43.3	bcdef	140.8	efghi
NO 10521	43.2	bcdefg	147.9	bcdef
COL NO K619	43.0	bcdefg	138.0	ghi
COL NO 36 PUNJAB	42.3	cdefgh	148.9	abcde
MATADOR	40.8	defgh	126.8	jk
EC 248A	40.6	defghi	137.2	ghi
LEWIS	40.0	defghij	125.5	jkl
PI 186477	39.0	defghijk	124.7	jkl
PLG 86	38.8	defghijk	155.5	abc
PI 263406	38.3	efghijk	143.3	defgh
PLG 241	38.3	efghijk	138.9	fghi
B-49824	38.1	efghijk	132.0	ijk
G-05	38.1	efghijk	132.5	ijk
IC-83 NO 3	37.4	efghijk	133.7	hijk
PLG 482	36.8	fghijk	156.0	ab
B-49823	36.7	ghijkl	126.1	jkl
SANTA CRUZ	36.1	hijkl	124.2	ijkl
LEWIS	35.2	ijkl	126.3	jk
MULKHANIA	34.3	ijkl	146.0	cdefg
SURTI	33.8	ijklm	126.8	jk
TX 78-3726	33.2	klm	132.8	ijk
TX73-2731	33.0	klm	132.4	ijk
WKP-88-43	30.2	lm	123.8	kl
B-49819	28.1	m	116.2	l

#### Guar Genetic Combination Trials:

Research is continuing as planned; no new data to report.

#### Guayule Salt Tolerance Trials:

Initial 11 guayule germplasm lines have been evaluated for salt tolerance. A visual grading scale has been established that will be used for the additional planned screenings (Figure 8).



**Figure 8.** Guayule salt tolerant grading scale: 1 = No effect; 2 = Yellow leaves (~10-25%), brown leaves (~10-25%); 3 = Yellow leaves (~10-25%), brown leaves (~25-50%); 4 = Yellow leaves (~10-25%), brown leaves (~50-75%); 5 = Mortality, complete or imminent (brown leaves >90%).

Six additional guayule germplasm lines were selected for the next round of salt tolerance trials, which have been started and the plants are being evaluated for symptoms.

**Objective 4. Deploy agronomic production practices; identify agronomic information for salinity, herbicide, and nutrients to support production; provide irrigation apps using algorithms to growers.**

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Conduct guar critical stage based deficit irrigation trial	Identify critical growth stage of guar to reduce irrigation water use	31 Aug 19
		Contribute data for developing guar crop coefficients (Kc) for irrigation management	31 Aug 19
		Present data at regional and national conferences	31 Aug 19
		Report on growth stage-based irrigation management	15 May 20
2 Angadi	Conduct incubator study to understand temperature and germination relationships	Identify optimum soil temperature for guar planting for available guar cultivars	31 Jul 20
		Present data/findings at national conference	30 Nov 19
3 Dierig	Density trials in Tucson and Eloy, AZ	Establish trial with different densities in Tucson, AZ	31 Dec 20
		Summarize plant growth, yield performance, and traits for density trial with 2 varieties and 5 densities in Eloy, AZ	30 Apr 22

4 Dierig	Bi-monthly harvest from irrigation trials	Growth data over seasons from two locations  Harvest plots for shrub dry biomass rubber/resin content and yield	31 May 20  30 Apr 20
5 Grover	Evaluate guar response to moisture stress	Track and collect research data on moisture stress experiment  Generate report/publication from results obtained  Present research results at regional/national conferences	31 Aug 20  31 Aug 20  31 Aug 20
6 Grover	Evaluate guar response to planting density	Track and collect research data on guar density experiment  Generate report/publication from results obtained	31 Aug 20  31 Aug 20
7 McClos	Collaborate with herbicide manufacturers on experiment design and data collection to support 24c SLN registration	Identify herbicide rates, application methods, and application timing for experiments	31 Aug 19
8 McClos	Conduct guayule herbicide tolerance study, Fall 2018 at Eloy and Maricopa, AZ	Track and collect research data to support 24c SLN preemergence herbicide registrations for metolachlor, bensulide, ethalfluralin, sulfentrazone, and acetochlor  Track and collect research data to support 24c SLN postemergence herbicide registrations for clethodim and carfentrazone  Generate report/publication from results obtained	31 Dec 19  28 Feb 20  31 Dec 19
9 McClos	Conduct guayule herbicide tolerance studies, Spring 2019 at Eloy and Maricopa, AZ	Track and collect research data to support 24c SLN preemergence herbicide registrations for metolachlor, bensulide, ethalfluralin, sulfentrazone, and acetochlor  Track and collect research data to support 24c SLN postemergence herbicide registrations for clethodim and carfentrazone  Generate report/publication from results obtained	31 Aug 19  31 Aug 19  31 Aug 19
10 Ogden	Development and testing of AquCrop model	Growth model compared to field data	30 Apr 20



11 Ogden	Development of BioCrop model	Preliminary output and evaluation of most important parameters	31 Aug 20
12 Ray	Guayule density trial	Yields for 2 lines, 5 densities, 2 locations, and 2 seasons compared	30 Nov 21
13 Ray	Biomass drying experiment	Biomass, resin, and rubber content analyzed	30 Sep 18
14 Ray	Guayule trials (direct-seeded and transplant-established)	Compare for root growth/water use	15 Feb 20
		Plantings established; Compare a range of N and P application rates	30 Nov 19
		Compare N and P utilization and effects of nutrients on biomass, rubber and resin production	30 Nov 20
15 Waller	Install TDR, infrared camera and flowmeter system	Provide data on guayule irrigation experiments	15 Jul 20
		Provide data set that can be used to refine the use of sensors for WINDS crop irrigation mgmt.	15 Jul 20
16 Waller	Integrate python MySQL WINDS model with existing tools	Integrate new python model with WINDS (winds.arizona.edu), and in-situ sensors	15 Jul 20
		Database available to economic modelers	15 Jul 20
17 Waller	Irrigation experiments: Guayule and Guar	Collect data; image collection, neutron probe readings, in-situ sensors, crop coefficient development and destructive plant samples for chemical analysis	15 Jul 20
		Document effects of irrigation treatment on plant growth, soil moisture, plant stress, plant chemical response, plant vegetative indices, and crop coefficient	15 Jul 20
		Generate a publication on guayule irrigation experiments	15 Jul 19
18 Waller	Deficit irrigation study (water stress); Eloy, AZ	Quantify effects of irrigation scheduling strategies on rubber/biomass yield and plant stress	15 Jul 20

#### Guar Critical Stage-Based Deficit Irrigation Trial:

Second year of deficit irrigation study is getting ready for harvest. Irrigation treatments and most of the seasonal observations were completed. We are planning to harvest the trial by end of October 2019. Combine harvest will be done during mid to end of November 2019. Some of the data on soil moisture and seed yield will be shared with Hadiqa Maqsood (Waller's lab) for her research work. An abstract has been submitted to ASA-CSSA-SSSA Annual meeting for presentation.

Dr. Diaa El-Shikha is collecting remote sensing data from deficit irrigation trial. Although not planned, Agadi is supporting his travel to Clovis for three times this season. Some of the essential ground data will be collected by the Clovis/NMSU crew along with remote sensed data.

#### Incubator Study to Understand Temperature and Germination Relationships:

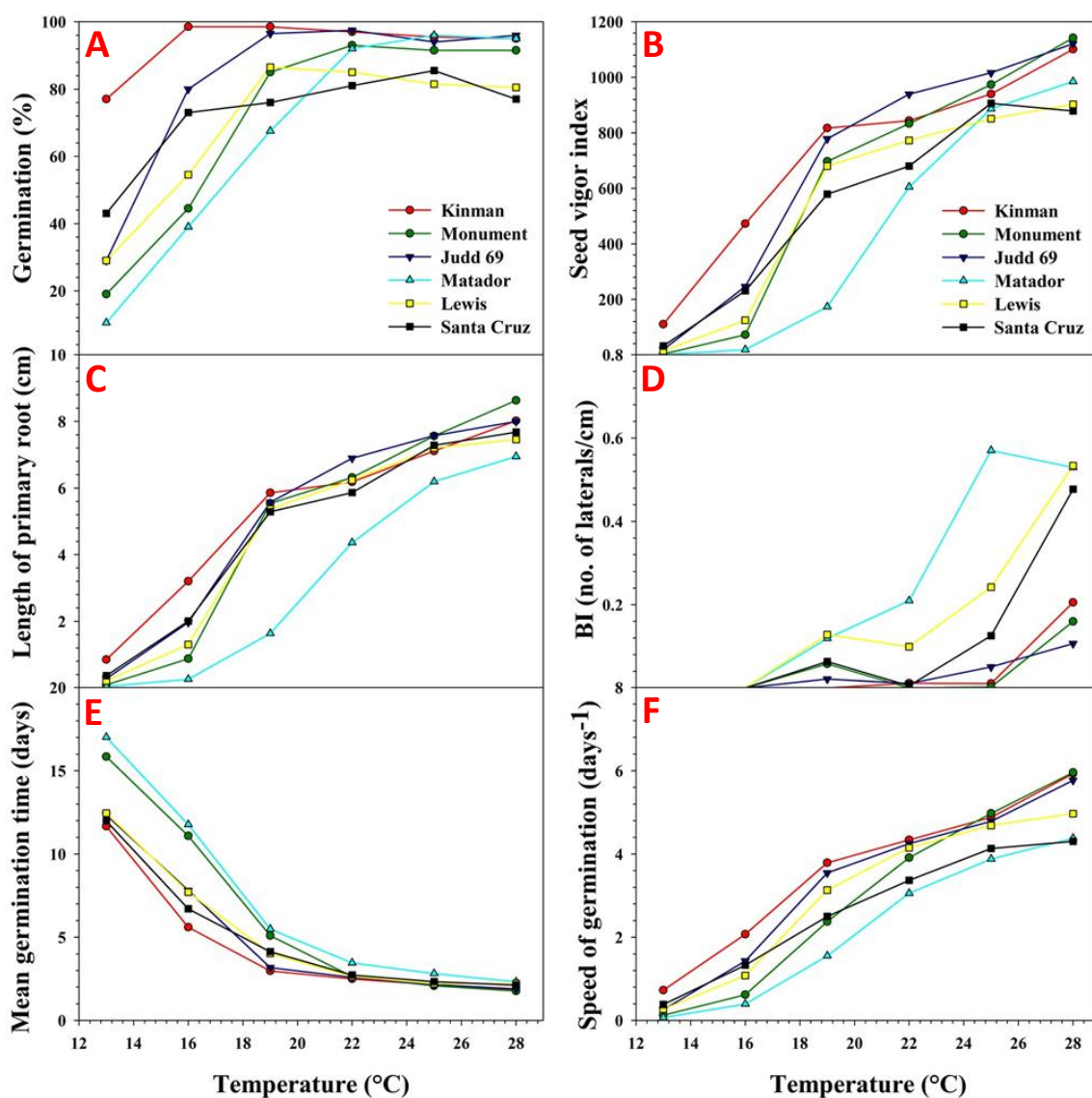
The incubator study that focused on assessing genetic variation among guar cultivars for temperature and crop establishment relationship, was conducted earlier in spring and summer 2019. Results from the studies are shown in Figures 9-10. Graduate student, Jagdeep Singh (Photo 5), processed and presented first year of data in SBAR annual retreat and his poster received second prize.



**Photo 5.** Jagdeep Singh, SBAR Graduate Student, presents his research on guar during an Agricultural Field Day, Clovis, New Mexico, 8 August 2019.



**Figure 9.** Representative growth images of seedlings (from left to right: Kinman, Santa Cruz, Judd 69, Lewis, Monument, and Matador) at 16°C temperature.



**Figure 10.** Effect of temperature on (A) final seed germination percentage, (B) Seed vigor index, (C) Length of primary root, (D) Branching intensity (BI), (E) Mean germination time, and (F) Speed of germination of available guar cultivars.

### Density Trials in Tucson and Eloy, AZ:

The densities are 30, 18, 12, 6, 3-inch in-row spacing for density 1, 2, 3, 4, 5. Plots will be harvested for year 1.5 at Eloy and year 1 at Tucson in October 2019; data will be reported next quarter.

### Bi-Monthly Harvest from Irrigation Trials:

The proportion of leaves, and stems remained consistent between June and August harvest and not affected by irrigation treatments. Since February, the proportion of leaves and stems on the plant is stable. Flower proportion was variable between the two harvests and between irrigation treatments over the summer months. (Figure 11)

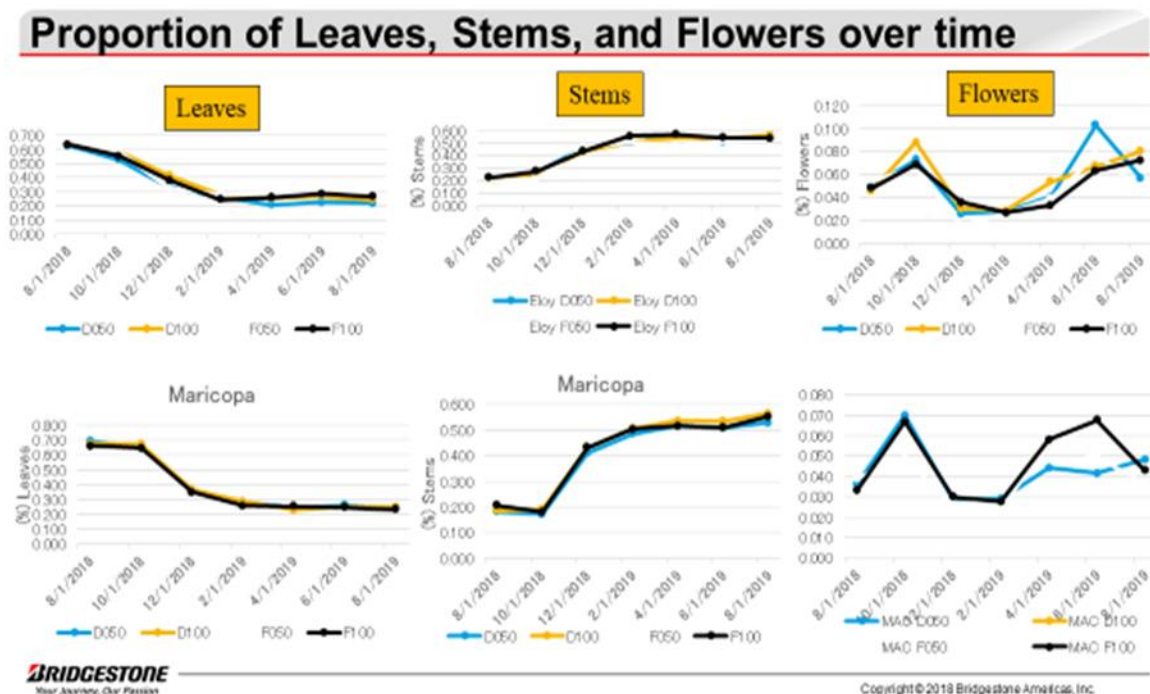
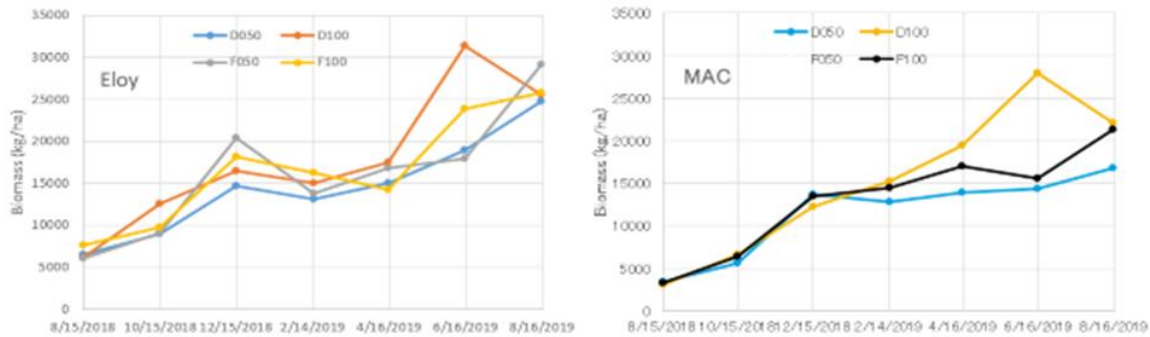


Figure 11. Comparison of leaves, stems, and flowers over time between Eloy and Maricopa locations.

Biomass accumulation decreased at both locations on the Drip 100 treatment over the summer. Other treatments at both locations increased between June and August. Biomass was higher at Eloy location for every treatment. (Figure 12)

## Biomass Accumulation at Eloy and MAC

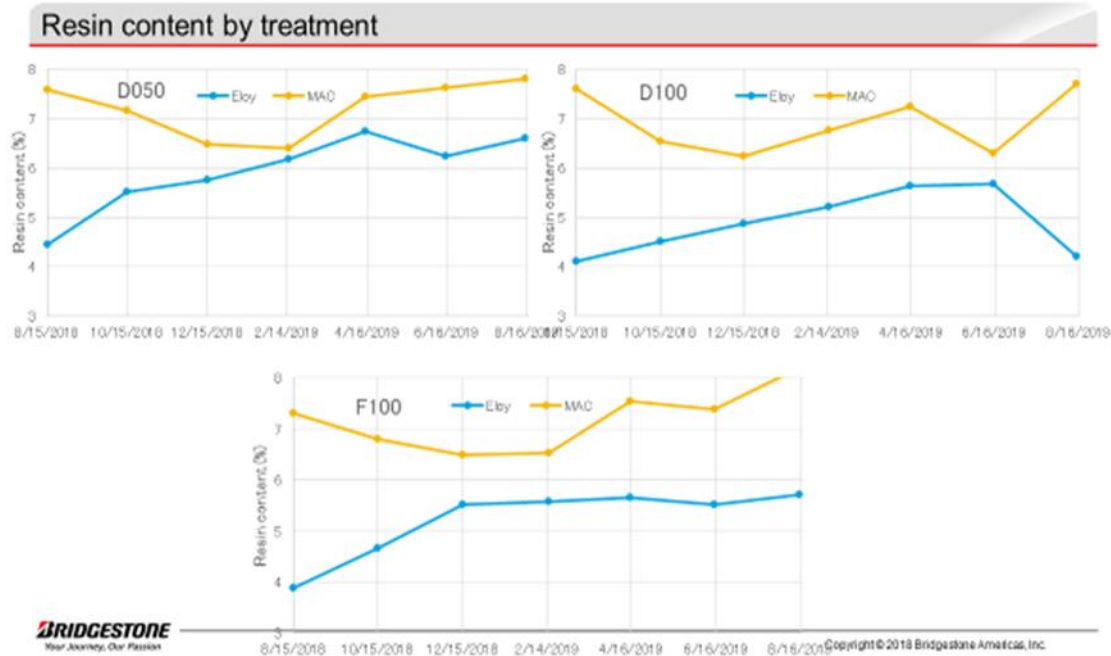


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Figure 12. Comparison of biomass yield over time at Eloy and Maricopa locations.

Resin content remained constant over the summer between June and August in the Drip 50 treatment. In the Drip 100 treatment, the two locations had opposite responses by almost 2%. The Flood 100 treatments showed an increase at Maricopa but no change at Eloy over the same time. (Figure 13)

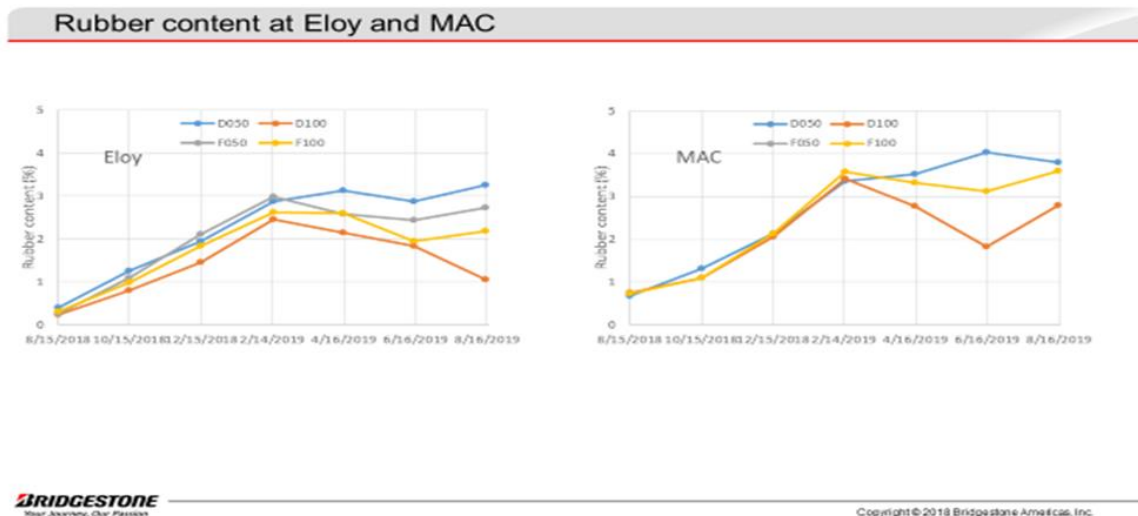


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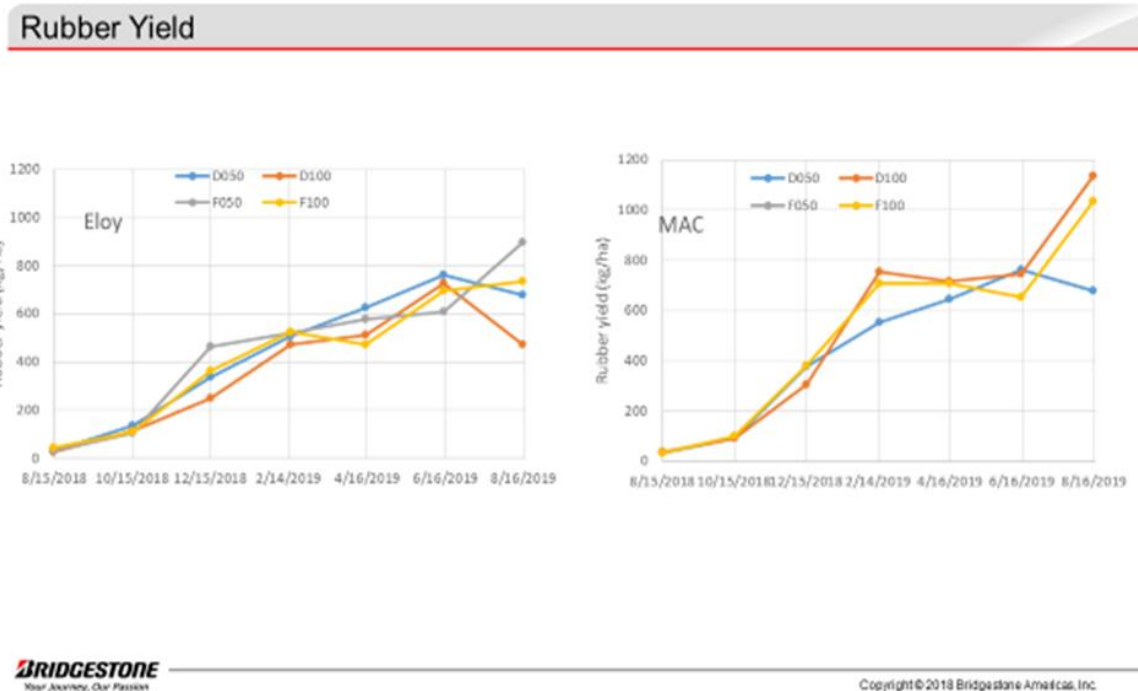
Figure 13. Comparison of resin % over time at Eloy and Maricopa locations.

Rubber content was highest in the stress treatments at both locations. A decrease in rubber content in the Drip 100 treatment occurred at Eloy. Overall, rubber content was higher at Maricopa than Eloy likely due to sandy soils at Maricopa causing more water stress resulting in higher rubber. (Figure 14)



**Figure 14.** Comparison of rubber % over time between Eloy and Maricopa locations.

Rubber yield was higher at Maricopa, even though overall biomass was lower there. The higher rubber content made a significant difference toward better yields. The Drip 100 and Flood 100 treatments were highest at Maricopa while the Flood 50 treatment was highest at Eloy location. These values will likely continue to change until final harvest next April. (Figure 15)



**Figure 15.** Comparison of rubber yield over time at Eloy and Maricopa locations.



#### Guar Response to Moisture Stress:

Compiled and presented information from the guar moisture stress response study.

#### Guar Response to Planting Densities:

Completed the final harvest seed yield and yield attributing characteristics from planting density study. Data collected from the first year's planting.

#### Collaboration with Herbicide Manufacturers in Support of 24cSLN Registrations:

Protocols were developed for the spring 2019 Eloy and Maricopa experiments based in part on data analysis of the fall 2018 experiments at Marana and Maricopa. Protocols were also developed for the fall 2019 experiments planned for Maricopa.

(See also Q1 report.) At the request of FMC, additional arfentrazone (Aim) guayule tolerance studies were planned for Eloy and Maricopa. A revised Prowl H<sub>2</sub>O SLN for Prowl use during guayule seedling establishment will be requested through the ADA based on experiments conducted in fall 2018 and spring 2019. To support registration efforts, an educational tour of guayule plots at Eloy and MAC and of the Bridgestone processing plant in Mesa was conducted for chemical industry scientists on May 6, 2019.

#### Guayule Herbicide Tolerance Study, Fall 2018 and 2019:

Three preemergence herbicide experiments and three preplant-incorporated experiments (each experiment included two herbicides) were established at MAC in October 2018 and data collection was completed in January 2019. Similarly, three preemergence herbicide experiments were established in Marana at Gary Deen's farm in September 2018 and completed in December 2018 to obtain additional data on a coarse textured soil (see previous quarterly report).

Publication of research reports were delayed to June 30, 2019 as we did not finish collecting data in the preemergence herbicide experiments until January 2019 and data analysis was not completed until the end of March. Publications have been further delayed in Q3 and are scheduled for Q4 of 2019.

#### Guayule Herbicide Tolerance Study, Spring 2019:

Three preemergence herbicide experiments and three preplant-incorporated experiments (each experiment included two herbicides, herbicides studied: ethalfluralin, pendimethalin, acetochlor, metolachlor, bensulide, and sulfentrazone) were established at MAC in the second quarter of 2019. Data was collected through July 2019 (Table 5).

**Table 5. Results of the 2019 preemergence experiments conducted at Maricopa, Arizona.**

<b>Spray Date</b>	<b>Chemicals Applied</b>	<b>Location/ Field</b>	<b>Method of Incorporation</b>	<b>ARM File Name / Data Tables?</b>	<b>Data Collected to Date</b>
4-23-2019	Prowl H2O Sonalan	MAC / F1 / B42	PPI-flat, field cultivator, lister, furrow irrigation	Prowl Sonalan PPI-Flat MAC Spring2019	6/5/2019 – Guayule 2 m stand counts 7/1/2019 – Guayule 2 m stand counts 7/11/2019 – Nadir photographs
4-23-2019	Prowl H2O Sonalan	MAC / F1 / B43	PPI-bedtop incorporator, rolling cultivator	Prowl Sonalan PPI- bedTop MAC Spring2019	6/5/2019 – Guayule 1 m stand counts 7/1/2019 – Guayule 1 m stand counts 7/1/2019 – Nadir photographs
4-23-2019	Dual Warrant	MAC / F1 / B44	PPI-flat, field cultivator, lister, furrow irrigation	Dual Warrant PPI-Flat MAC Spring2019	6/5/2019 – Guayule 2 m stand counts 7/2/2019 – Guayule 2 m stand counts 7/11/2019 – Nadir photographs
4-23-2019	Dual Warrant	MAC / F1 / B45	PPI-bedtop incorporator, rolling cultivator	Dual Warrant PPI-Bed Top MAC Spring2019	6/5/2019 – Guayule 1 m stand counts 7/2/2019 – Guayule 1 m stand counts 7/1/2019 – Nadir photographs
4-23-2019	Spartan Prefar	MAC / F1 / B46	PPI-flat, field cultivator, lister, furrow irrigation	Spartan Prefar PPI-Flat MAC Spring2019	6/5/2019 – Guayule 2 m stand counts 7/2/2019 – Guayule 2 m stand counts 7/11/2019 – Nadir photographs
4-23-2019	Spartan Prefar	MAC / F1 / B47	PPI-bedtop incorporator, rolling cultivator	Spartan Prefar PPI- BedTOP MAC Spring2018	6/5/2019 – Guayule 1 m stand counts 7/1/2019 – Guayule 1 m stand counts 7/1/2019 – Nadir photographs
4-23-2019	Prowl H2O Sonalan Dual Magnum Warrant Spartan Prefar	MAC / F4 / B50-51	PPI-flat with field cultivator, sequential PPI- bedtop with incorporator	Guayule Herb Systems MAC Spring 2019 F4B50-51	6/11/2019 30 foot stand counts Poor emergence due to lack of pre-irrigation Project abandoned

Four postemergence guayule tolerance studies with Aim (carfentrazone) and two studies with paraquat (Gramoxone SL 2.0) were conducted at MAC in the second quarter of 2019. Similarly two grass herbicide tolerance studies including clethodim (Select 2E), fluazifop-p-butyl (Fusilade DX) were also conducted at MAC in the second quarter with data collected through July 2019 (Table 6).

**Table 6. Results from the 2019 post emergence herbicide experiments conducted at Eloy and Maricopa, Arizona.**

<b>Spray Date</b>	<b>Chemicals Applied</b>	<b>Location/Field</b>	<b>Method of Irrigation</b>	<b>ARM File Name / Data Tables?</b>	<b>Data Collected to Date</b>
5-13-2019	Aim Activator 90 0.5% v/v	Bridgestone / B2W	Furrow	Aim Guayule Spring 2019 4 LEAF Eloy  Aim Guayule Spring 2019 7 LEAF Eloy	5/10/2019 – Guayule Pre-spray 2 m stand Counts in both 4 & 7 leaf exp. 5/21 – Post-spray 2 m stand counts in both 4 & 7 leaf experiments 5/21 – Visual estimates of necrosis and stunting in 4 & 7 leaf experiments 5/30 – Visual estimates of stunting in 4 leaf experiment.
6-4-2019	Aim	MAC / F1 / B48 / east	Sprinkler for establishment than furrow	MAC Aim Guayule Spring 2019 2 LEAF F2_B48E	4/22 – Prowl H <sub>2</sub> O applied PPI-flat @ 2 pt/A 6/3/2019 – Prespray 2 m stand count 6/4 – Leaf count in control plots 6/12 – Visual injury ratings (necrosis, burning) 6/21 – Stand counts 2 m 7/11 – Visual injury rating (necrotic spots) 7/12 – Stand counts 2m 7/12 – Nadir pictures 7/23 – Nadir pictures
6-13-2019	Aim	MAC / F1 / B48 / middle	Sprinkler for establishment than furrow	Aim Guayule Spring MAC2019 4 LEAF	4/22 – Prowl H <sub>2</sub> O applied PPI-flat @ 2 pt/A 6/13/2019 – Leaf count in control plots 6/24 – Stand count 2 m (also counted dead plants to simulate prespray count) 7/11 – Visual injury rating (necrotic spots) 7/12 – Stand counts 2 m 7/12 – Nadir pictures 7/23 – Nadir pictures
6-25-2019	Aim	MAC / F1 / B48 / west	Sprinkler for establishment than furrow	Aim Guayule Spring MAC2019 7 LEAF	4/22 – Prowl H <sub>2</sub> O applied PPI-flat @ 2 pt/A 6/21/2019 – Prespray 2 m stand count 6/25 – Leaf count in control plots 7/11 – Visual injury rating (necrotic spots) 7/12 – Stand counts 2 m 7/12 – Nadir pictures 7/23 – Nadir pictures
6-25-2019	Aim Gramoxone 2SL Talinor Callisto	MAC / F3 / B6 / west	Sprinkler for establishment than furrow	MAC Aim Paraquat Talinor Guayule Spring2019 3 LF F3B6	6/26/2019 – Prespray 2 m stand count 6/26 – Leaf count in control plots 7/15 – Stand counts 2 m 7/13 – Nadir Pictures 8/13 – Nadir Pictures
6-6-2019	Fusilade DX Poast Select 2E	MAC / F1 / B49 / north	Sprinkler for establishment than furrow	MAC Aim Paraquat Talinor Guayule Spring2019 3 LF F3B6	4/22 – Prowl H <sub>2</sub> O applied PPI-flat @ 2 pt/A 6/4/2019 – Prespray 2 m stand count 6/6 – Leaf count in control plots 7/11 – Visual rated injury symptoms 7/12 – Stand counts 2 m 7/12 – Nadir pictures
6-18-2019	Fusilade DX Poast Select 2E Gramoxone 2SL	MAC / F1 / B49 / south	Sprinkler for establishment than furrow	MAC Aim Paraquat Talinor Guayule Spring2019 3 LF F3B6	4/22 – Prowl H <sub>2</sub> O applied PPI-flat @ 2 pt/A 6/21/2019 – Prespray 2 m stand count (dead plants included for starting count) 6/18 – Leaf count in control plots 7/11 – Visual rated injury symptoms 7/12 – Stand counts 2 m 7/12 – Nadir pictures

Work on publications was postponed to Q4 of 2019.

Research technician Bryan Pastor was largely responsible for setting up the experiments, spraying the herbicide treatments, and collecting the data with some help from me. Bryan is (was) also responsible for all data entry into a database program for field research (Agricultural Research Manager; Gylling Data Management, Inc.) and for the analysis of the nadir photographs.

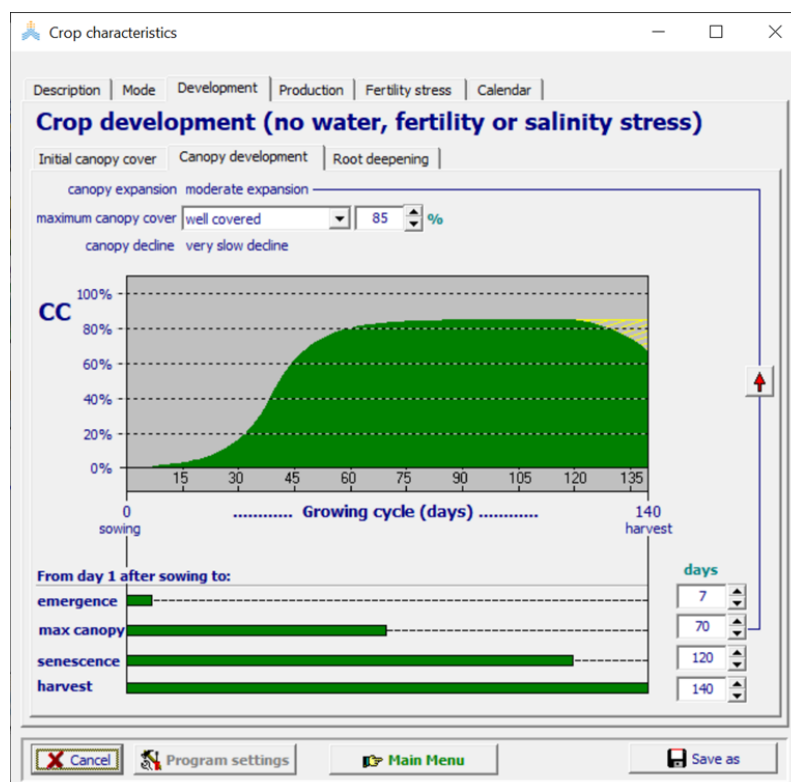
#### Literature Review for Field/Plant Growth Models:

We have studied the project detail and found suitable plant growth models for guayule. We recently focused on 2 plant growth models: AquaCrop and BioCrop. The literature review process is complete.

#### Phase I Growth Models Developed:

Progress we've made in the AquaCrop and BioCrop models is summarized below.

AquaCrop model: AquaCrop is being used to simulate the growth cycle of guayule (Figure 16). The main difficulty is adapting the model to the three periods of dormancy that the plant goes through each year. Simulation output includes canopy cover (CC), Root depth, Water fluxes, Biomass, and Yield. One question that has arisen is: "How to divide up the guayule growth process?" (> 4 stages of time steps)



**Figure 16.** Screenshot capture of the AquaCrop model information generated for guayule under generic conditions.

Data for Eloy experiments has been received from D. El-Shikha. The most significant parameters appear to be: crop input, water stress coefficients. The MATLAB model is completely up and running and is ready to modify. We are almost finished with pre-packaged model and can instantly start the sensitivity analysis. A summary of data sourced for the model efforts has been compiled (Table 7).

**Table 7.** Data sources for the AquaCrop modeling efforts as of Spring 2019.

Data	Source
Weather Information	<a href="https://cals.arizona.edu/azmet/data/">https://cals.arizona.edu/azmet/data/</a>
Water Table Information	Diaa El-Shikha
Soil Texture	Diaa El-Shikha
Soil Profile	Diaa El-Shikha
Soil Hydrology	Pete Waller, Doug Hunsaker
Soil Mechanics	Doug Hunsaker
CO2 Data	<a href="http://www.esrl.noaa.gov/gmd/ccgg/trends/">www.esrl.noaa.gov/gmd/ccgg/trends/</a>
Irrigation Schedule	Diaa El-Shikha
Irrigation Management	Doug Hunsaker
Water Content	Doug Hunsaker
Field Management	Doug Hunsaker
Crop Rotation	Pete Waller
Crop Mix	Pete Waller
Crop	Pete Waller

Current modification of the AquaCrop model is underway. The model can only simulate complete periods of growth (seed/transplant to harvest). It is possible to piece together parts of different simulations to create a complete model via parsing. The model output then would be a “piecewise” simulation around dormancy. (*Big Question: When to split the model? This can be done programmatically via python.*)

There are a number of significant parameters included in the AquaCrop model. The packaged version includes statistical analysis (sensitivity analysis), and the MATLAB version does not (although it can be programmed to vary chosen parameters). The most important parameters are most likely the water stress coefficients. For the record, a summary of the parameters has been compiled, along with the source (Table 8). Variables to modify → Important time constraints (Highlighted in teal)

**Table 8.** Summary of the significant parameters included in the AquaCrop model that can be modified, along with time constraints.

Parameter	Value	Comments	Source
Planting date	April 2018		
Harvest date	April 2020		
Emergence	80	Use the first month data, from Diaa use the data till May 23, 2019-----from Doug use the data from the first day to 7 to 12 weeks)	Doug Hunsaker
Maxrooting	1400	(use April to Aug about 5 months for this time growth)	Doug Hunsaker
Senescence	1400	Growing degree/Calendar days from sowing to senescence	
Maturity	1700	Use till full cover...1 year for transplant..... Diaa about a year data recheck with the data to 100 percent coverage use till the Jan the 2, 2019)	Doug Hunsaker
Histart	880	Growing degree/Calendar days from sowing to start of yield formation	Doug Hunsaker
Flowering	-999	Duration of flowering in growing degree/calendar days (-999 for non-fruit/grain crops)	Doug Hunsaker
Yldform	750	Duration of yield formation in growing degree/calendar days	Doug Hunsaker
Tbase	10	Base temperature (degc) below which growth does not progress	Dennis Ray
Tupp	37.78	Upper temperature (degc) above which crop development no longer increases	Dennis Ray
Polheatstress	1 or 0	Pollination affected by heat stress (0: No; 1: Yes)	Dennis Ray
Tmax_up	32.22	Maximum air temperature (degc) above which pollination begins to fail(32.22-37.78)	Dennis Ray
Tmax_lo	43.33	Maximum air temperature (degc) at which pollination completely fails	Dennis Ray
Polcoldstress	0 or 1	Pollination affected by cold stress (0: No; 1: Yes)	Dennis Ray
Tmin_up	10	Minimum air temperature (degc) below which pollination begins to fail	Dennis Ray
Tmin_lo	10	Minimum air temperature (degc) at which pollination completely fails	Dennis Ray
Biotempstress	1	Biomass production affected by temperature stress (0: No; 1: Yes)	Pete Waller

GDD_up	0 to 4	Minimum growing degree days (degc/day) required for full biomass production	Doug Hunsaker
GDD_lo	-2.5 or 12.5	Growing degree days (degc/day) at which no biomass production occurs	Doug Hunsaker
Fshape_b	13.8135	Shape factor describing the reduction in biomass production for insufficient growing degree days	Pete Waller
Pctzmin	70 to 75	Initial percentage of minimum effective rooting depth	Doug Hunsaker
Zmin	0.3	Minimum effective rooting depth (m)	Doug Hunsaker
Zmax	2.1	Maximum rooting depth (m)	Doug Hunsaker
Fshape_r	1.3	Shape factor describing root expansion	Doug Hunsaker
Fshape_ex	-6	Shape factor describing the effects of water stress on root expansion	Doug Hunsaker
Sxtopq	0.0104	Maximum root water extraction at top of the root zone (m3/m3/day)	Pete Waller
Sxbotq	0.0026	Maximum root water extraction at the bottom of the root zone (m3/m3/day)	Pete Waller
A_Tr	1	Exponent parameter for adjustment of Kcx once senescence is triggered	Doug Hunsaker
Seedsize	6.5	Soil surface area (cm2) covered by an individual seedling at 90% emergence	Doug Hunsaker
Plantpop	48000	Number of plants per hectare	Doug Hunsaker
Ccmin	0.1	Minimum canopy size below which yield formation cannot occur	Doug Hunsaker
Ccx	1	Maximum canopy cover (fraction of soil cover)	Doug Hunsaker
Cdc	0.01	Canopy decline coefficient (fraction per gdd)	Doug Hunsaker
Cgc	0.0125	Canopy growth coefficient (fraction per gdd)	Pete Waller
Kcb	1.3	Crop coefficient when canopy growth is complete but prior to senescence	Doug Hunsaker
Fage	0	Decline of crop coefficient due to ageing (%/day) %%	Doug Hunsaker
Wp	33.7	Water productivity normalized for et0 and c02 (g/m2)	Sarocho Pradyawong
Wpy	100	Adjustment of water productivity in yield formation stage (% of WP)	Sarocho Pradyawong
Fsink	0.2	Crop co2 sink strength coefficient	Sarocho Pradyawong
Bsted	0.000138	Wp co2 adjustment parameter given by steduto et al. 2007	Sarocho Pradyawong
Bface	0.001165	Wp co2 adjustment parameter given by face experiments	Sarocho Pradyawong



Hi0	0.06 to 0.07	Reference harvest index	Doug Hunsaker
Hiini	0.01	Initial harvest index	Doug Hunsaker
Dhi_pre	0	Possible increase of harvest index due to water stress before flowering	Doug Hunsaker
A_HI	0	Coefficient describing positive impact on harvest index of restricted vegetative growth during yield formation	Pete Waller
B_HI	0	Coefficient describing negative impact on harvest index of stomatal closure during yield formation	Pete Waller
Dhi0	0	Maximum allowable increase of harvest index above reference	Pete Waller
Determinant	1	Crop Determinancy ('0': Indeterminant, '1': Determinant)	Pete Waller
Exc	0	Excess of potential fruit	Pete Waller
Maxflowpct	33.33	Percentage of total flowering at which peak flowering occurs	Doug Hunsaker
P_up1	0	Upper soil water depletion threshold for water stress effects on affect canopy expansion	Doug Hunsaker
P_up2	0.69	Upper soil water depletion threshold for water stress effects on canopy stomatal control	Doug Hunsaker
P_up3	0.95-1	Upper soil water depletion threshold for water stress effects on canopy senescence	Doug Hunsaker
P_up4	0.8	Upper soil water depletion threshold for water stress effects on canopy pollination	Doug Hunsaker
P_lo1	0.1	Lower soil water depletion threshold for water stress effects on canopy expansion	Doug Hunsaker
P_lo2	0.1	Lower soil water depletion threshold for water stress effects on canopy stomatal control	Doug Hunsaker
P_lo3	0.1	Lower soil water depletion threshold for water stress effects on canopy senescence	Doug Hunsaker
P_lo4	0.1	Lower soil water depletion threshold for water stress effects on canopy pollination	Doug Hunsaker
Fshape_w1	2.9	Shape factor describing water stress effects on canopy expansion	Doug Hunsaker
Fshape_w2	6	Shape factor describing water stress effects on stomatal control	Doug Hunsaker

Fshape_w3	2.7	Shape factor describing water stress effects on canopy senescence	Doug Hunsaker
Fshape_w4	1	Shape factor describing water stress effects on pollination	Doug Hunsaker
Etadj	0	Adjustment to water stress thresholds depending on daily ET0 (0: 'No', 1: 'Yes')	Doug Hunsaker
Aer	5	Vol (%) below saturation at which stress begins to occur due to deficient aeration	Doug Hunsaker
LagAer	3	Number of days lag before aeration stress affects crop growth	Doug Hunsaker
Beta	12	Reduction (%) to p_lo3 when early canopy senescence is triggered	Pete Waller
Germthr	0.4-0.5	Proportion of total water storage needed for crop to germinate	Doug Hunsaker

BioCrop model: This is on hold at this time as S. Pradyawong is on leave.

#### Plant Density Trials:

Heights of all plants were measured on August 8 (Tables 9-11). No clear trend is seen, except that AZ2 is growing taller than Sel1 and there are no differences by treatment for AZ2.

**Table 9.** Mean heights by treatment of plants in guayule density trial measured on 8 August 2019. Values followed by the same letter are not significantly different.

Treatment	N	Mean	Std Dev	
1 plant /76 cm	40	58.0	14.3	a
1 plant/46 cm	40	56.1	14.9	a
1 plant/30 cm	40	59.5	15.3	a
1 plant/15 cm	40	60.5	13.5	a
1 plant/7 cm	40	58.5	13.5	a

**Table 10.** Mean heights of guayule variety AZ2 in density trial measured on 8 August 2019. Values followed by the same letter are not significantly different.

Treatment	N	Mean	Std Dev	
1 plant /76 cm	20	71.1	5.9	a
1 plant/46 cm	20	69.9	5.6	a
1 plant/30 cm	20	73.6	6.9	a
1 plant/15 cm	20	73.0	5.3	a
1 plant/7 cm	20	70.8	6.5	a

**Table 11.** Mean heights of guayule variety Sel1 in density trial measured on 8 August 2019. Values followed by the same letter are not significantly different.

Treatment	N	Mean	Std Dev	
1 plant /76 cm	20	44.9	4.6	bc
1 plant/46 cm	20	42.3	5.1	c
1 plant/30 cm	20	45.4	3.8	ab
1 plant/15 cm	20	48.1	4.9	a
1 plant/7 cm	20	46.3	4.1	ab

One-year old plants will be harvested in October in one-meter sections for each line and density.

#### Biomass Drying Experiment:

First biomass drying experiment was completed in June 2018; no new data to report.

#### Guayule Trials (Direct-Seeded and Transplant-Established):

Roots harvested July 30 (84 Days After Planting [DAP]) and August 22 (106 DAP). Dried for 48 hours. Above-ground biomass and 20 cm sections of roots were weighed (Table 12).

**Table 12.** Mean above-ground guayule biomass (ABG) and root weights by depth (g) measured at 84 and 106 days after planting. Values in column marked with \* are significantly different.

	AGB (g)		Total Root Wt (g)		Plant Height (cm)	
	MEAN	SD	MEAN	SD	MEAN	SD
<b>84 DAP</b>						
Direct seeded (n=4)	9.23	2.37	3.01	0.59	23.9	3.8
Transplanted (n=4)	10.75	2.02	5.48*	0.53	20.9	1.9
<b>106 DAP</b>						
Direct seeded (n=4)	10.99	3.05	6.09	0.95	22.9	3.4
Transplanted (n=4)	14.63	4.55	12.61	8.72	23.5	4.4

Transplanted seedlings are significantly greater than direct-seeded in total root weight at 84 DAP but above-ground biomass of direct-seeded plants has “caught up” and by 106 DAP, roots have as well. No significant differences between treatments for resin or rubber (Table 13).

**Table 13.** Mean values for "resin" (acetone-extractables) and "rubber" (cyclohexane-extractables) in guayule plants harvested at 49 and 84 days after planting. No significant differences between treatments.

	RESIN %				RUBBER %			
	AGB		0-20 cm roots		AGB		0-20 cm roots	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
<b>49 DAP</b>								
Direct seeded (n=4)	3.81	1.29	na		1.04	0.59	na	
Transplanted (n=3)	3.75	1.04	na		1.32	0.54	na	
<b>84 DAP</b>								
Direct seeded (n=4)	3.90	0.67	3.57	0.98	1.74	0.60	0.96	0.24
Transplanted (n=4)	4.49	1.12	3.75	1.26	1.78	0.23	1.16	0.15

#### Installation of TDR, Infrared Cameras, and Flowmeter System:

The TDR and infrared camera are complete and automatically uploading data to the cloud and server database from the field. We are still calibrating sensors and learning to install everything correctly (trouble-shooting).

Danielle Murdoch-Hoare and Matt Katterman presented a poster on their field sensor systems for soil moisture monitoring (TDR), and infrared cameras at the SBAR Annual Retreat. They are powered by solar power and automatically send data to the cloud and to our server on campus.

#### Python MySQL WINDS Model Integration with Existing Tools:

Hadiqa Maqsood presented results (two presentations) on guar and guayule modeling with the WINDS model to the AAIC conference in September 2019.

We are continuing our collaboration with Sangu Angadi on the 2019 guar experiments in Clovis and can simulate his experiments, as well as the Maricopa and Eloy guayule experiments in the WINDS model. We are collaborating with Dr. Haiquan Li and a high school intern to develop a phone app for the WINDS model.

#### Irrigation Experiments – Guayule and Guar:

Diaa El-Shikha took three trips to Clovis this summer in order to conduct drone flyovers of the guar experiments. We have done most of the leg work on setting up the Aquacrop model for Dr. Angadi's guar experiments. We will also add in the 2019 guar experiment data for the WINDS and Aquacrop models.

Guayule irrigation experiments at Maricopa:

1. Used the neutron probe data and Irrigation model to schedule irrigation for the two fields (at MAC and Eloy).

2. Collected remote sensing data once a week from the field at MAC and once a month from Eloy. Images were processed (stitching/ orthomosaic generation) using desktop image processing software.
3. We have now added a thermal sensor to the drone, and it is showing a temperature trend for canopy irrigation as a function of irrigation treatment.
4. Field data was collected (height, width) once a month from both locations.

#### Other Tasks:

Stress Irrigation Trials at Eloy: Planning for this new experiment occurred this quarter. We have discussions on the treatments, lines, and data collected, as well as budget allocations. There will be 2 germplasm lines, 5 treatments, and 3 replications planted at Eloy with furrow irrigation. Each plot will be 130 ft long and 8 rows wide.

Data Sharing: We are working with the team from Colorado School of Mines to make data available for modeling efforts.

### ***Objective 5. Develop soil quality and health knowledge critical to environmental sustainability.***

Task #	Description of Task	Deliverable	Target Completion Date
1 Maier/ Neilson	Chemical and physical analysis of 108 soil samples	pH, EC, OrgM, NO <sub>3</sub> -N, P, K, cations, and SAR analysis complete	31 Dec 19
		Soil texture characterization complete	31 Dec 19
2 Maier/ Neilson	DNA extraction of soil samples for microbiome analysis	DNA extraction from samples	1 Feb 20
		Amplicon sequencing	1 Apr 20
		Bioinformatics analysis of data generated from amplicon sequencing	1 Jun 20
		Assess spatial/temporal distributions of fungal pathogens on microbial community dataset	1 Jun 20
3 Maier/ Neilson	Soil sample collection for guayule-microbe irrigation study	Collect/archive soil samples for DNA and RNA analysis from 108 samples immediately after harvest	1 Apr 20
4 Maier/ Neilson	Winter dormancy rubber production studies	Chemical analysis of root zone soils collected; analyzed for pH, EC NH <sub>4</sub> -N, bioavailable P and Organic C	31 Dec 20
		DNA extraction of guayule root zone samples	31 Oct 20

		Quantification of bacteria and fungi	31 Dec 20
		Amplicon sequencing of bacteria, archaea, and fungi	31 Jan 20
		Statistical analysis of microbial community dynamics and associations	30 Jun 20
5 Maier/ Neilson	Temporal microbiome analysis of community interactions	Sample F50 and F100 treatments of Eloy irrigation trial	1 May 20
		Collect temperature data	1 May 20
		DNA extraction for 215 samples	30 Jun 20
		Amplicon sequencing: bacteria, archaea, fungi	1 Aug 20
		Generate microbial community profiles and network analysis	1 Oct 20

#### Chemical and Physical Analysis:

Three separate experiments (Tasks 1 – 3) are being conducted simultaneously to characterize effects of guayule establishment on the soil microbiome. Specifically, associations between spatial and temporal variability in microbial and chemical soil composition and guayule growth and rubber production are being characterized. Tasks 1 and 2 are being conducted in collaboration with multiple SBAR research groups to facilitate comparison of soil data with plant data collected at each sample time.

The first experiment was designed to evaluate the effect of guayule plant establishment on soil biological and chemical properties under different irrigation treatments in both the MAC and Eloy fields. Samples were collected from both fields immediately following plant germination and after one year of growth. Progress continues, but has been slow due to complications with sample analysis; however, all issues have been addressed and a revised plan is in place as indicated in the Issues & Risks section (see above).

Quality assessment was conducted in the Maier Lab of soil analysis results obtained from NMSU. We determined that some analyses must be repeated by a commercial lab. A new undergraduate was hired and trained to complete analysis of Year 1 Eloy soils. Analysis is now complete for 50% of Eloy soils; MAC soil are 100% complete.

#### DNA Extraction for Microbiome Analysis:

DNA extraction for the Year 1 samples is almost complete. Analysis of spatial heterogeneity in microbial community composition and diversity will begin this fall. In addition, samples will be screened for the relative abundance of soil fungal pathogens known to infect guayule.



DNA extraction and purification of Year 1 Eloy soil samples is complete. DNA extraction of Year 1 MAC soil samples is 90% complete. Year 2 samples are stored for future extraction.

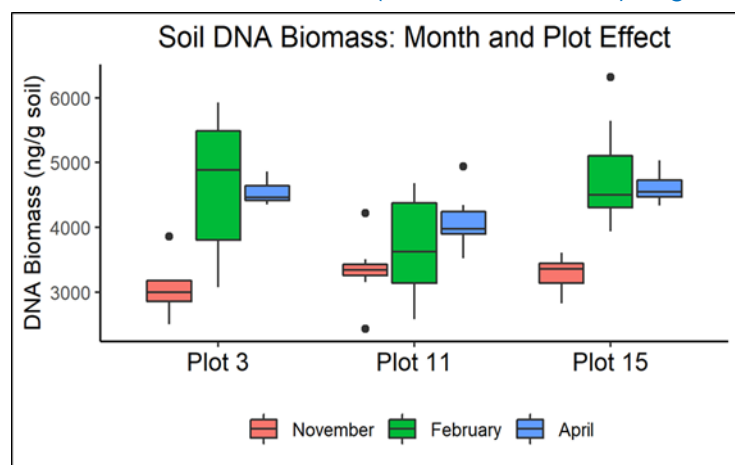
#### Baseline Microbiome Profile and Spatial Variations:

Amplicon sequencing complete for Year 1 Eloy soil samples.

Bioinformatics analysis is in progress to determine microbial community composition metrics.

#### Soil Sampling for Guayule Microbiome Winter Dormancy Studies:

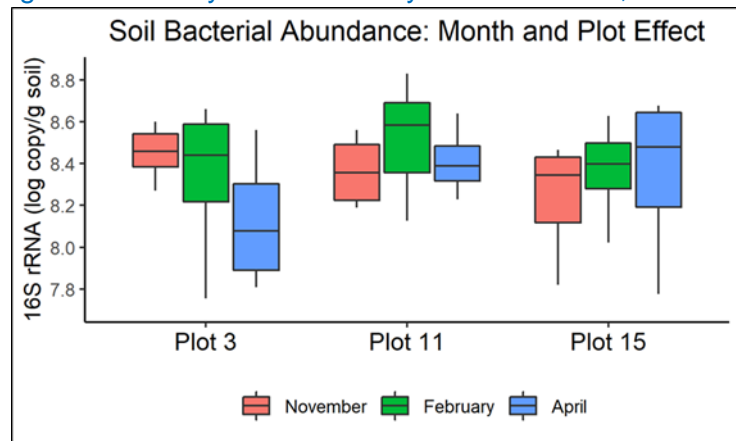
Significant progress was made on the Guayule Winter Dormancy study during the third quarter. Microbial and chemical analyses were performed on root zone soils collected in conjunction with Colleen McMahan's lab to facilitate analysis of associations between guayule growth stage, plant rubber production and below ground soil fertility metrics during three guayule growth stages. The growth stages were represented by three sampling dates in November (cold-induced increase in rubber biosynthesis), February (winter dormancy period with little biomass growth but active rubber synthesis), and April (return to rapid growth). DNA was extracted from all root zone samples in quadruplicate to reveal temporal changes in soil biomass and bacterial abundance for 6 plants collected from six field locations in the three replicate plots of the Drip 100 treatment at MAC farm (Plots 3, 11 and 15). Figure 17 shows that soil biomass was



significantly higher in February during the period of winter dormancy than during active growth in November. Biomass remained high when the plant resumed active growth in April. No significant spatial variability was observed in soil biomass across field locations in November (ANOVA;  $p=0.16$ ); however, biomass levels varied significantly with field location in both February (ANOVA;  $p<0.001$ ) and April (ANOVA;  $p=0.007$ ).

**Figure 17.** Soil DNA biomass changes with guayule growth cycle.

Soil biomass includes bacterial, archaeal, fungal, animal and some plant genomic DNA. Quantification of the separate microbial groups is being conducted to understand the source of the variation. Figure 18 reveals a different pattern for the abundance of root-zone soil bacteria. As with biomass, no significant spatial difference across field locations was observed in November (ANOVA;  $p=0.09$ ); however, significant spatial differences were observed in February and April. Unlike total biomass, bacterial abundance in February was similar to November. Fungal abundance will be quantified to determine whether the biomass patterns are explained by variations in fungal abundance. Soil DNA has been submitted to the UA Microbiome core for amplicon sequencing to allow analysis of variability in the bacterial, archaeal and fungal community diversity and composition at the different growth stages. Chemical analysis showed significant temporal changes in ammonium content and EC, but no significant change in pH. Organic carbon and bioavailable phosphorus are currently being analyzed for these samples. All soil data will be compared with plant rubber production metrics to determine whether observed variability in any soil properties correlates with rubber production metrics.



**Figure 18.** Bacterial abundance changes with guayule growth cycle; however, the pattern is distinct from the soil biomass pattern.

Sampling is now complete for the winter dormancy study. DNA extractions, biomass determination, bacterial abundance quantification is completed for all samples. Chemical analysis is completed for pH, EC, and  $\text{NH}_4\text{-N}$ .

#### Year 2 Guayule Plant and Soil Sampling:

Year 2 soil sampling is completed for the Eloy an MAC guayule field trials in coordination with plant sampling so that plant and soil samples were collected simultaneously. This task is now 100% complete.

#### Temporal microbiome analysis of community interactions:

The last experiment (Task 6) was designed this quarter to further evaluate the impact of guayule growth stage on microbial community interaction patterns that could influence soil functional capacity. Sample collection began in August 2019 and will continue monthly until March 2020. This project will target the Flood 50 and Flood 100 treatments at the Eloy field.

## POST-HARVEST LOGISTICS & CO-PRODUCTS

**Project Coordination:** The Logistics working group meetings are hosted by NMSU twice monthly. Beginning in Q4, there will be only one set meeting per month. During these meetings, progress reports for all component tasks are provided by team members, issues and challenges are discussed for resolution, and specific tasks are integrated where possible. Data exchange is accommodated via a shared access folder online.

### Issues/Risks:

**Brewer:** Continued from last quarter: preparation of the manuscript on the guar variety trials, incorporating the bagasse characterization information, is delayed as growth information and gum characterization still need to be added. Audu has completed his components of the manuscript and the draft was sent to the Grover group. Dehghanizadeh's anticipated visit to the USDA ARS lab in Albany has been postponed due to international visitor clearances and the need for more time to plan his experimental work there on guayule resin separation/analysis.

Of the \$110k in the original quote for the lab-scale supercritical CO<sub>2</sub> extraction instrument, \$80k of the funding has been secured. An updated quote will be sought from the manufacturer including more specific details about sample vessels needed, which is expected to reduce the amount of the total cost to ~\$100k. Brewer is currently seeking the remaining funding from the NMSU VPR. In the meantime, Dehghanizadeh will focus on the review manuscript and accelerated liquid/green solvent extractions.

**Gunatilaka:** The work on chemical and microbial transformations of guayule co-products did not proceed as anticipated causing delays in completing work proposed under tasks.

**Holguin:** We have one gas chromatography down, which is a primary instrument for metabolomics work. We will be scheduling a field engineer visit. Funds have also been late for distribution to NMSU resulting in delays for supplies and personnel. We have an institutional waiver approved, which allows us to continue spending until the Year 3 funds arrive.

**Ogden:** A risk is that S. Pradyawong had to return to her home country and we are unsure when she will return. A. Smith is a first-year graduate student and is just learning.

### ***Objective 1. Evaluate how seasonality, processing, and storage affect product quality, conversion efficiency, and economics.***

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Provide guayule (and guar) bagasse characterization support for ongoing feedstock trials	Capture and collate data on the average variability of bagasse lignocellulosic biomass characteristics	31 Aug 19
2 Holg	Biochemical composition analysis of guayule and respective products	Metabolomics and lipidomic assessment during abiotic stress and adaptation	31 Aug 20

		Generate 2 <sup>nd</sup> manuscript on metabolomics cold adaptation/ pathway regulation	31 Aug 20
		Generate manuscript on high resolution mass spectrometry analysis of guayule resin	31 Aug 20
3 Holg	Biochemical composition analysis of guar and respective products	Develop standard operational methods to characterize polysaccharide composition of purified guar gum	31 Aug 20
4 Holg	Analytical evaluation of thermochemical conversion products	Determine composition information and sample extracts	31 Aug 20

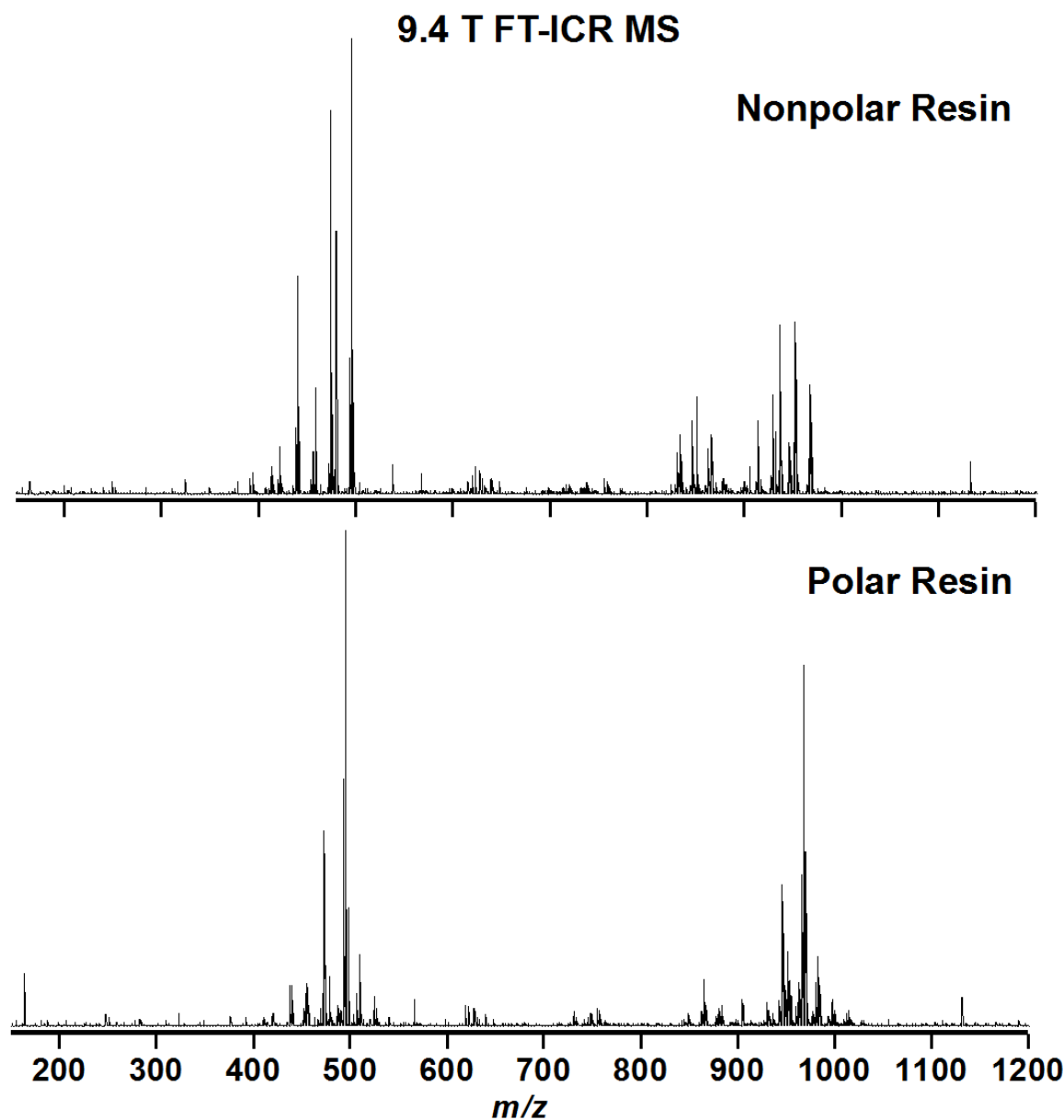
#### Bagasse Characterization Support:

Rosalez completed HTL conversion experiments on wastewater treatment algae alone, guayule alone, and the first of the algae + guayule co-HTL tests. Those experiments are expected to be completed in Q4 with ongoing product characterization. Rosalez is planning to defend in spring or summer 2020.

#### Guayule Biochemical Composition Analysis:

We continue to perform biomass characterization methods with Dr. Brewer's group on bagasse material. Dr. Jacqueline Jarvis at NMSU. Dr. Jarvis has generated a total of 42 high-resolution FTICR spectra to process for this project, which includes +/- ESI and + APPI of 11 guayule, algae, or guayule/algae biocrudes and 3 resin samples (nonpolar, polar, and resin) (Figure 19).

We performed High Temperature GC-TOF MS followed by NIST library spectra matching, DDA MS2 Acquisition followed by library spectral matching, Unambiguous molecular formula assignment FT-ICR MS and isotopic fine structure, De-novo molecular structure elucidation by fragmentation trees (Figure 19). Also we will provide information on the lipids identified in the resin samples.



**Figure 19.** *Ultrahigh resolution and accurate mass FT-ICR MS of resin samples.*

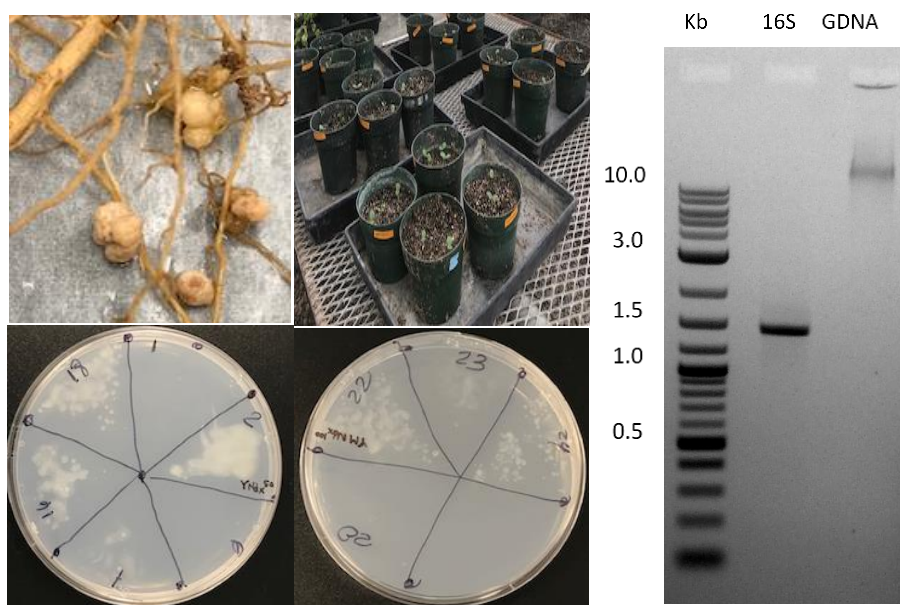
Guar Bagasse Biochemical Composition Analysis:

We have completed the enzyme analysis and size exclusion analysis for all guar samples and are now combining the results into a report. We have found a discrepancy in the values obtained on our samples from those reported in literature for gum yield using the enzymatic kit. We are consulting the manufacture as well as improving the process to get more accurate yields.

Recently noted was the nodulation of guar varieties in the field. We capitalized on this event to identify the rhizobium in hopes of increasing guar/gum yields with low field inputs. We have

Isolation of *Rhizobium* from nodules of guar plants grown at NMSU: Leyendecker Plant Science Center and Fabian Garcia Science Center (Figure 20).

- Two types of nodules were found in guar roots: **determinate** and **indeterminate**.
- **Determinate** nodules were found in guar plants from NMSU Leyendecker Plant Science Center and **indeterminate** in guar plants from Fabian Garcia Science Center.
- *Rhizobium* was isolated from both kinds of nodules.
- Genomic DNA was isolated from *Rhizobium* from both types of nodules.
- The 16S ribosomal gene was amplified from *Rhizobium* genomic DNA and sequenced.
- *Rhizobium* was identified for the determinate nodules and is being identified for the *Rhizobium* found in indeterminate nodules.



**Figure 20.** Isolation of *Rhizobium* from guar nodules. Guar nodules fixing nitrogen (top left); *Rhizobium* isolated from nitrogen fixing guar nodules (bottom left and right); nodulation of guar lines with the isolated *Rhizobium* (mid top); and amplification of 16S gene from *Rhizobium* genomic DNA (far right).

**Metabolomics and Biochemical Analysis** – We have also continued our work with Dr. Von Mark V. Cruz and Dr. David Dierig on characterization of cold adaptation of guayule leaf material. Ms. Ujala Sehar has joined this quarter to begin processing the metabolomic samples.

Sixty-eight guayule leaf and stem samples were harvested from Cold Germination, Freeze tolerant, and Survivor plants grown at the Leyendecker Plant Science Center on October 11 for new metabolomic studies.

A draft of the publication “Natural Products in the Desert Southwest: Guayule (*Parthenium argentatum*) and Guar (*Cyamopsis tetragonolobus*)” is being finalized and formatted. We anticipate submission in Fall 2019 for publication to the “Plant Management Network”.



## ***Objective 2. Demonstrate feasibility of farm to fuel conversion of bagasse.***

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Prepare 2 manuscripts on guayule/guar bagasse composition, biomass-to-conversion method matching (HTL product yields)	Manuscripts prepared	31 Aug 20
		Manuscripts submitted for peer-review process	31 Aug 20
2 Holg	Analytical evaluation of thermochemical conversion products	Complete composition information and sample extracts	31 Aug 20
		Contribute to manuscripts	31 Aug 20

### Manuscript Preparation:

The review article manuscript on pyrolysis conversion of low-cost, higher-nitrogen biomass residues was submitted; that manuscript is currently under revision. The other two parts of the review manuscript: one focused on feedstock characteristics and one focused on biochemical conversion methods are drafted and circulating among the authors for editing.

Two manuscripts on the development and testing of the pilot-scale hydrothermal liquefaction (HTL) continuous flow reactor (work in Year 1) were submitted; the original research article has now been published and the methods article is under review. The manuscripts on guayule bagasse and resin characterization are currently under final editing with Brewer, then will be sent to Bridgestone for a final review (they have reviewed previous drafts) before submission in the near future. Those manuscripts include the first high-resolution FT-MS data on the guayule resin.

Cheng and Audu continue to contribute to manuscript preparation and editing from Worcester Polytechnic Institute even though they are no longer supported on SBAR after July and August, respectively.

### Analytical Evaluation of Thermochemical Conversion Products:

Research continues as planned; no new data to report.

## ***Objective 3. Identify economic co-products in guayule and guar, e.g., biologically active components.***

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Literature review at experiment design/set-up for isolation/purification of guayule resin compounds in commercially relevant quantities	Define research questions for guayule resin separation methods	31 Aug 19

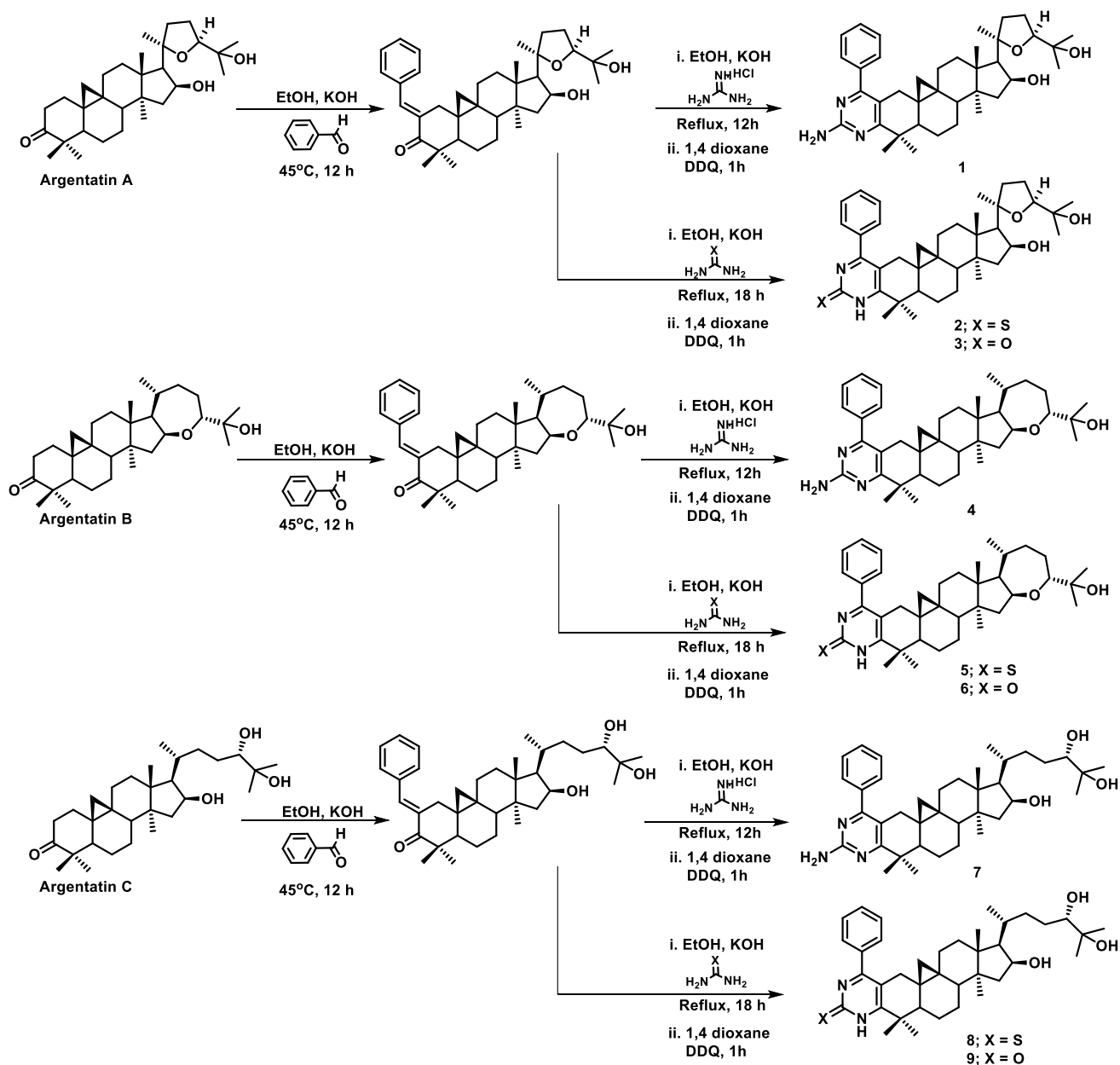
		Preliminary experimental designs defined for guayule resin separation methods	31 Aug 19
2 Brewer	Perform separations and fraction characterization of guayule resin	Purchase supercritical solvent extraction system	31 Aug 20
		Perform liquid-liquid, accelerated, and filtration separations	31 Aug 20
		Prepare manuscript of guayule resin separation	31 Aug 20
3 Gunat	Chemical and microbial transformations	Develop chemical and/or microbial methods for the conversion of guayule by-products into value-added products	31 Dec 19
4 Gunat	Evaluate major metabolites of guayule	Evaluate transformation products of argentatins A, B, C for potential anticancer/antimicrobial activities	30 Apr 20
5 Gunat	Isolate and characterize major metabolites of guayule terpene solution	Identify metabolites within solution that can be converted to value-added products	31 Jul 20
6 Ogden	Evaluation of major fractions of guayule resin	Recommendation of potential products that can be separated from resin fractions	31 Aug 20
7 Ogden	Cost analysis of potential resin products	Initial incorporation of resin products into TEA	31 Aug 20

#### Literature Review and Experiment Design/Set-up for Isolation/Purification of Guayule Resin Compounds:

Dehghanizadeh prepared an outline of a guayule resin composition and applications review. That draft has been sent to Sproul at CSU to incorporate economic information about the reported applications and to Bridgestone for input. That manuscript will be submitted in Q1 in 2020. Resin separation experimental design and characterization is currently underway. Dehghanizadeh received a graduate student travel award from AAIC to present at the annual meeting in Tucson in September.

#### Chemical and Microbial Transformations:

Semi-syntheses of nine novel ring A-fused pyrimidine analogues of argentatins A–C were completed. The resulting analogues **1–9** (Figure 21) were subjected to biological assays to evaluate their potential anticancer (cytotoxic) and antimicrobial activities.



**Figure 21.** Semi-synthesis of pyrimidine analogues 1-9 of argentatins A-C.

### Cytotoxic activity of pyrimidine analogues 1–9 of argentatins A, B and C

All semi-synthetic pyrimidine analogues (1–9) of argentatins A–C were evaluated for their cytotoxic activity against three sentinel cancer cell lines (NCI-H460, SF-268 and MCF-7) and normal human epithelial cells (WI-38) at 5 and 10  $\mu\text{M}$  concentrations. The results revealed that at 10  $\mu\text{M}$ , the 2-oxo-pyrimidine analogue of argentatin B (6) showed moderate cytotoxicity (% inhibition) for cancer cell lines [NCI-H460 (82%), SF-268 (82%), MCF-7 (67%)] with some selectivity over normal cells [WI-38 (48%)]. Moreover, compounds 1, 3 & 9 showed weak activity against cancer cell lines, NCI-H460 and MCF-7.

#### Evaluate Major Metabolites of Guayule:

##### **Antimicrobial activity of pyrimidine analogues 1–9 of argentatins A, B and C**

Semi-synthetic analogues (1–9) of argentatins A–C were also screened for antimicrobial activity against *Escherichia coli* ATCC 25922, *Candida albicans* ATCC 10261, *Staphylococcus aureus* ATCC 25923 and *Pseudomonas aeruginosa*. The results showed that compound 3 (2-oxo-pyrimidine analogue of argentatin A) displayed moderate activity against *Staphylococcus aureus* [minimum inhibitory concentration (MIC) between 25–12.5 µg/mL]. The remaining compounds (1, 2 and 4–9) were found to be inactive up to a concentration of 100 µg/mL.

#### Isolate and Characterize Major Metabolites of Guayule Terpene Solution:

Research continues as planned; no new data to report.

#### Major Fractions of Guayule Resin:

We have begun initial studies into the project sustainability and potential of high value-added products obtained from guayule resin. We recently focused on the adhesion properties of the resin. A new graduate student – Andrew Smith – will be working on this, and a meeting has been set with Bridgestone in November.

#### Cost Analysis of Potential Resin Products:

No new activity to report.

## SYSTEM PERFORMANCE & SUSTAINABILITY

Project Coordination: Colorado State University (CSU) leads the bi-monthly working group webinar/phone calls. The meetings are leveraged to ensure all team members are on schedule and work can seamlessly integrate across institutions. The focus this quarter has been on the following:

- Development of LCA capabilities in the integrated model using the economic foundation
- Finalizing integrated model results including economics and environmental impacts
- Model integration across the sustainability team
- The continued development and validation of individual sub-process models
- Coordinating and leading Sustainability working session prior to all-hands meeting
- Preparation and attendance at the all-hands meeting
- Presentation of results at the ACLCA conference
- Development of Sustainability team meetings on a bi-monthly basis in support of model integration

All notes and presentation materials are maintained in a community workspace available to all partners for future reference.

### Issues/Risks:

**Fan:** Regarding task “Build system-level model and algorithm to integrate three modules (smart facility planning and transportation, smart farm production and scheduling, and sustainability and economics analysis) for decision support in the biomass supply chain for Guar and Guayule”, in order to build the system-level model, stochastic scenarios need to be determined. Although we have identified potential scenarios, feedback from our partners and other group members (especially Sustainability group) is necessary. Therefore, we will present them multiple scenarios to discuss on the SUS group meetings and UA research team meetings in Fall 2019.

**Seavert:** (Explanation for change in scope.) The break-even model will provide more realistic financial information to potential growers of Guar and Guayule. Rather than developing representative farms and their financial structures at this time, the break-even model will replace these representative farms as they show more personal economic and financial results. Working with lenders later to provide representative financial targets and benchmarks could create an alliance that would better serve producers in workshops.

**Teegerstrom:** Continue to work with tribal farms and Bridgestone on their interest in collaborating, but changes in tribal farm management and it being lower on their priority list for many of the tribal farms is slowing the process. Looking into two other tribal farms – one in central Arizona and one on the Colorado River.

**Objective 1. Develop a scalable engineering process model for crop production and processing that is coupled with Techno-Economic Analysis (TEA) and Life Cycle Analysis (LCA) to understand the economic impact to rural communities through input-output methods.**

Task #	Description of Task	Deliverable	Target Completion Date
1 Gutierr	Functional integration of economic analysis into system model	Gather information for farm level scenarios using different avg. farm sizes, irrigation, and acreages	31 Aug 20
		Conduct input/output analysis of system model results	31 Aug 20
		Validate preliminary analysis for farm production and profitability	31 Aug 20
		Generate publication on the economic analysis for guar and guayule	31 Aug 20
2 Gutierr	Initiate development/testing of online producer systems model	Create online tool for evaluating guar/guayule alternative crops	31 Mar 20
3 Landis	First order LCA model	Complete preliminary LCA	30 Sep 18
4 Landis	LCA first order model integration	Integrated modular model in collaboration with broader team	31 Dec 18
		Refining LCA model integration	31 Mar 19
5 Landis	Collect agricultural data from field trials	Update agriculture model inputs	31 Dec 19
		Re-run model with new information	31 Dec 19
6 Landis	Field data transfer	Develop SOP/protocol for transferring field data to LCA team in useful formats	31 Dec 19
7 Landis	Integrate current field data into LCA/TEA model	Update LCA/TEA model inputs with field data; identify new scenarios	31 Aug 20
8 Landis	Sensitivity and scenario analysis	LCA Scenario Analysis complete	31 Aug 20
		Manuscript generated/submitted	31 Aug 20
9 Quinn	Techno-economic and Life Cycle Assessment results	Update/finalize economic and environmental impact results	1 Aug 19
10 Quinn	Data integration	Integrate experimental data into foundational processing model	31 Aug 20
11 Seav	Co-develop enterprise budgets that contain costs/returns of growing current cropping system and new crops that include outputs for LCA	Completed budgets for integration into Sustainability model	28 Jan 19



12 Seav	Develop financial ratios and performance measures for representative farms in AZ and NM	Meet with area lenders and accountants to gather info	31 Mar 19
		Complete two whole-farm case studies (AZ and NM)	31 Mar 19
		Case study info integrated into Sustainability model	31 Mar 19
13 Seav	Validated integrated model	Update and incorporate new information under various scenarios	31 Aug 20
14 Seav	Diversify integrated model for broader audience	Incorporate returns/costs of additional crops into integrated model	31 Aug 20
15 Teeg	Facilitate working agreement between Tribal Farms and Bridgestone to establish experimental plots	Signed agreement established between Gila River Farms and Bridgestone	31 Aug 20
		Experimental plots established on Tribal lands	31 Aug 20
16 Teeg	Co-develop enterprise budgets that contain costs/returns of growing current cropping system and new crops that include outputs for LCA	Completed budgets for integration into Sustainability model	28 Jan 19
17 Teeg	Develop financial ratios and performance measures for representative farms in AZ and NM	Meet with area lenders and accountants to gather info	31 Mar 19
		Complete two whole-farm case studies (AZ and NM)	31 Mar 19
		Case study info integrated into Sustainability model	31 Mar 19
18 Teeg	Validated integrated model	Update and incorporate new information under various scenarios	31 Aug 20

#### Functional Integration of Economic Analysis into System Model:

The current status of the project in meeting defined milestones for the recent quarter (Q1), 2019 is on schedule. The proactive bi-weekly meetings with project partners motivated the team to meet the identified task and set targets.

- Farm Level Economics for Integrated Systems Model:** The goal of identifying farm level inputs to be used in the integrated systems model was accomplished. The first draft of the farm level economics has been integrated into the systems model. NMSU has been in collaboration with OSU and UA in developing the farm level model. The whole farm level economic analysis has been successfully developed for integration into system model. Identify crop mix and potential acreage of crops in southern NM counties.
  - Analyze potential acreage for adoption of guar and guayule at 10%, 15%, and 20% adoption rates.
  - Validate preliminary analysis; finalize farm level analysis

- **Partial budget analysis for guar and guayule:** The enterprise budgets dealing with costs and returns and narrative detailing the agronomic and cultural practices in production of guar and guayule have been developed in draft form and is under the peer review among SBAR teams. Also, a sensitivity analysis associated with net returns of guar and guayule production has been developed with varying costs, yields and price per pound of dry matters from our key assumption.
- **Guar Needs Assessment Survey – New Mexico Producers:** A total of 54 needs assessment survey have been completed and collected from producers in NM. Those survey data were entered in the online system Qualtrics and have been summarized for analysis. The team will analyze the survey data and use the information to create extension bulletins to answer producer's questions on sustainability and production of guar and guayule in southern New Mexico.

Future plans include the following:

1. As new, confidential field level information is provided in the production of guar and guayule, the costs to establish and produce these crops will be incorporated or revised in the integrated model. Testing the computations of crop under various scenarios will occur to validate the integrated model.
2. Efforts will continue to coordinate with Techno-Economic Analysis (TEA) and Life Cycle Analysis (LCA) team members to enhance the integrated model and provide economic information to the team for publication and presentation.
3. As we learn more about the producers who may want to grow guayule and guar in other geographical regions, additional crop budgets in the model will be created.
4. Research the implications of adopting new crops into current cropping systems and how that changes the break-even prices.
5. Economic impact will be evaluated using IMPLAN, a regional IO model. IMPLAN enables us to track inputs required for production through the supply chain, including the ability to purchase locally. By varying the scale and supply chain, we can investigate the impacts of SBAR growth to employment, real estate, income, trade, and local/regional business.

#### First Order LCA Model:

First order LCA model of guar agriculture from literature full article draft writing is in progress. Progress made on methods, results figures, and discussion.

#### LCA First Order Model Integration:

First order LCA modeling for Guayule resin was completed in summer internship work at USDA-ARS-WRRC. Internship research included an environmental assessment of potential process for resin fractionation. Solvent-solvent extractions of purified guayule resin were performed, with a focus on green solvents.

Still waiting on response from Alex M. at Guar Resources from initial guar agricultural and processing data validation, inputs and outputs accuracy check, and inquiry on whether we could speak with their farmers and/or be directed to Guar Resources' agricultural expert(s) to better detail our ag inputs and processes in the model. Final wave of ag LCA integration was completed before the SBAR annual retreat.

#### Collect Agricultural Data from Field Trials:

Mines is leading the sustainability team's communication efforts with all field trial teams with VeeAnder as the designated point of contact for data collection.

VeeAnder developed guar and guayule field trial summary tables, displaying all field trials, associated PIs and their purpose in one location. Initial data inquiries and requests have been sent. Data collection from groups is still in progress.

#### Techno-economic and Life Cycle Assessment Results:

Research for this objective is complete; no new data to report.

#### Data Integration:

Experimental data integration represents a critical need for the sustainability team. In collaboration with CSM the agricultural partners have been contacted and we are working on a format to facilitate the seamless integration of experimental data for model validation.

#### Enterprise Budget Development:

In lieu of working with lenders to define representative whole farm case studies, a break-even model was created for the Extension Team that accounts for whole farm costs and returns as the adoption rate changes for Guar and Guayule. This model shows the changes to net present values of future net returns as acres for a model farm change.

#### Development of Financial Ratios and Performance Measures for Representative Farms in AZ and NM:

Enterprise budgets are complete. The budget templates are available via the team Box file. Refinements will reflect the new production information.

#### Working Agreements between Tribal Farms and Bridgestone to Establish Experimental Plots:

Continue to assist in securing experimental plots on at least two tribal farms. 1) Connect Bridgestone and CRIT farms for experimental acreage agreement, establish introduction meeting and started contract negotiations 2) Connecting Bridgestone and Fort McDowell Farm for experimental acreage agreement. Started the conversation and in the process of setting up the first meeting with both farms. This is a long process and will take some time to complete.

***Objective 2. Integrate regionally appropriate metrics and combine results from SBAR-developed data into sustainability models to provide a path to commercialization of biofuels and bioproducts.***

Task #	Description of Task	Deliverable	Target Completion Date
1 Quinn	Model integration	Integration of upstream and downstream modeling efforts	1 Jan 19
2 Quinn	Sensitivity analysis	Generate results for sensitivity analysis	1 Apr 19

		Present results of sensitivity analysis to SBAR LEADS for feedback	1 Apr 19
3 Quinn	Process modeling	Improve downstream process modeling fidelity  Re-run results for further analysis (and to identify next steps)	1 Jun 19  1 Jun 19
4 Quinn	Downstream process modeling	Integrate downstream process modeling	1 Nov 20
5 Quinn	Scenario modeling	Generate results of scenario analysis  Present results of scenario analysis at conferences for feedback	1 Feb 20  28 Feb 20
6 Quinn	Stochastic modeling	Evaluate system at a system level through Monte Carlo sensitivity modeling	30 Jun 20

#### Model Integration:

CSU has taken the lead on the LCA modeling integration effort. CSU this quarter started from scratch and used the foundational work from the ag economics to build the LCA component in the integrated model. This task was completed prior to the all-hands meeting such that the sustainability team delivered on the goals of the project for this past year.

The primary push here was on the LCA side of modeling as outlined above. There were efforts on the other aspects of the model to ensure the results to be presented at the all-hands meeting were robust.

CSU continues to lead the integration effort with the development of a modeling framework to support the integration of the research across all research groups. As previously reported, an integrated model has been developed and the CSU team continues to work with collaborators in improving the fidelity of individual components of that model. This quarter included integrating results from transportation logistics as well as updating ag economics.

#### Sensitivity Analysis:

No new data to report.

#### Engineering Process modeling:

The process modeling foundation is continuing to evolve and be improved. The focus this past quarter has been on ag economics. As a part of the LCA work, areas for model improvement on the ag foundation were identified and improved with the help of Clark S. A short summary of accomplishments on each of the crops and downstream process modeling is provided below:

**Guar.** In order to establish equally capable models by the annual meeting, the Guar model tasks that were completed directly overlap those of Guayule. Three goals were achieved: 1) economic costs for agricultural processes, such as equipment replacement costs, where improved, 2) additional agricultural scenario where built into the model for cultivation variations

and 3) LCA results were reevaluated to ensure consistency between agricultural and processing methods. Additional minor changes within the downstream processing model included refining and adding sub-processes, improved labor economics and worked with Texas A&M Extension to better understand the yields from the field as well as corresponding seed amount after harvest.

**Guayule:** Modeling work on guayule has achieved three main accomplishments. First, economic costs for agricultural processes were reviewed and improved. This included improving the calculations for equipment replacement costs which has a significant impact on costs of cultivating the crop. Second, additional scenarios were built in to evaluate an overall conservative and optimistic estimate for guayule costs across agriculture and downstream processing. This yields a range of economic results which can be used to gauge the potential of further crop development. Third, all life cycle inventory data was reevaluated to ensure consistency across agriculture and processing. This data was applied to the foundational agricultural modeling developed by the agricultural economics team. As a result, the full guayule model is now connected across a common set of input parameters and a single unified modeling framework.

***Objective 3. Interface with regional growers to de-risk US production of guayule and guar while evaluating social impacts.***

Task #	Description of Task	Deliverable	Target Completion Date
1 Landis	Clarify social sustainability metrics	Develop overview of sustainability tools and list of potential metrics	30 Nov 19
		Generate publication/presentation for conference proceedings	30 Nov 19
2 Landis	Social sustainability	Collect data from annual SBAR meeting	31 Dec 19
		Data analyzed and report drafted	31 Aug 20

Clarify Social Sustainability Metrics:

Data from social sustainability breakout session at SBAR retreat has been reviewed and summarized. Data is currently being used to identify appropriate indicators that can better inform the models that our team is developing.

Social Sustainability:

No new data to report.

**Objective 4. Develop and optimize system-level logistics models for demand-driven harvesting.**

Task #	Description of Task	Deliverable	Target Completion Date
1 Fan	Feedstock logistics data collection (farm fields, road networks, water supply, existing facilities, etc.)	Define data and parameter settings for input	1 Aug 19
		Preliminary model and algorithm developed	1 Aug 19
2 Fan	Integrate and analyze economic benefits and environmental influences within optimization model	Identify parameter settings for optimization model	1 Aug 19
		Complete data input within optimization model	1 Aug 19
		Complete sensitivity analysis for future model and algorithm development	1 Aug 19
3 Fan	Develop hybrid optimization models for operations (flexible biomass harvest scheduling, etc.)	Complete hybrid optimization model for operations	31 Aug 19
		Present research findings at regional/national conferences	31 Aug 19
		Generate publication(s) highlighting research	31 Aug 19
4 Fan	Comprehensive sustainability and economics analysis	Conference presentation	31 Mar 20
		Manuscript submitted to peer review journal	31 Mar 20
5 Fan	Apply integer optimization approaches to design smart farm production plan/scheduling	Manuscript submitted to conference/ journal summarizing research	31 Aug 20
6 Fan	System-level model/algorithm generation for decision support for guar and guayule	Preliminary results shared during project component team meetings	31 Aug 20
		Data/model/algorithm shared for Yr4 research (integration of 3 decision modules)	31 Aug 20

Feedstock Logistics Data Collection:

This task is complete; no new data to report.

Economic Benefits and Environmental Influences:

This task is complete; no new data to report.

Hybrid Optimization Models for Operations:

We have developed the hybrid and system-level optimization model for operations, which is used to obtain facility location and capacity, as well as transportation decisions from field to



processing facilities to customers. (See the manuscript “*GIS-Based Two-Stage Stochastic Facility Location Problem Considering Planting Plan Uncertainty*”, discussed in the annual retreat meetings, and will be presented in AIChE 2019 meeting in Nov 2019).

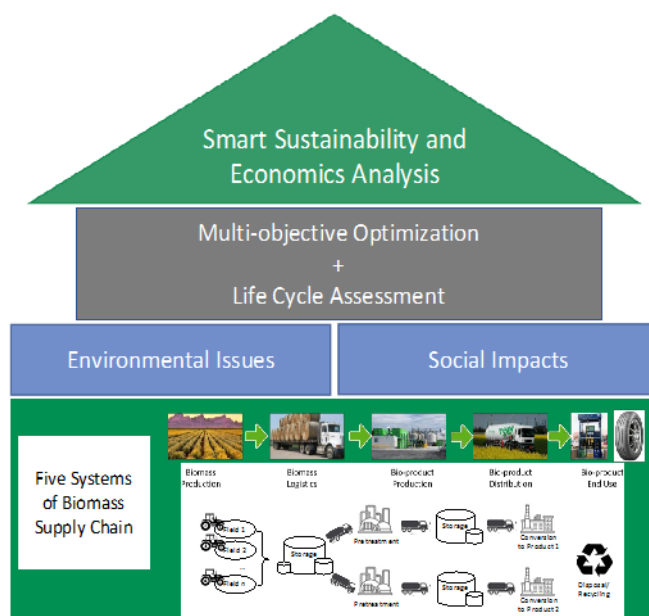
Also, this model will be the major part of Year 3 task for comprehensive sustainability and regional economic analysis (for some preliminary results, see poster “*Two-stage Stochastic Multi-objective Optimization for Biomass Supply Chain Integrating Environmental and Social Impacts*,” September 12, University of Arizona, 2019 SBAR Annual Retreat, poster presented by Daniel Zuniga).

#### Comprehensive Sustainability and Regional Economics Analysis:

In Quarter 3 of 2019, we continued the data collection, and mainly focused on the environmental issues and social impacts. Working with the Sustainability group and the feedback from the 2019 SBAR Annual Retreat we have been working on incorporating native nations and soil information (Figure 22).

#### Integer Optimization Approaches for Smart Farm Production/Scheduling:

A literature review has been performed on other multi-objective biofuel supply chain papers including social and environmental impacts. Based on the review, the Sustainability group and the feedback from the 2019 SBAR Annual Retreat, we have been working to model an integer optimization approach.



**Figure 22.** Integrating sustainability and economics analysis into the Biomass Supply Chain.

#### System-level Model/Algorithm for Decision Support:

Build system-level model and algorithm to integrate three modules is on the way. We have been working on a first draft of based on the framework for biomass supply chain of Guayule based on a stochastic mixed-integer optimization approach.

Additionally, we are collecting the information/data for Guar, and plan to have some preliminary results to apply developed models and algorithms for Guar supply chain.

## EXTENSION & OUTREACH

Project Coordination: Dr. O. John Idowu (New Mexico State University) and Blase Evancho (University of Arizona) continue to serve as the co-leads for the Extension & Outreach working team. When the larger Education and Extension & Outreach components jointly meet, Dr. Idowu and Evancho work with Dr. Chavarria to draft meeting agendas.

The Extension & Outreach team has two main foci – youth development (through 4-H activities and STEM mini-camps), and grower education/outreach. These two sub-groups meet at least once per month to discuss tasks and to improve component integration. The combined Education and Extension & Outreach teams meet once monthly to provide updates and address larger concerns regarding tasks and project implementation in Arizona and New Mexico.

### Issues/Risks:

**Angadi:** Guar demonstration was originally planned for third year. But, during EEO meeting at Las Cruces I added a large scale demonstration (managed with farm scale equipment) and developing time-lapse video development to my commitments for year two. The year was unusual and wet. Delayed planting of crops in the region, kept most of the farmers extremely busy during guar planting season. As a result, we could not plant demonstration this year.

**Idowu:** Farm walk (for guar) will not take place at the grower sites this year due to one of the farmer-managed trial being terminated due to weed pressure. The other grower is not yet willing to host a farm walk because he feels that the time is not yet ripe. He wants to understand the crop management better before hosting a farm walk.

Also, we could not establish any guayule on-farm trials this year due to the lack of seeds.

**Rock:** This year we feel that we were successful in recruitment of new SBAR faculty to serve as *Project Puente* mentors for high school students. However, we still feel that broader participation from SBAR faculty would be helpful in meeting our program objectives to recruit a higher number of interns into the program. Because our budget to include *Project Puente* students in 2020 in New Mexico was denied by the SBAR advisory board, we will spend efforts for 2020 in additional recruitment of SBAR Tucson-based faculty to participate. We will do this by re-enforcing the message as to the importance of mentoring students at a young age as well as the importance of training the next generation of STEM-related scientists and extension professionals. We will aim to attend at least one research team meeting in person in 2020 to be more available to answer questions and concerns of SBAR faculty to host high-school interns in their research programs. Additionally, we will call upon Dr. Neilson and Dr. Lopez to speak about their positive experience in 2019 as participants of the program.

One of the suggestions from the SBAR annual meeting, included the idea of training the SBAR 'project puente' interns in a skill that would be beneficial to the mentors. One of these ideas was the generation of on-line social media content or fact-sheet/publication writing. We will take this idea back to the research and extension teams to evaluate for inclusion in the 2020 year of interns.

**Objective 1. Produce Extension bulletins and web materials to inform growers of agronomic and irrigation requirements.**

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Arrange guar field day/field walks at Agricultural Science Center, Clovis NM	Present guar crop info to ~100 producers in the region	31 Aug 19
		Visit guar farmers' fields to identify future research needs	31 Aug 19
		Visit Guar Resources to identify research needs	31 Aug 19
2 Angadi	Guar photographs and videos	Obtain photographs of guar growth stages	31 Aug 20
		Create videos of guar germination and growth	31 Aug 20
		Provide photos and videos for publication	31 Aug 20
3 Angadi	Guar phosphorus and rhizobium study	Gather/analyze data; develop peer-reviewed paper on guar Phosphorus and rhizobium needs	31 Aug 19
		Train graduate students in guar agronomic management	31 Aug 19
4 Angadi	Guar agronomy research	Gather/analyze data; develop peer-reviewed article on N and P fertilization study	31 Aug 20
		Train graduate students in guar agronomic management	31 Aug 20
5 Angadi	Guar critical stage irrigation study	Produce report on guar crop growth based on irrigation management	31 Aug 20
6 Evan	Produce guayule newsletter articles	At least 2 guayule articles drafted and published – targeting AZ growers	31 Aug 20
7 Evan	Develop outreach documents for guayule	Produce a USDA Plant Guide for guayule in Arizona	31 Aug 20
8 Fields	Design/schedule evaluation tools, protocols, and metrics for all Extension & Outreach activities	Fall tools developed/refined; evaluation data gathered	31 Dec 19
		Spring tools developed/refined; evaluation data gathered	31 May 20
		Summer tools developed/refined; evaluation data gathered	31 Jul 20
		Data synthesized; evaluation report generated	31 Aug 20

9 Grover	Establish guar trial and showcase guar as potential crop in NM	Host field day	31 Aug 20
		Collect data; results synthesized	31 Aug 20
		Generate peer-reviewed Extension publication	31 Aug 20
10 Grover	Guar demonstration	Identify farm willing to host a demonstration field trial	31 Aug 20
		Collect data; results synthesized	31 Aug 20
11 Gutierr	Develop extension programs and reports for guar/quayule demonstrations	Summarize and validate quayule and guar demonstration farms' data	31 Aug 20
		Develop producer summary and presentations for agronomic, climatic, input/output, field emissions, and plant growth data	31 Aug 20
		Generate 3 extension bulletins	1 Feb 20
12 Idowu	Travel to conferences	Present SBAR info/materials at 4-5 grower commodity conferences	31 Aug 20
13 Idowu	Establish quayule and guar trials in Las Cruces, Los Lunas, Clovis, and Tucumcari, NM	Showcase trial experiments at field days	31 Aug 20
		Gather data/synthesize results (toward generating an Extension bulletin)	31 Aug 20
		Generate first year trial summary (published on SBAR website)	31 Aug 20
14 Idowu	Establish on-farm demonstration trials	Identify locations for 3 on-farm guar trials	31 Aug 20
		Plant guar on-farm trials	31 Aug 20
		Identify locations for 2 on-farm quayule trials	31 Aug 20
		Plant quayule on-farm trials	31 Aug 20
		Collect and summarize planting data for on-farm trials	31 Aug 20
		Schedule/Host on-farm walking tour for guar and quayule on-farm demonstration sites	31 Aug 20
15 Idowu	Host guar-focused conference for producers and ag professionals	Present research results and information on guar	31 Mar 20
			31 Mar 20

		Showcase on-farm and on-station trials	
16 Idowu	Newsletters to inform stakeholders	Produce 3 newsletters to highlight SBAR project	31 Aug 20
		Distribute fall newsletter	31 Dec 19
		Distribute spring newsletter	30 Apr 20
		Distribute summer newsletter	31 Aug 20
17 Idowu	Design/schedule/implement E&O evaluation	Fall evaluation data gathered	31 Dec 19
		Spring evaluation data gathered	31 May 20
		Summer eval data gathered	31 Jul 20
		Eval info synthesized; report generated	31 Aug 20
18 Rock	Deploy stakeholder needs assessment survey in AZ	Survey results collected from grower stakeholders in AZ	31 Dec 18
19 Rock	Survey results from Arizona	Summarize survey results; generate Extension publication	31 Mar 19
		Generate peer-reviewed manuscript using AZ survey results	31 May 19
20 Teeg	Generate updated cost-production budgets for current cropping systems (guayule and guar)	Develop 5 enterprise budgets showcasing different scenarios	30 Jun 19
		Generate summary; publish results (SBAR website)	30 Jun 19
21 Teeg	Co-develop informational tools for driving profitability/feasibility of crop adoption in AZ & NM	Extension bulletins submitted for review	31 Aug 20
		Enterprise budget and BENCO Model available online	31 Aug 20
22 Teeg	Participate in Extension meetings; disseminate economic info for guar and guayule	Provide 2 presentations to growers in NM	31 Aug 19
		Provide 2 presentations to growers in AZ	31 Aug 19

#### Field Days and Site Visits:

The Angadi team presented guar research to area farmers, researchers, extension personnel and public during annual field day of Agricultural Science Center at Clovis on August 8, 2019. Visited guar fields near Vernon, TX and had discussion with one farmer about guar research needs and things needed to develop local supply of guar for oil and natural gas and other industries.

Frequent rainfall in the region affected planting different crops and farmers struggled to plant most of their crops. Angadi arranged for a large demonstration of guar on a farmer's field. Guar Resources provided the seeds needed for the demonstration. However, the farmer backed out

of it due to other field activities in the last minute. Need to find new collaborator for upcoming season.

Our effort to develop time-lapse videos of guar emergence has made significant progress. We are still working on addressing some of the issues. Once we address those, we will have time-lapse videos showing some of our objectives on guar crop (e.g. temperature on germination).

Guar Phosphorus Rhizobium Study:

Dr. Idowu led trial on N and P effect on guar productivity is ready for harvest. The trial will be harvested in November 2019.

Guar Deficit Irrigation Study:

Nothing new to report.

Produce Guayule Newsletter Articles:

One newsletter article was written for the April 2019 issue of the Pinal County Cooperative Extension Quarterly Newsletter. (Appendix 3)

Design and Implement Evaluation Tools:

**Grower-Focused Extension** – Evaluation for the grower-focused extension group centered largely around documenting their outreach, communications, and relationship building with stakeholders, primarily potential growers. We discussed the challenges of documenting reach, particularly when much of the work is incremental, sometimes based on individual conversations rather than large scale events. While the group was able to better capture the large events, we brainstormed ways to better capture the collective impact of their reach through the use of a map. Additional information is available in the Evaluation Report (Appendix 4).

**4-H Youth Development** – Evaluation for the 4-H group was covered in the Q2 report, but is described in more detail in the Yr 2 evaluation report. (Appendix 4)

Showcase Guar as Potential Crop in New Mexico:

Dr. Grover's group visited grower fields, presented information related to guar, and planted guar for production and demonstration in Anthony, New Mexico. Data continues to be collected and compiled from on-station guar demonstrations.

Develop Producer-Level Partial Budget Analysis for Guayule and Guar:

Nothing new to report.

Travel to Conferences:

Nothing new to report.

Establish Guayule and Guar Trials in New Mexico:

Four on-station guar trials were established at the Leyendecker Plant Science Center, Los Lunas Ag. Science Center, Clovis Ag. Science Center and Tucumcari Ag. Science Center in New Mexico.

Graduate student/technician (Darien Pruitt) and two undergraduate students (Julia Miller and Adah Gellis) continue to provide support for field data collection and assisting with different events where SBAR information is presented.

Establish On-Farm Demonstration Trials:

Two on-farm trials were initiated with two farmers in the Dona Ana County of New Mexico, testing guar growth and yield under farmer-managed conditions. However, one trial had to be terminated due to weed pressure. All of the trials are still in the field and will be harvested this fall.

Host Guar-Focused Conference for Producers and Ag Professionals:

Activities progress as planned; nothing new to report.

Newsletter to Inform Stakeholders:

Nothing new to report.

Design and Implement Extension & Outreach Evaluation:

Nothing new to report.

Stakeholder Needs Assessment in Arizona:

This task is complete.

Cost-Production Budgets for Current Cropping Systems:

Enterprise budgets are complete for Guar and Guayule; budgets are formatted for publication when the team feels confident in the cost and return data.

Dissemination of Guayule and Guar Economic Information through Extension Meetings:

The results from Sustainability models generated provides Extension faculty an interactive tool that calculates the break-even yield and price and whole farm net returns based on acres of Guayule and Guar as growers determine if or how much of each crop to incorporate into their current cropping system.

Input Tool for Potential Adoption Rates in Arizona and New Mexico:

Continue to refine the AZ and NM whole farm scenarios, which will serve as the baseline for whole farm analysis and presentations during the extension/outreach activities. We are working with the Extension team to start setting dates for inclusion in extension workshops using the whole farm and budgeting tools.

***Objective 2. Hold workshops throughout the region on sustainable practices to expand crop production to new rural regions and Native Nation lands.***

Task #	Description of Task	Deliverable	Target Completion Date
1 Angadi	Arrange guar field day/field walk at Agricultural Science Centers, NM	Present guar crop information to ~100 producers in the region	31 Aug 20



2 Angadi	Educate local growers	Establish guar demonstration on a local farmer's field	15 Jul 20
1 Evan	Hold workshops and present information to growers in Arizona	Host two presentations on guayule agronomic production and irrigation at regional extension events	31 Aug 20
		Present guayule production to Native American farming communities	31 Aug 20
		Collect needs assessment information directly from Native American farming communities	31 Aug 20
2 Grover	Hold workshops and present information to growers	Host 2 presentations on guar agronomic production as an interim step to bulletin	31 Aug 20
		Present SBAR project information and materials	31 Aug 20

#### Grower Workshops in Arizona:

Continual contact is being made with growers and agricultural professionals in Arizona during farm visits and casual interactions. During the 3rd quarter we documented SBAR related interactions with at least 30 individuals in Arizona with 12% being of Mexican heritage and 6% of Native American heritage.

#### Present Guayule Information to Native Nation Communities

Contact has been made with 2 Native American farming communities to discuss the potential of guayule production on their land. Both are interested and discussions have commenced about the requirements required for guayule production. Trent Teegerstrom, U of A Native American Liaison, and David Dierig Bridgestone, were also involved with these conversations and we are working towards installing acreage with one community as early as 2019. Meetings with Native American communities will continue throughout the year.

#### Needs Assessment Information from Native Nation Communities

We modified the SBAR needs assessment and removed or edited questions that were not appropriate for Native Nation Communities. Surveys were emailed to several Native American communities and we will evaluate responses in the coming months.

Grower Workshops in New Mexico:  
Although not specifically for growers, Grover's team presented a talk on guar at the SBAR Train the Trainer Workshop in support of the Education Professional Development Training hosted in Las Cruces, New Mexico, in July 2019.



**Photo 6.** Dr. Kulbhushan Grover presenting to a group of SBAR Fellows in Las Cruces, New Mexico. July 2019.

**Objective 3. Involve youth in internships, 4-H projects, and STEM summer camps.**

Task #	Description of Task	Deliverable	Target Completion Date
1 Gutierr	Develop/improve SBAR 4-H Camp curriculum	Adapt camp curriculum for use in NM (train-the-trainer and 4-H camps)	31 May 19
2 Gutierr	SBAR 4-H Day camps and/or mini-camps	Plan/Host 6 SBAR 4-H Day camps and/or mini-camps targeting Hispanic and Native youth in Southern and Northern NM	31 Aug 19
3 Gutierr	School enrichment and 4H Camp/FFA activities	Plan/Host 6 SBAR Day camps targeting Hispanic and Native youth	31 Aug 20
		Plan/Host 15 SBAR school enrichment events	31 Aug 20
		Host a train-the-trainer camp for 4H Agents and teachers	31 Aug 20
		FFA Science Fair: Promote SBAR curriculum use	30 Jun 20
4 Lopez	Order equipment/supplies for biofuel activities	4-H Biofuel outreach activities prepped/ready for implementation	30 Apr 19
		Summer camp curriculum finalized	30 Apr 19
5 Lopez	Provide 4-H biofuel activities to 4-H youth	Hold 2 biofuel activities (at least one reaching rural 4-H youth)	31 Jul 19
6 Lopez	Expand 4-H biofuel camp	Host a biofuel-focused 4-H summer camp	31 Jul 19
			31 Jul 19

		Increase participation to 20 students	
7 Lopez	Refine evaluation instrument for the BYOE program	Revised and updated evaluation instrument available for SBAR biofuel activities	31 Jul 19
		Revised and updated evaluation instrument available for SBAR biofuel summer camp	31 Jul 19
8 Rock	Develop SBAR internal factsheets on <i>Project Puente</i>	Generate <i>Project Puente</i> resource document(s) for SBAR faculty	28 Feb 20
9 Rock	Recruit students for summer <i>Project Puente</i> internships	Update application materials to highlight on-going SBAR research opportunities	1 May 19
		Recruit 6 students for Yr3 cohort of <i>Project Puente</i> interns	1 May 19
10 Rock	Recruit faculty mentors for summer <i>Project Puente</i> internships	Recruit 5 faculty mentors for Yr3 cohort of <i>Project Puente</i> interns	1 May 19
11 Rock	<i>Project Puente</i> student project development and deployment	Work with SBAR faculty to identify appropriate internship projects (research and extension)	26 Jul 20
		Facilitate SBAR internship projects; final poster presentations highlighting student work	31 Aug 20
12 Rock	<i>Project Puente</i> case study video	Design and develop short video highlighting student/mentor experiences for future training needs	31 Aug 20

#### SBAR 4-H Camp Curriculum:

Curriculum for use in NM train-the-trainer and 4H was developed and used in the train the trainer and in the SBAR 4H Day camps and/or mini-camps. SBAR FFA curriculum is currently under development for use by High School FFA instructors.

#### SBAR 4-H Day Camps or Mini-Camps:

A total of three 4-H Camp activities were developed and tested by 38 Native American high school students from the NMSU DreamKeepers Summer program, 180 junior age 4-H students, 23 Senior 4-H'ers, and 8 Hispanic sophomore students from the NMSU-CAMP/Medicinal Plants Internship.

New contacts were established with Carmella Quam and Kamala Devi Sharma, program coordinator of the leadership Institute Santa Fe Indian School and Professor of Chemistry Division Chair Mathematics, Physical and Natural Sciences, University of New Mexico-Gallup.

Gutierrez's team also presented a tag-team oral presentation entitled "Implementing the science of SBAR with youth" to the SBAR UA Research Team in September.

Efforts are underway to begin developing curriculum for FFA and f4H, and Gutierrez's team met with Mr. Jerrod Smith (FFA Director, New Mexico) in October.

Biofuel Activities Supplies:

Nothing new to report.

4-H Biofuel Activities to Youth:

Nothing new to report.

Expand 4-H Biofuel Camp:

Nothing new to report.

Refine Evaluation Instrument for the BYOE Program:

Nothing new to report.

Internal Factsheets on *Project Puente* Internships:

No new activity to report this quarter.

*Project Puente* Internship Recruitment:

During this reporting period the Arizona Extension team worked alongside Central Arizona College to recruitment of *Project Puente* student interns to participate in in the SBAR internship program for Summer 2019. Outreach materials and flyers were developed as resources for students interested in the program as well as SBAR faculty interested in mentoring students.

*Project Puente* Student Project Development and Deployment:

Student interns were located at the Maricopa Agricultural Center as well as on campus at the University of Arizona in Tucson. Student interns participated in both research and Extension projects related to the focal areas of SBAR and were able to interact with SBAR industry members, faculty, staff and students as part of their project(s). Each student worked on projects for a total of 6 weeks under the director of a SBAR faculty mentor and is scheduled to share their findings at a culmination event in July 25<sup>th</sup> of 2019 at the Maricopa Agricultural Center with the faculty mentors, teachers, and families. The Extension team was able to recruit a total of 4 interns for the 2019 program. While we did not meet the target of 6 interns, we were able to recruit two additional SBAR faculty to participate in the mentoring program this year, Dr. G. Lopez and Dr. J. Neilson.

One of the tactics that we used this year that was different from last year, to better facilitate meaningful student intern experiences, was to partner with 4H STEM specialist Dr. Lopez. Dr. Lopez worked to recruit at local High school students in Tucson for the extension team. Additionally, in-order to aid in information transfer to student interns across the State, we arranged for Zoom classroom sessions that linked Maricopa and Phoenix-based students with those in Tucson. We feel that this is a successful model for future engagement of students in year 2020 of the grant.

## EDUCATION

**Project Coordination:** Dr. Sara Chavarria (University of Arizona) serves as the lead for the Education Team, which meets at least twice monthly to cover broader topics related to specific Education objectives and tasks. Smaller working groups meet weekly for specific action items (such as planning and coordinating the weekly SBAR Fellow Seminar). The Education Team also meets monthly with the Extension & Outreach Team to ensure that selected curriculum and activities is integrated for associated workshops and camps.

### Issues/Risks:

**Brewer:** The relationship between the SBAR fellows' and teachers' activities, and the 4-H activities, is still not clear. There is potential to use the activities from the afterschool program and the train-the-trainers curriculum for 4-H if the leadership structure, communication, and schedule with the 4-H agents and volunteers can be worked out.

One of the NM SBAR teachers, Grijalva, switched from classroom teaching in middle school to serving as the assistant principle at an elementary school right before the beginning of the school year. Her new role includes assisting the 4<sup>th</sup> and 5<sup>th</sup> grade science teachers with curriculum development and implementation. Her paired fellow, Usrey, has been assisting in the elementary science classrooms and participating in the afterschool program/field trips at Lynn Middle School. Grijalva's new role and schedule leave her little time to mentor Usrey. Discussions are still underway as to what Usrey's goals in the elementary classrooms should be this year, and how his time might be managed to include preparation of website materials and/or continued work with the afterschool program to complete the rest of his weekly hours.

### ***Objective 1. Train teams of students and teachers with focus on rural and under-represented groups.***

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Supervise/Assist NM SBAR Fellows and Teacher Mentors through 2018-2019 school year	Design/deliver after school program for middle school	31 May 20
		Design/vet STEM activities	31 May 20
2 Brewer	Recruit and train SBAR Fellows and Teachers for 2019-2020 school year	Identify 4 new NM SBAR Fellows and any replacements, as necessary	31 Jul 20
		Identify 4 new NM SBAR Middle school teachers	31 Jul 20
3 Chav	Plan/Design/Coordinate Fall 2018 and Spring 2019 SBAR Fellow seminar	Plan Fall 2018 seminar content	31 Aug 18
		Plan Spring 2019 seminar content	31 Dec 18
		Generate education products on SBAR Fellow activities (digital publications)	31 Jul 19

4 Chav	Plan/Design/Coordinate Fall 2019 and Spring 2020 SBAR Fellow seminar	Plan Fall 2019 seminar content	31 Aug 19
		Plan Spring 2020 seminar content	31 Dec 19
		Generate education products on SBAR Fellow activities (digital publications)	31 Jul 20
5 Chav	Visit classrooms for observations (delivery of SBAR content)	Implement Fall teacher observation	30 Nov 19
		Implement Fall SBAR Fellow observation	30 Nov 19
		Implement Spring teacher observation	30 Apr 20
		Implement Spring SBAR Fellow observation	30 Apr 20
6 Chav	Recruit for summer Teacher Professional Development	Plan/develop itinerary for summer PD session	31 Jan 20
		Recruit 10+ teachers	30 Apr 20
7 Fields	Design/Schedule classroom evaluation tools, protocols and metrics for all Education activities	Fall tools developed/refined; evaluation data gathered	31 Dec 19
		Spring tools developed/refined; evaluation data gathered	31 May 20
		Summer tools developed/refined; evaluation data gathered	31 Jul 20
		Data synthesized; evaluation report generated	31 Aug 20

#### New Mexico SBAR Fellows and Teacher Mentors (2018-2019):

Brewer worked with the UA education team to refine the plans for summer 2020 training/PD and SBAR implementation in Years 4 and 5 through the Zoom meetings and at the Annual Retreat. Among the changes was to focus on online delivery of materials: the summer teacher PD, a MOOC on Arid Lands that could be used as PD for teachers in communities where guar and guayule growth was likely to take place, complete lesson plans in a standardized format and posted to the SBAR website, videos of researcher interviews and field/lab tours, and a boot camp set of online pre-training materials and pre-assessments, followed by week of in-person training, to accelerate the development of interns assisting with SBAR research projects (which could also be part of train-the-trainers for teachers and 4-H leaders). The revised goals also included shifting from a PhD education student at NMSU focused on translation of middle school SBAR materials to elementary school, to more staff time at UA to prepare and implement the online components.



### Recruit and Train SBAR Fellows and Teachers (2019-2020):

In August, fellows began their work in the classroom with their teachers, including incorporation of SBAR-related lessons. Guardians of the Biosphere afterschool program began its 2<sup>nd</sup> year at Lynn Middle School with a goal of 10-15 participants, with Rosalez and Usrey leading demonstrations and refining materials. Every two weeks, the fellows meet with Brewer to review progress, work on their lesson plans, and to discuss readings/presentations from the UA fellows' seminar (since the seminar is currently scheduled at the same time as the after school program).

### SBAR Fellow Seminar (Fall 2018 / Spring 2019):

**Fellow Seminar** – Nothing new to report.

### **Summer Teacher Professional Development (PD)**

– The summer PD program took place July 1-3, 2019 and July 8-12, 2019. The NM Train the Trainer program took place July 1-3, 2019 and the Professional Development Workshop at University of Arizona took place July 8-12, 2019. The summer PD allowed for the teachers and fellows to work collaboratively, plan for the year and develop a draft lesson plan. The outcome of the summer workshop was good but discussion at the SBAR retreat education meeting covered how these two weeks (Train the Trainer in NM and the PD workshop at UA) need to be more directly related to each other. The NM workshop was more focused on advanced scientific concepts and the AZ PD was more focused on collaborative co-design. In the SBAR retreat discussion with the education team we began planning for the summer 2020 Teacher PD we explored the idea of doing more of a digital PD to reach out to rural areas and to cut down on the costs of transporting and housing teachers.

### SBAR Fellow Seminar (Fall 2019 / Spring 2020):

The Fall Seminar began Aug 28<sup>th</sup> and meets weekly on Wednesdays from 2-3 pm. Topics covered so far include: Case Study Method of Learning, Lesson Planning Review, 5 E Model, Inclusive Science Learning and Culturally Relevant Pedagogy. The Seminar began with the 5 NM SBAR Fellows attending via Zoom, but with scheduling conflicts in NM and the challenges of doing group work/partnering up on Zoom, the NM Fellows are no longer attending. At the



**Photo 7.** Participants at the SBAR Summer Teacher Professional Development session hosted in Las Cruces, New Mexico.



**Photo 8.** SBAR Fellows practicing and perfecting SBAR classroom activities during the Summer Professional Development session, New Mexico State University, Las Cruces, New Mexico.



SBAR Retreat Education meeting we worked out with Brewer that she will hold her own SBAR Seminar for fellows every two weeks. We are meeting with Brewer bi-monthly to share what we've done in the UA Seminar so she can use the same PPT, reading assignments and approach with her NM fellows.

Classroom Observations (Delivery of SBAR Content):

Nothing new to report.

Teacher Recruitment for Summer Professional Development:

Nothing new to report.

Design and Implement Classroom Evaluation Tools:

Evaluation activities for the Education team during the Q3 centered primarily around the summer PD experience. The experience took place in two parts – the first in Las Cruces, NM was led by Catie Brewer from July 1-3; the second took place in Tucson, AZ, led primarily by Corey Knox and Torran Anderson. Evaluation tools were implemented during both components, and I was present as an observer at both sessions. **6 returning teachers, 4 new teachers** participated in the 2-week training and will continue with the project in Year 3.

Five returning fellows and 7 new fellows participated in the 2-week training and will continue with the project in Year 3. A needed shift in approach toward curriculum development was made so that SBAR concepts and content can more easily be incorporated into existing school curriculum structures. It would be difficult, if not impossible, to create a stand-alone 'SBAR Curriculum' that teachers would be able to implement IN ADDITION to the required curriculum. Therefore, the team (staff, teachers, fellows) has shifted their approach to contextualizing SBAR themes such as arid lands, sustainability under climate change, bioeconomies, systems thinking, and other themes where SBAR can be used as a case study within existing courses. All teachers and fellows (new and returning) will work collaboratively throughout Year 3 to continue to develop, implement and test lessons that are aligned with middle school courses such as life science, physical science, earth science, and other subject area standards. They will use SBAR concepts (to build a repository of SBAR related curriculum, modules, activities and other resources that will ultimately contribute towards the 5-year outcome of a replicable school-based curriculum.

I was also able to participate in the pre-retreat meeting for Education where I shared an overview of the evaluation findings with the full team, met individually with the Education and the Extension teams to discuss more details as well as provide suggestions for programmatic and/or data collection methods moving forward into year 3. I also was able to fully participate in the annual retreat, sharing input especially during the breakout sessions. Additional details are available in the Year 2 Evaluation Report (Appendix 4).

**Objective 2. Develop and disseminate agricultural bioenergy and bioproduct K-12 modules.**

Task #	Description of Task	Deliverable	Target Completion Date
1 Brewer	Develop/Offer train-the-trainer biofuels education program for 4-H agents/volunteers and teachers/fellows	Develop/Host 3-day summer train-the-trainer program at NMSU	31 Jul 20
		Recruit 4-H youth and GK-12 participants	31 Jul 20
2 Chav	Edit Cohort 1 lessons and materials for online publication	Edit lessons	31 Oct 19
		Submit final lessons/activities for SBAR website and online publication	31 Dec 19
3 Chav	Support lesson plan design by teacher-Fellow partnerships	Fall lesson plans from each Fellow developed	30 Nov 19
		Spring lesson plans from each Fellow developed	30 Apr 20
		Advice and support NM teach as requested/needed	31 May 20
		Draft lesson plans from Cohort 2 teachers	31 Jul 20
		Cohort 2 summer support on lesson redesign for publication	31 Jul 20

Design and Implement Train-the-Trainer Education Program for 4-H Youth Development:

The 10 current SBAR fellows and 9 SBAR teachers, in addition to other SBAR staff and researchers, participated in three-day Train-the-Trainers workshop at NMSU over July 1-3. Workshop included a curriculum organized around 25 Take Home Messages, lectures and activities on chemistry, plant and soil sciences, engineering, and economics concepts related to SBAR; lab exercise on separations, and field tours of guar and guayule plots. The 4 NM SBAR fellow-teacher pairs participated in the Teacher PD the following week at UA, each producing a draft lesson plan, arranging a schedule for the school year, and brainstorming ideas for the Arid Lands focus.

Cohort #1 Lessons and Materials:

The review of SBAR lessons and materials is underway. A template is being revised with the help of a UA student worker from IES. The lesson review process has highlighted how in-depth and time consuming the revision process is. Corey Knox created a checklist for reviewing of lessons which addresses identifying the creator of the lesson (whether adapted or new), the accuracy of the science, the connections to the science standards and then to SBAR, clarity of the instructions, and the completeness of the PowerPoints, readings/resources, student

worksheets, activities, materials, teacher keys, etc. Additional support from student workers in the layout and design of the lesson will be helpful.

Support Lesson Plan Design by Teacher-Fellow Partnerships:  
Nothing new to report.

***Objective 3. Develop a biofuel certificate program at the university level.***

Task #	Description of Task	Deliverable	Target Completion Date
1 Molnar	Develop MS and/or PhD education opportunities within the University of Arizona around the theme of “Sustainable Bioeconomy”	At least 2 tracks (study concentration areas) within UA GIDPs	31 Dec 19

Development of Education Opportunities:  
This task is complete; nothing new to report.

## AWARDS

### 2019

*SBAR Interdisciplinary Face-Off – Ninja Visionary Award for Best Overall Concept.* **Brown, K.; Dehghanizadeh, M.; Lohr, P.; Singh, P.; Soto, A.; Zuniga-Vasquez, D.**  
SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

*SBAR Interdisciplinary Face-Off – Silver Lightning Award for Best Overall Design.* **Bayat, H.; Hoare, D.; Moreno, L.; Singh, J.; Steichen, S.; Summers, H.; Wright, A.**  
SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

*SBAR Interdisciplinary Face-Off – Smooth Moves Award for Most Creative Concept.* **Bayat, H.; Hoare, D.; Moreno, L.; Singh, J.; Steichen, S.; Summers, H.; Wright, A.**  
SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

*SBAR Interdisciplinary Face-Off – Energy Zone Award for Overall Audience Favorite.*  
**Katterman, M.; Ossanna, L.; Pruitt, D.; Soliz, N.; Sproul, E.**  
SBAR Annual Retreat, University of Arizona, Tucson, Arizona.

## PRODUCTS GENERATED.

### September 2017 – June 2019

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#### PUBLICATIONS, CONFERENCE PAPERS AND PRESENTATIONS

##### Publications

1. **Abdell-Haleem H.; Luo Z.; Ray, D. 2019.** Chapter 6. Genetic Improvement of Guayule (*Parthenium argentatum* A. Gray): An Alternative Rubber Crop. In: J. Al-Khayri (ed.). Advances in Plant Breeding Strategies: Industrial and Food Crops. Springer Nature Switzerland AG (Invited Book Chapter). p.151-178.
2. **Cheng, F.; Jarvis, J.M.; Yu, J.; Jena, U.; Nirmalakhandan, N.; Schaub, T.M.; Brewer, C.E. 2019.** Bio-crude oil from hydrothermal liquefaction of wastewater microalgae in a pilot-scale continuous flow reactor, *Bioresource Technology*, 294, 122184, accepted, in press.
3. **Cheng, F.; Le-Doux, T.; Treftz, B.; Miller, J.; Woolf, S.; Yu, J.; Jena, U.; Brewer, C.E. ND.** Modification of a pilot-scale continuous flow reactor for hydrothermal liquefaction of wet biomass. *MethodsX*, under review.
4. **Cheng, F.; Bayat, H.; Jena, U.; Brewer, C.E. ND.** Impact of feedstock composition on pyrolysis of low-cost, protein-rich lignocellulosic biomass: a review. *Journal of Analytical & Applied Pyrolysis*, in revision.
5. **Cheng, F.; Dehghanizadeh, M.; Audu, M.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. ND.** Characterization and evaluation of guayule bagasse and processing residues as potential feedstock for biofuel and chemical production. *Industrial Crop & Products*, in prep.
6. **Dehghanizadeh, M.; Cheng, F.; Jarvis, J.M.; Holguin, F.O. Brewer, C.E. ND.** Characterization of resin extracted from guayule (*Parthenium argentatum*): a dataset including GC-MS and FT-ICR MS. *Data in Brief*, in prep.
7. **Nelson, A.D. L.; Ponciano, G.; McMahan, C.; Ilut, D.C.; Pugh N.A.; Elshikha, D.E.; Hunsaker, D.J.; Pauli, D. 2019.** Transcriptomic and evolutionary analysis of the mechanisms by which *P. argentatum*, a rubber producing perennial, responds to drought. *BMC Plant Biology*. 19:494.  
<https://bmcpplantbiol.biomedcentral.com/articles/10.1186/s12870-019-2106-2>
8. **Sun, O.; Fan, N. 2019.** A Review on Optimization Methods for Biomass Supply Chain: Models and Algorithms, Sustainable Issues, Challenges and Opportunities. *Process Integration and Optimization for Sustainability*, (Submitted, In review).

##### Conference Papers

1. **Audu, M.; Dehghanizadeh, M.; Cheng, F.; Bayat\*, H.; Holguin, O.; Jena, U.; Brewer, C.E. 2019.** Co-Products and Biofuels from Guar and Guayule Processing Residues, 2019 ASABE Annual International Meeting. Boston, Massachusetts. 8 July. Paper #1900361.
2. **Cruz, V.M.V.; Lynch, A.; Wang, G.S.; Dittmar, S.; Sullivan, T.; Prock, R.; Niaura, W.; Dierig, D.A. 2019.** Guayule germplasm characterization for variation in ploidy and biomass production. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 36.

3. **Dehghanizadeh, M.\*; Cheng, F.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2019.** *High Resolution Mass Spectrometry for Characterization of Resin from Guayule (Parthenium argentatum)*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 39.
4. **Dierig, D.A.; Wang, G.S.; El-Shikha, D.E.M.; Sullivan, T.; Dittmar, S.; Cruz, V.M.V. 2019.** *Guayule growth and yield over time at two locations at high and low irrigation treatments*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 31.
5. **Dong, C.; Ponciano, G.; Wang, Y.; Huo, N.; Hunsaker, D.; El-Shikha, D.E.M.; Gu, Y.Q.; McMahan, C. 2019.** *Gene expression of guayule field plants under drought stress: A comparative RNA-Seq study*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 35.
6. **El-Shikha, D.E.M.\*; Waller, P.M.; Hunsaker, D.J.; Dierig, D.A.; Wang, G.S.; Cruz, V.M.V.; Thorp, K.R.; Bronson, K.F.; Katterman, M.E. 2019.** *Growth and yield of direct-seeded guayule under SDI and furrow irrigation*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 30.
7. **Khanal, S.; Robbs, J.; Acharya, R.; Gutierrez, P. 2019.** *Import demand and potential for domestic production of guar*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 43.
8. **Maqsood, H.; Waller, P.; El-Shikha, D.E.M.; Hunsaker, D.; Katterman, M.E.; Dierig, D.A.; Wang, G.S.; Ogden, K. 2019.** *Assessment of irrigation requirement for guayule using WINDS model*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 32.
9. **Maqsood, H.; Angadi, S.; El-Shikha, D.E.M.; Waller, P.; Singh, J.; Hunsaker, D.; Barau, B. 2019.** *Evaluating crop water status for guar using WINDS model*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 42.
10. **McCloskey, W.; Wang, G.S. 2019.** *Guayule (Parthenium argentatum A. Gray) seedling tolerance to topically applied carfentrazine-ethyl herbicide*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 34.
11. **Placido, D.F.; Dong, N.; Pham, T.; Huynh, T.; Amer, B.; Baidoo, E.; McMahan, C. 2019.** *Down-regulation of squalene synthase in guayule (Parthenium argentatum)*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 37.
12. **Seavert, C.; Teegerstrom, T.\*; Gutierrez, P.; Khanal, S. 2019.** *Whole farm analysis tool for evaluating the adoption of guayule and guar into southwest producers' current operation*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona.

8-11 September. p. 40. Best Oral Presentation Award for the Rubber and Resin Division.

13. **Wang, G.S.; Dierig, D.A.; Ray, D.T. 2019.** *Guayule response to plant population*. In: 31<sup>st</sup> Annual Meeting Program and Abstracts of the Association for the Advancement of Industrial Crops. Cruz, V.M.V. and Berti, M. (eds.). Tucson, Arizona. 8-11 September. p. 38.

#### Scholarly Presentations

1. **Angadi, S.V. 2018.** *Sustainable Bio-economy for Arid Regions: Growing Guar*. Extension Field Day. Clovis, New Mexico. 9 August.
2. **Angadi, S.V.\*; Begna, S.H.; Singh, S.; Katuwal, K.; Singh, J.; Gowda, P.; Ghimire R. 2018.** *Multiple Approaches to Sustain Ogallala Aquifer in the Southern Great Plains of the United States of America*. Agrosym 2018. Jahorina, Bosnia. 4-7 December.
3. **Angadi, S.V.\*; Begna, S.H.; Singh, S.; Katuwal, K.; Singh, P.; Singh, J.; Umesh, M.R. 2019.** *Crop Diversification and Critical Stage-Based Irrigation to Sustain Ogallala Aquifer*. UCOWR/NIWR Annual Water Resources Conference, Snowbird, Utah. 11-13 June.
4. **Angadi, S.V.\*; Begna, S.H.; Umesh, M.R. 2018.** *Crop diversification for sustainable soil and water resources use in semi-arid regions of USA*. XXI Biennial National Symposium of Indian Society of Agronomy, Udaipur, India. 24-26 October.
5. **Angadi, S.V.\*; Singh, J.; Begna, S.H. 2019.** *Crop growth stage based deficit irrigation management in guar crop*. Annual Report, Agricultural Science Center at Clovis, New Mexico. 20 February.
6. **Audu, M.\*; Dehghanizadeh, M.; Cheng F.; Bayat H.; Holguin, O.; Jena U.; Brewer, C.E. 2019.** *Co-Products and Biofuels from Guar and Guayule Processing Residues*. ASABE Annual International Meeting, Boston, Massachusetts, 7-10 July.
7. **Bayat, H.\*; Cheng, F.; Jena, U.; Brewer, C.E. 2019.** *Introduction to low-cost protein-rich lignocellulosic biomass for advanced biofuels*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
8. **Brewer, C.E. 2018.** *Pairing biomass residues with conversion technologies*. Advanced Bioeconomy Leadership Conference, Washington, D.C. 28 February.
9. **Brewer, C.E. 2018.** *Polymerization and guar gum bubbles*. Outreach event activity. New Mexico 4-H State Conference. 11 July.
10. **Brewer, C.E. 2018.** *Identifying Co-Products from Guar and Guayule Processing Residues*. 2018 American Institute of Chemical Engineers Annual Meeting. Pittsburgh, Pennsylvania. 30 October.
11. **Brown, K.S.\*; Neilson, J.W.; Waller, P.M.; Ray D.T.; Dierig, D.; Maier, R.M. 2018.** *Microbial contributions to soil health: Optimizing guayule (*Parthenium argentatum*) production in an arid environment*. SWESx Earthday Symposium. Tucson, Arizona. 15 April. [poster]
12. **Brown, K.S.\*; Neilson, J.W. 2018.** *Microbial contributions*. SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. April.
13. **Brown, K.S.\*; Neilson, J.W.; Waller, P.M.; Ray D.T.; Dierig, D.; El-Shikha, D.; Maier, R.M. 2019.** *Microbial contributions to soil health: Optimizing guayule (*Parthenium argentatum*) production in an arid environment*. SWESx Earthday Symposium. Tucson, Arizona. 27 March. [poster]



14. **Brown, K.S.\*; Neilson, J.W.; Waller, P.M.; Ray, D.T.; Wang, S.; Dierig, D.; El-Shikha, D.E.M.; Maier, R.M. 2019.** *Soil health and guayule microbial community metrics*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
15. **Cheng, F.\*; Audu, M.; Dehghanizadeh, M.; Treftz, B.; Le-Doux, T.; Jena, U.; Brewer, C.E. 2018.** *Characterization and Conversion of Guar and Guayule Bagasse as Potential Resources for Biofuels Production*. Symposium on Thermal and Catalytic Sciences for Biofuels and Biobased Products. Auburn, Alabama. 9 October.
16. **Cheng, F.; Le-Doux, T.; Jena, U.; Brewer, C.E.\* 2018.** *Characterization and Conversion of Guar Bagasse*. Symposium on Thermal and Catalytic Sciences for Biofuels and Biobased Products. Auburn, Alabama. 9 October.
17. **Cheng, F. 2018.** *Hydrothermal Liquefaction of Microalgae in Batch and Continuous Flow Reactors*. PhD Dissertation Defense. New Mexico State University, Las Cruces, New Mexico. 24 October.
18. **Cheng, F.\*; Rosalez, R.; Dehghanizadeh, M.; Brewer, C.E. 2019.** *Co-Hydrothermal Liquefaction of Guayule Bagasse and Wastewater Treatment Microalgae*. AIChE Annual Meeting, Orlando, Florida. 10-15 November.
19. **Cheng, F.\*; Le-Doux, T.; Treftz, B.; Woolf, S.; Guillen, S.; Usrey, J.; Martinez Bejarano, C.; Bayat, H.; Jena, U.; Brewer, C.E. 2018.** *Characterization of Flow and Heat Transfer Parameters in a Continuous Flow Hydrothermal Liquefaction Reactor*. 2018 American Institute of Chemical Engineers Annual Meeting, Pittsburgh, Pennsylvania. 1 November.
20. **Cheng, F.\*; Rosalez, R.; Dehghanizadeh, M.; Brewer, C.E. 2019.** *Co-Hydrothermal Liquefaction of Guayule Bagasse and Wastewater Treatment Microalgae*. 2019 American Institute of Chemical Engineers Annual Meeting, Orlando, Florida. 10-15 November.
21. **Dehghanizadeh, M.\*; Cheng, F.; Jarvis, J.M.; Holguin, F.O.; Brewer, C.E. 2019.** *High Resolution Mass Spectroscopy for Characterization of Resin from Guayule*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
22. **Dierig, D. 2017.** *Bridgestone's perspective on a domestic source of natural rubber in the desert*. Invited Speaker at the New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico. 13 December.
23. **Dong, C.; Ponciano, G.; Wang, Y.; Huo, N.; Hunsaker, D.; Elshikha, D.; Gu, Y.Q.; McMahan, C. 2019.** *Transcriptome analysis of guayule reveals rubber biosynthesis pathways' response to drought stress*. SBAR Annual Retreat, University of Arizona, Tucson Arizona. 11-13 September. [poster]
24. **El-Shikha, D.E.M. 2018.** *Update – Guayule irrigation experiments at Maricopa Agricultural Center*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 12 September.
25. **El-Shikha, D.E.M.\*; Waller, P.M.; Hunsaker, D.J.; Dierig, D.; Wang, S.; Cruz, V.M.V.; Bronson, K.F.; Katterman, M.E. 2019.** *Direct seeded guayule grown in Arizona under furrow and subsurface drip irrigation*. American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting, Boston, Massachusetts. 8 July. [poster]
26. **El-Shikha, D.E.M.\*; Waller, P.M.; Hunsaker, D.J.; Dierig, D.; Wang, G.S.; Cruz, V.M.V.; Thorp, K.R.; Katterman, M.E.; Bronson, K.F.; Wall, G. 2019.** *Growing direct-*

- seeded guayule with furrow and subsurface drip irrigation in Arizona. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]*
27. **Evancho, B.\*; Teetor, V.H.; Willmon, J.; Bennett, M.C.; Montes, M.; Schmaltzel, C.; Ray, D.T. 2018.** *Root structure differentiation between common guayule planting methods.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]
  28. **Evancho, B. 2018.** *Guayule Fuels the Future.* IES – Energy Talks Seminar, Sky Bar, Tucson, Arizona. 9 October.
  29. **Evancho, B. 2019.** *Guayule: How Close Are We?* Marana Winter Field Crops Clinic. Marana, Arizona. 10 January.
  30. **Evancho, B. 2019.** *Guayule: How Close Are We?* Casa Grande Winter Field Crops Clinic. Casa Grande, Arizona. 15 January.
  31. **Evancho, B.\*; Moreno, L.; Peck, A.; Teetor, V.H., Schmaltzel, C.; Ray, D.T. 2019.** *Root structure differentiation between guayule planting methods.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
  32. **Fan, N. 2018.** *Review on Optimization Methods for Biomass Supply Chain.* SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 28 November.
  33. **Garcia, A.\*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Growth and performance of guar (*Cyamoposis tetragonoloba* L.) under various irrigation regimes in semi-arid region of New Mexico.* 73<sup>rd</sup> SWCS International Annual Conference, Albuquerque, New Mexico. 29 July – 1 August.
  34. **Garcia, A.\*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Growth and performance of guar under various irrigation regimes in semi-arid region of New Mexico.* Annual SBAR Retreat, University of Arizona, Tucson, Arizona. 1-3 August. [poster]
  35. **Garcia, A.\*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Performance of guar under various irrigation regimes in southern New Mexico.* Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico. 23 August.
  36. **Garcia, A.\*; Grover, K.; Stringam, B.; Schutte, B.; VanLeeuwen, D. 2018.** *Performance of guar under various irrigation regimes in southern New Mexico.* New Mexico Sustainable Agriculture Science Conference, Los Lunas, New Mexico. 12 December.
  37. **Garcia, A.\*; Grover, K.; Schutte, B.; Stringam, B.; VanLeeuwen, D. 2018.** *Growth and performance of guar under various irrigation regimes.* Proceedings of the 2018 Annual Meeting of the American Society of Agronomy, Crop Science Society of America and the Soil Science Society of America. Baltimore, Maryland. 4-7 November.
  38. **Garcia, A.\*; Grover, K.; Schutte, B.; Stringam, B.; VanLeeuwen, D. 2019.** *Growth and performance of guar under different irrigation regimes.* NMSU College of Agriculture, Consumer and Environmental Sciences (ACES) Open House. 6 April. [poster]
  39. **Gloria, T.\*; Grover, K.; Garcia, A. 2018.** *Guar: a potential alternative crop in New Mexico.* Annual SBAR Retreat, University of Arizona, Tucson, Arizona. 1-3 August. [poster]
  40. **Gloria, T.\*; Grover, K.; Garcia, A. 2018.** *Guar: a potential alternative crop in New Mexico.* Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico. 23 August.

41. **Gloria, T.\*; Grover, K.; Garcia, A. 2018.** *Guar: a potential alternative crop in New Mexico*. New Mexico Sustainable Agriculture Science Conference, Los Lunas, New Mexico. 12 December.
42. **Gloria, T.\*; Flores, M.; Allen, R.; Valenzuela, V.; Ben, G.; Moore, K.; Castillo, P.; Garcia, A.; Grover, K. 2019.** *Evaluating guar as a potential alternative crop in New Mexico*. NMSU College of Agriculture, Consumer and Environmental Sciences (ACES) Open House, Las Cruces, New Mexico. 6 April. [poster]
43. **Godfrey, D.J; Bennett, M.C.\*; Willmon, J.; Waltz, Q.; Coronado, G.; Teetor, V.H.; Schmalzel, C.; Ray, D.T. 2018.** *Vegetative propagation of Parthenium argentatum (Guayule)*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster] Won first place for undergraduate posters.
44. **Godfrey, D.\*; Willmon, J.; Teetor, V.H.; Schmalzel, C.; Ray, D.T. 2018.** *Vegetative propagation of guayule*. 2018 Annual Conference, American Society for Horticultural Science, Washington D.C. 30 July – 3 August 2018.
45. **Gonzalez, C.; Dierig, D.A.; Cruz, V.M.V.\* 2019.** *Pollen studies in guayule: Comparison of staining and sampling procedures and survey of pollen size variation*. 31<sup>st</sup> Annual Meeting for the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
46. **Gonzalez, C.\*; Cruz, V.M.V.; Dierig, D.A. 2019.** *Pollen viability and size variation in guayule germplasm*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
47. **Grover, K. 2017.** *Guar as a potential alternative crop in New Mexico*. Invited Speaker at the New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico. 13 December.
48. **Grover, K. 2018.** *Sustainable agriculture and guar production in New Mexico*. New Mexico State 4-H Conference, Las Cruces, New Mexico. 10 July.
49. **Grover, K. 2018.** *An overview of guar and other research in the Plant and Environmental Sciences Department*. A presentation to student ambassadors of College of Agriculture, Consumer and Environmental Sciences, New Mexico State University, Las Cruces, New Mexico. 8 August.
50. **Grover, K. 2018.** *Guar as an alternative crop in New Mexico*. Extension Field Day, New Mexico State University Agriculture Science Center, Clovis, New Mexico. 9 August.
51. **Grover, K. 2018.** *Guar as an alternative crop in New Mexico*. Extension Field Day, New Mexico State University Agriculture Science Center, Artesia, New Mexico. 23 August.
52. **Grover, K. 2018.** *Guar and Sustainable Crop Production*. An invited presentation to students of AGRO/HORT 100 Introductory Plant Sciences. New Mexico State University, Las Cruces, New Mexico. 31 August.
53. **Grover, K. 2018.** *Guar and Sustainable Crop Production*. An invited presentation to students of AXED 466V: “John Muir: Lessons in Sustainability.” New Mexico State University, Las Cruces, New Mexico. 25 September.
54. **Grover, K. 2019.** *Guar as an alternative rotation crop in the chili production system of New Mexico*. New Mexico Chili Industry and Researcher Meeting, Las Cruces, New Mexico. 5 February.

55. **Grover, K. 2019.** *Guar: A potential alternative crop in New Mexico.* Climate Change Strategies for a Changing World Workshop, New Mexico State University, Las Cruces, NM. 5 February. [invited speaker]
56. **Grover, K. 2019.** *Do you know what plants are these and what's in them?* Future Farmers of America (FFA), New Mexico Chapter Presentation. Las Cruces, New Mexico. 5 April.
57. **Grover, K. 2019.** *Guar: A potential alternative crop in New Mexico.* New Mexico Master Gardener's Meeting. Las Cruces, New Mexico. 8 May.
58. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico.* New Mexico Sustainable Agriculture Field Day. Las Cruces, New Mexico. 26 June.
59. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico.* SBAR Train-the-Trainer Workshop. Las Cruces, New Mexico. 2 July.
60. **Grover, K.\*; Garcia, A. 2018.** *Evaluating guar as a potential alternative crop in New Mexico.* University Research Council Meeting, New Mexico State University. Las Cruces, New Mexico. 15 February.
61. **Grover, K. 2019.** *Guar as an alternative crop in New Mexico.* SBAR Train-the-Trainer Workshop, Las Cruces, New Mexico. 2 July.
62. **Hoare, D.M. 2018.** *Irrigation Sensors and the WINDS Model.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 26 September.
63. **Hoare, D.M.\*; Katterman, M.; Waller, P. 2019.** *Development of a remote crop condition sensing system utilizing Internet of Things.* 31<sup>st</sup> Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
64. **Idowu, O.J. 2018.** *Introduction to the SBAR Project.* Las Cruces, New Mexico. 6 Feb.
65. **Idowu, O.J. 2018.** *Sustainable Bio-economy for Arid Regions: Update.* Extension Field Day, Clovis, New Mexico. 9 August.
66. **Idowu, O.J. 2018.** *Sustainable Bio-economy for Arid Regions: Guar and Guayule.* Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico. 23 August.
67. **Idowu, O.J.\*; Pruitt, D. 2019.** *Sustainable Bio-economy for Arid Regions.* Extension Field Day. Fabian Garcia Research Center, Las Cruces, New Mexico. 26 June.
68. **Khanal, S.\*; Gutierrez, P.; Robbs, J.; Acharya, R. 2019.** *The Economic Potential of Producing Guayule in the Southwest.* Department of Agricultural Economics and Agricultural Business, New Mexico State University, Las Cruces, New Mexico. [poster]
69. **Khanal, S.; Seavert, C.; Gutierrez, P.; Teegerstrom, T.\* 2019.** *The economic potential of producing guayule in the Southwest.* 31<sup>st</sup> Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
70. **Leo, A. 2019.** *Microbial adaptations for arid regions and middle schoolers.* Institute for Energy Solutions (IES) Energy Talks public lecture series, Sky Bar, Tucson, Arizona. 14 March.
71. **Levy, T.\*; Rock, C.; Idowu, O.J.; Dery, J.; Brassil, N.; Zozaya, S. 2019.** *Growers' perceptions and comprehension of biofuel, bioproducts, and guar in the Southwest Arid Region.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]



72. **Lewis, M.\*; Judkins, A.; Teetor, V.H.; Ray, D.T. 2019.** *Evaluating guayule germplasm for salt tolerance.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
73. **Lopez, E. 2018.** *Sustainable Bioeconomy for Arid Regions: Activities for education, extension and outreach.* American Institute of Chemical Engineers Rocky Mountain Regional Student Conference. Provo, Utah. 23 March.
74. **Lopez, E.\*; Fox, S.; Brewer, C.E. 2018.** *GK-12 Lesson Documentation Spreadsheet.* American Institute of Chemical Engineers Annual Meeting, Pittsburg, Pennsylvania. 29 October.
75. **Maqsood, H. 2018.** *Guar Crop Coefficient Development for New Mexico Environments.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 7 November.
76. **Maqsood, H.\*; Angadi, S.; El-Shikha, D.E.M.; Waller, P.; Singh, J.; Hunsaker, D.; Barua, B. 2019.** *Evaluating crop water status for guar using WINDS model.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
77. **Marinez, C.\*; Lopez, G.U.; Cabrera D.d.J. 2019.** *The University of Arizona Cooperative Extension 4H Program Collaborating Statewide in Preparing the Next Generation of STEM Innovators.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
78. **McCloskey, W. 2018.** *Weed Trial Results for Guayule.* SBAR UA Research Team Seminar. University of Arizona. Tucson, Arizona. 14 November.
79. **McMahan, C. 2018.** *Flowering Reduction in Guayule.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 19 September.
80. **McMahan, C. 2019.** *USDA-ARS Rubber Lab Update.* SBAR UA Research Team Seminar Series, Tucson, Arizona. 27 March.
81. **McMahan, C.\*; Placido, D.; El-Shikha, D.E.M.; Dong, C.; Ponciano, G.; Neilson, J.W. 2019.** *Dormancy and the guayule (Parthenium argentatum A. Gray) soil microbiome.* 31<sup>st</sup> Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
82. **Mealing, V. 2018.** *An overview of sustainability analysis methods of a new biofuel feedstock: bagasse from guar.* 6<sup>th</sup> Colorado School of Mines Graduate and Discovery Symposium. Golden, Colorado. 5 April.
83. **Mealing, V. 2019.** *Criteria, Methods, Opportunities, and Needs for Social Sustainability of Emerging Technology.* 7<sup>th</sup> Colorado School of Mines Graduate Research and Discovery Symposium. Golden, Colorado. April.
84. **Mealing, V. 2019.** *Sustainability assessment of guayule agriculture: Potential processing improvements for guayule co-products.* USDA-ARS, Western Regional Research Center, Albany, California. 3 July. [invited speaker]
85. **Mealing, V.\*; Harris, T.; Landis, A.E. 2019.** *Criteria, Methods, Opportunities, and Needs for Social Sustainability of Emerging Technology.* 15<sup>th</sup> International Conference on Environmental, Cultural, Economic and Social Sustainability. Vancouver, Canada. February.
86. **Mealing, V.\*; Summers, H.M.; Sproul, E.; Eranki, P.L.; Landis, A.E.; Quinn, J.C. 2018.** *Life Cycle Assessment of Cultivating Guar in the American Southwest.* LCA XVIII Conference. Fort Collins, Colorado. October [poster] Won second place in graduate student posters.

87. **Mealing, V.\*; Summers, H.M.; Sproul, E.; Eranki, P.L.; Quinn, J.C.; Landis, A.E.. 2018.** *Life Cycle Assessment of Cultivating Guar in the American Southwest*. National Society of Black Engineers, Fall Regional Conference. Las Vegas, Nevada. November [poster]
88. **Mealing, V.S.\*; Landis, A.E. 2019.** *Life cycle assessment of guar agriculture in the Southwest, USA*. 31<sup>st</sup> Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
89. **Mealing, V.S.\*; Landis, A.E. 2019.** *SBAR Sustainability*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
90. **Mi, W.\*; Teetor, V.H.; Ray, D.T. 2018.** *Rubber and Resin Extraction of Differentially Treated Biomass in Guayule (*Parthenium argentatum*)*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]
91. **Neilson, J.W. 2019.** *Soil Microbiome Resilience to Stress: How much is too much?* USDA-ARS, Western Regional Research Center, Albany, California. June. [invited speaker]
92. **Niu, D., 2018.** *Partial cloning of APETALA1 (AP1) gene from guayule*. cDNA Lab Seminar, USDA-ARS Western Regional Research Laboratory. 28 March.
93. **Ogden, K. 2017.** *Introducing new USDA NIFA CAP grant awardees – Developing regional AJF supply chains: Sustainable Bioeconomy for Arid Regions*. CAAFI-SOAP Jet Webinar. Hosted online. 13 October. [invited speaker]
94. **Ogden, K. 2017.** *Sustainable Bioeconomy for Arid Regions*. Biomass Research and Development Technical Advisory Board Meeting. 15 November. [invited speaker]
95. **Ogden, K. 2018.** *Sustainable Bio-economy for Arid Regions*. Southwest Indian Agricultural Association Meeting. Laughlin, Nevada. 16-18 January.
96. **Ogden, K. 2018.** *Potential of the Bioproducts and Biofuels Economy*. AIChE Annual Meeting, Pittsburgh, Pennsylvania. October [invited speaker]
97. **Ogden, K.\*; White, R., Brewer, C.E. 2018.** *Public Private Partnerships*. ABLC Conference. Washington, D.C. 27-28 February.
98. **Ossanna, L.\*; Placido, D.; El-Shikha, D.E.M.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M., Neilson, J.W. 2019.** *Root-zone microbiome dynamics and guayule rubber production*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
99. **Ponciano, G.\*; Dong, N.; Placido, D.; Borg, K.; Fonseca, L.; Howard, C.; Shintani, D.; McMahan, C. 2019.** *Bioengineering of guayule (*Parthenium argentatum*) to enhance tocopherols content*. 31<sup>st</sup> Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]
100. **Rock, C.\*; Brassill, N. 2018.** *Importance of Cooperative Extension in University Research*. University of Arizona, Tucson, Arizona. 14 March.
101. **Rogstad, A. 2018.** *Real World Supply Chain Development: USDA Coordinated Agriculture Projects*. SBAR Overview. CAAFI Biennial General Meeting and Integrated ASCENT Symposium. Washington, D.C. 4-6 December. [invited speaker]
102. **Rogstad, A. 2019.** *SBAR Overview*. Association for the Advancement of Industrial Crops 31<sup>st</sup> Annual Meeting. Tucson, Arizona. 8 September. [invited speaker]
103. **Rodriguez-Uribe, L.\*; Gutierrez, P. 2019.** *Implementing the Science of SBAR with Youth*. SBAR UA Research Team Seminar, University of Arizona, Tucson. 25 September.

104. **Rosalez, R.\*; Brewer, C.E.; Jena, U. 2019.** *Co-Hydrothermal liquefaction (HTL) of guayule bagasse and wastewater treatment microalgae.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
105. **Singh, J.\*; Angadi, S.V.; Begna, S.H. 2018.** *Crop Growth Stage Based Deficit Irrigation Management in Guar Crop.* The Western Sustainable Agriculture Conference (WSARE), University of New Mexico – Valencia Campus, Los Lunas, New Mexico. 12 December [poster]
106. **Singh, J.\*; Angadi, S.V.; Begna, S.H.; Guzman, I.; Idowu, J. 2019.** *Sustaining water resources using guar crop under different irrigation practices.* ACES-Open House, New Mexico State University, Las Cruces, New Mexico. 6 April. [poster]
107. **Singh, J.\*; Angadi, S.V.; Begna, S.H.; Idowu, J.; Guzman, I.; VanLeeuwen, D. 2019.** *Water extraction patterns of guar under different irrigation strategies in the Southern High Plains.* Western Society of Crop Science Annual Meeting. Pasco, Washington. 25-26 June. [poster] Won 1<sup>st</sup> Place in student poster competition.
108. **Singh, J.\*; Angadi, S.V.; Begna, S.H.; Idowu, J.; Guzman, I.; VanLeeuwen, D. 2019.** *Evaluating the effect of different irrigation practices on guar in the Southern High Plains.* Western Society of Crop Science Annual Meeting. Pasco, Washington. 25-26 June. Won 2<sup>nd</sup> Place in student oral presentation competition.
109. **Singh, J.\*; Angadi, S.V.; Begna, S.H.; Idowu, J. 2019.** *Guar as an alternative crop.* Annual Agricultural Field Day. Agricultural Science Center, Clovis, New Mexico. 8 August.
110. **Singh, J.\*; Angadi, S.V.; Begna, S.H. 2019.** *Identify guar germplasm suitable for cooler northern latitudes.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster] Won 2<sup>nd</sup> Place in graduate student poster presentation competition.
111. **Skuse, K.\*; Dery, J.; Zozaya, S.; Brassill, N.; Rock, C. 2018.** *Public interest in guayule being used as a biofuel.* University of Arizona, Maricopa Agricultural Center, Maricopa, Arizona. 26 July. [poster]
112. **Skuse, K.\*; Dery, J.; Zozaya, S.; Brassill, N.; Rock, C. 2018.** *Public interest in guayule being used as a biofuel.* Oral presentation of student internship work. University of Arizona, Maricopa Agricultural Center, Maricopa, Arizona. 26 July.
113. **Soliz, N.\*; Brewer, C.E.; Jena, U.; 2019.** *Bomb calorimetry of guayule bagasse and hydrothermal liquefaction products.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
114. **Soto, A.L.\*; Placido, D.; Dong, C.; Ponciano, G.; McMahan, C.; Maier, R.M.; Neilson, J.W. 2019.** *Soil parameters that influence natural rubber production in guayule (*Parthenium argentatum*) during winter dormancy.* SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster] Won 2<sup>nd</sup> Place in intern student poster presentation competition.
115. **Sproul, E.\*; Summers, H.M.\*; Quinn, J.C. 2019.** *Techno-Economic and Environmental Impact Analysis of Guayule and Guar.* International Symposium on Sustainable Systems and Technology, Portland, Oregon. June. [poster] Won 1<sup>st</sup> Place in student poster competition.
116. **Sproul, E.\*; Summers, H.M.; Mealing, V.; Landis, A.E.; Seavert, C.; Teegerstrom, T.; Gutierrez, P.; Robbs, J.; Fan, N.; Sun, O.; Quinn, J.C. 2019.** *Integrated environmental and economic assessment of guar and guayule.* American Center for



Life Cycle Assessment (ACLCA) LCA XIX, Tucson, Arizona. 24-26 September.  
[poster]

117. **Sun, O. 2018.** *GIS-Based Two-stage Stochastic Facility Location Considering Planting Plan Uncertainty*. INFORMS Annual Meeting, Phoenix, Arizona. 5 November.
118. **Sun, O. 2018.** *GIS-Based Two-stage Stochastic Facility Location Considering Planting Plan Uncertainty*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 28 November.
119. **Sun, O. 2019.** *Optimization of a Biomass Supply chain from Economic, Environmental, and Social Perspectives*. Dr. Fan's Group Meeting, University of Arizona, Tucson, Arizona. 13 March.
120. **Sun, O. 2019.** *Biomass Supply Chain Configuration and Management*. SBAR UA Research Team Seminar. University of Arizona, Tucson, Arizona. 10 April.
121. **Sun, O. 2019.** *Integrating Environmental and Social Impacts into Biomass Supply Chain*. SBAR System Performance and Sustainability Team Seminar. Virtual meeting space, Tucson, Arizona. 2 May.
122. **Sun, O.\*; Fan, N. 2018.** *Harvest scheduling*. SBAR Logistics Team Group Meeting. (webinar) New Mexico State University. Las Cruces, New Mexico. 5 February.
123. **Sun, O.\*; Fan, N. 2018.** *Optimization of feedstock logistics*. SBAR UA Research Seminar. University of Arizona. Tucson, Arizona. 14 February.
124. **Sun, O.\*; Fan, N. 2018.** *Optimally locating biorefineries*. SBAR Sustainability Working Group Seminar. (webinar) Colorado State University. Lakewood, Colorado. 8 March.
125. **Summers, H.M.\*, Sproul, E., Johnson, J., Quinn, J.C. 2017.** *Sustainability assessment of bioproducts from southwest arid crops*. 21<sup>st</sup> Century Energy Transition Symposium, Colorado State University, Fort Collins, Colorado. October.
126. **Summers, H.M.\*, Sproul, E., Johnson, J., Quinn, J.C. 2017.** *Sustainability assessment of bioproducts from southwest arid crops*. Colorado State University Graduate Student Showcase, Colorado State University, Fort Collins, Colorado. November.
127. **Summers, H.M.\*; Sproul, E.; Johnson, J.; Quinn, J.C. 2018.** *Economic Viability and Environmental Impact of processing arid crops in the American Southwest*. International Congress on Environmental Modelling and Software. Colorado State University, Fort Collins, Colorado. June.
128. **Summers, H.M.\*; Sproul, E.; Johnson, J.; Quinn, J.C. 2019.** *Economic and Environmental Impact Assessments of Drought Tolerant Crops in the American Southwest*. 21<sup>st</sup> Century Energy Transition Symposium, Denver, Colorado. April.
129. **Summers, H.M.\*; Sproul, E.; Mealing, V.; Eranki, P.L.; Landis, A.E.; Quinn, J.C. 2018.** *Process Modeling and Life Cycle Assessment of Rubber from Guayule*. LCA XVIII Conference, Fort Collins, Colorado. October.
130. **Usrey, J.\*; Dehghanizadeh, M.; Audu, M.; Rosalez, R. 2019.** *SBAR Education/Outreach at Lynn Middle School and Mesilla Valley Leadership Academy*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
131. **Waller, P. 2018.** *WINDS Model: A status report and connection to SBAR research*. SBAR UA Research Team Seminar Series, Tucson, Arizona. 10 October.
132. **Wang, G.S.\*; Lynch, A.; Cruz, V.M.V.; Dierig, D.A. 2019.** *Temperature requirements for guayule seed germination*. 31<sup>st</sup> Annual Meeting of the Association for the Advancement of Industrial Crops. Tucson, Arizona. 8-11 September. [poster]

133. Willmon, J.\*, Hu, J., Teetor, V.H., and Ray, D.T. 2018. *Screening Parthenium argentatum for resistance to Phymatotrichum omnivorum*. 2018 Annual Conference, American Society for Horticultural Science, Washington, D.C. 30 July – 3 August.
134. Willmon, J.; Montes, M.\*; Coronado, G.; Bennett, M.C.; Teetor, V.H.; Hu, J.; Ray, D.T. 2018. *Screening Parthenium argentatum for Resistance to Phymatotrichum omnivora*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 2 August. [poster]
135. Wright, A.\*; Brewer, C.E.; Jena, U. 2019. *CHNS elemental analysis of guayule and products*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]
136. Zuniga-Vasquez, D. 2019. *Two-stage stochastic multi-objective optimization for biomass supply chain integrating environmental and social impacts*. SBAR Annual Retreat, University of Arizona, Tucson, Arizona. 11-13 September. [poster]

*Total Audience Demographics for Project-Related Presentations (when captured)*

Audience Demographic Parameter	Previous Total (Cumulative)	This Quarter Total	Cumulative Project Total
<b>Gender</b>			
Males	874	291	1,165
Females	367	139	506
<b>Race/Ethnicity</b>			
Hispanic	174	59	233
Asian	107	36	143
Native American	174	60	234
African American	41	13	54
Anglo/White	745	262	1,007

**Audience Cumulative Total (when captured): 1,671 ppl**

## WEBSITE(S) OR INTERNET SITE(S)

SBAR Project Website

1. <https://sbar.arizona.edu>

## NEW TECHNOLOGIES OR TECHNIQUES GENERATED

*None this reporting period.*

## INVENTIONS, PATENT APPLICATIONS, AND/OR LICENSES

1. **Dec 2017.** 24c SLN Label for Gramoxone SL 2.0 Herbicide (Paraquat dichloride), for control of weeds in guayule. SLN Registration Number: AZ120005. Expiration: 31 Dec 2022. Arizona Department of Agriculture, Environmental Services Division.

2. **Dec 2017.** 24c SLN Label for Fusilade DX Herbicide (*Propanoic acid, 2-(4-((5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)-, butyl ester, (R)-*), for control of emerged weeds in guayule. SLN Registration Number: AZ070006. Expiration: 31 Dec 2022. Arizona Department of Agriculture, Environmental Services Division.

## OTHER PRODUCTS GENERATED

### Brochures, Factsheets, and Flyers

1. **Duncan, C.M. 2018.** SBAR USDA-NIFA graduate student fellowship: UA Students. One page promotional flyer. February and March.
2. **Duncan, C.M. 2018.** SBAR USDA-NIFA graduate student fellowship: NMSU Students. One page promotional flyer. February and March.
3. **Duncan, C.M. 2018.** SBAR call for middle and high school science teachers. One page promotional flyer. February and March.
4. **Duncan, C.M. 2018.** SBAR 4-H summer camp: Biofuels powering your world. One page promotional flyer. March.
5. **Duncan, C.M. 2019.** SBAR Call for Middle & High School Science Teachers. One page promotional flyer. March.
6. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate student fellowship: UA Students. One page promotional flyer. March.
7. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate student fellowship: NMSU Students. One page promotional flyer. March.
8. **Duncan, C.M. 2019.** SBAR USDA-NIFA graduate science education fellowship. One page general recruiting flyer. April.
9. **Evancho, B. 2019.** Guayule Information & Feedback Session. One page invitation to attend field day and tour. May.
10. **Grover, K. 2018.** Guar – A potential alternative crop in New Mexico. Two page informational handout. January.
11. **Kiela, C. 2018.** Guayule. SBAR Project two-page fact sheet. March.
12. **Kiela, C. 2018.** Guar. SBAR Project two-page fact sheet. April.
13. **Kiela, C. 2018.** History of Guayule. SBAR Project two-page fact sheet. April.
14. **Rogstad, A. 2017.** SBAR – Sustainable Bioeconomy for Arid Regions. One-page informational and promotional card. November.

### Press Releases and News Articles

1. 26 Sep 2017. “As NIFA awards \$21.1M to grow the bioeconomy, CABLE debuts to bridge students and industry.” BiofuelsDigest.  
<http://www.biofuelsdigest.com/bdigest/2017/09/26/as-nifa-awards-21-1m-to-grow-the-bioeconomy-cable-debuts-to-bridge-students-and-industry/>
2. 16 Oct 2017. “UA to Head New Center Focusing on Biofuels and Bioproducts.” UA News. <https://uanews.arizona.edu/story/ua-head-new-center-focusing-biofuels-and-bioproducts>
3. 4 Nov 2017. “Biofuels, bioproducts, and an Arizona bioeconomy?” Arizona Daily Wildcat. <http://www.wildcat.arizona.edu/article/2017/11/science-biofuels-and-bioproducts>

4. 29 Nov 2017. "NMSU to host state sustainable agriculture conference in Los Lunas." News Bulletin. [http://www.news-bulletin.com/news/nmsu-to-host-state-sustainable-agriculture-conference-in-los-lunas/article\\_a45281f6-d540-11e7-9530-27dc93258a79.html](http://www.news-bulletin.com/news/nmsu-to-host-state-sustainable-agriculture-conference-in-los-lunas/article_a45281f6-d540-11e7-9530-27dc93258a79.html)
5. 16 Jan 2018. "Dr. Quinn's Sustainability Expertise Recruited for Multi-Million Dollar DOE and USDA Grants." Colorado State University, Mechanical Engineering Featured Projects. <http://www.engr.colostate.edu/me/2018/01/16/dr-quinns-sustainability-expertise-recruited-for-multi-million-dollar-doe-and-usda-grants/>
6. 21 Feb 2018. "NMSU collaborating in Sustainable Bio-economy for Arid Regions project." New Mexico State University News Center. <http://newscenter.nmsu.edu/Articles/view/12961/nmsu-collaborating-in-sustainable-bio-economy-for-arid-regions-project>
7. 27 Feb 2018. "Bridgestone receives guayule research grant from USDA." The Smithers Report - A daily and weekly tire industry news source. (4,500 daily subscribers) <https://www.smithersrapra.com/publications/the-smithers-report>
8. 27 Feb 2018. "Bridgestone and research partners earn \$15 Million grant for guayule work." MTD (Modern Tire Dealer). UMV: 62,085. <http://www.moderntiredealer.com/news/728673/bridgestone-and-research-partners-earn-15-million-grant-for-guayule-work>

#### Tabling Events and Workshops – Marketing and Outreach

1. 14 July 2017. New Mexico Cotton Ginners Conference. New Mexico.
2. 17 Aug 2017. SBAR Project Kick-off Meeting. Tucson, Arizona.
3. 28 Oct 2017. Rocky Mountain Zone Summit (sustainability focus). Denver, Colorado.
4. 05 Dec 2017. Valencia County (New Mexico) Forage Conference. New Mexico.
5. 13 Dec 2017. New Mexico Sustainable Agriculture Conference. Los Lunas, New Mexico.
6. 15-17 Feb 2018. SBAR Display Table. New Mexico Organic Farming Conference. Albuquerque, New Mexico.
7. 24 Feb 2018. Farm Science Day. USDA-ARS, Arid-Land Agricultural Resource Center. Maricopa, Arizona.
8. 24 Feb 2018. 2018 Engineering Fair – Recycled papermaking and guar gum bubbles activity. Las Cruces Museum of Science and Nature. Las Cruces, New Mexico.
9. 15 Mar 2018. Zia Middle School Project – Lead the Way NMSU College of Engineering Day. Recycled papermaking and guar gum bubbles activity. Las Cruces, New Mexico.
10. 22-24 Feb 2018. Southwest Ag Summit. Yuma, Arizona.
11. 19 Mar 2018. Roosevelt Irrigation District Board Meeting. Buckeye, Arizona.
12. 28 Mar 2018. Alfalfa and Forage Workshop. Maricopa, Arizona.
13. 11 Jul 2018. New Mexico 4-H State Conference – Polymerization and guar gum bubbles activity. Albuquerque, New Mexico.
14. 9 Aug 2018. Extension Field Day, New Mexico State University Agricultural Science Center, Clovis, New Mexico.

15. 23 Aug 2018. Extension Field Day, New Mexico State University Agricultural Science Center, Artesia, New Mexico.
16. 12 Dec 2018. New Mexico Sustainable Agriculture Conference, Las Cruces, New Mexico.
17. 10 Jan 2019. Marana Winter Field Crop Clinic. University of Arizona Cooperative Extension, Marana, Arizona.
18. 15 Jan 2019. Casa Grande Winter Field Crop Clinic. University of Arizona Cooperative Extension, Casa Grande, Arizona.
19. 23 Jan 2019. New Mexico Cotton Growers Association Conference, Ruidoso, New Mexico.
20. 13 Feb 2019. Desert Hills S.T.E.A.M. Night. (Science, Technology, Engineering, Art, and Math) Desert Hills Elementary School, Las Cruces, New Mexico.
21. 15-16 Apr 2019. New Mexico Organic Farming Conference, Albuquerque, New Mexico.
22. 11 Apr 2019. Spring Extension Field Day, New Mexico State University Agricultural Science Center, Clovis, New Mexico.
23. 15 May 2019. Annual Agricultural Research Congressional Exhibition and Reception. Rayburn House, Washington, D.C.
24. 30 May 2019. Market Discussion and Field Day. Bridgestone Guayule Research Farm, Eloy, Arizona.
25. 26 Jun 2019. Extension Field Day. Fabian Garcia Research Center, Las Cruces, New Mexico.
26. 2 Jul 2019. SBAR Train the Trainers Workshop. Las Cruces, New Mexico.
27. 8 Aug 2019. Annual Agricultural Field Day. Agricultural Science Center, Clovis, New Mexico.
28. 8 Aug 2019. Agricultural Science and Field Day. Agricultural Science Center, Tucumcari, New Mexico.
29. 15 Aug 2019. Annual Agricultural Field Day. Agricultural Science Center, Los Lunas, New Mexico.
30. 21 Aug 2019. USAID Cochran Fellows Visit from Mali, Clovis, New Mexico.

→Total Reach via Tabling Events and Workshops (when captured): **2,728 participants**

## YOUTH ACTIVITIES

### Biofuel Lessons in Classrooms (SBAR Teacher/Fellow Cohort 2018-2019)

1. Apollo Middle School, Tucson, Arizona.
2. Mesilla Valley Leadership Academy, Las Cruces, New Mexico.
3. Pueblo High School, Tucson, Arizona.
4. Quail Run Elementary School, Marana, Arizona.
5. Sierra Middle School, Las Cruces, New Mexico.
6. Valencia Middle School, Tucson, Arizona.
7. Walter Douglas Elementary School, Tucson, Arizona.

### Biofuel Lessons in Classrooms (SBAR Teacher/Fellow Cohort 2019-2020)

1. Apollo Middle School, Tucson, Arizona.

2. Camino Real Middle School, Las Cruces, New Mexico.
3. Mesa Middle School, Las Cruces, New Mexico
4. Mesilla Valley Leadership Academy, Las Cruces, New Mexico.
5. Quail Run Elementary School, Marana, Arizona.
6. Pueblo High School, Tucson, Arizona.
7. Saguaro National Park Environmental Education, Tucson, Arizona.
8. Santa Rosa Ranch School, Sells, Arizona.
9. Sierra Middle School, Las Cruces, New Mexico.
10. Walter Douglas Elementary School, Tucson, Arizona.

Youth participation through classroom activities is tracked at the beginning of the school year in September because the same students are being reached each week by the teacher fellow pairs.

Other SBAR youth activities (4H camps, after school programs, Native Youth Outreach, etc.) are also included in the total when they occur.

*Youth Participation Demographics for Project-Related Activities (when captured)*

Youth Participation Demographic Parameter	Previous Total (Cumulative)	This Quarter Total	Cumulative Project Total
<b>Age Level</b>			
11-13 years	503	580+16	1,099
14-16 years	64	211+2	277
<b>Gender</b>			
Males	281	384+9	674
Females	286	407+9	702
<b>Race/Ethnicity</b>			
Hispanic	407	355	762
Asian	10	17	27
Native American	12	107	119
African American	16	24	40
Anglo/White	122	304	426
Multiracial	0	2	2

**Youth Cumulative Total (when captured): 1,376 ppl**

## PARTICIPANTS AND COLLABORATING ORGANIZATIONS.

### September 2017 – September 2019

#### PARTNER ORGANIZATIONS

Organization Person*	Project Role	Project Component
<b>Bridgestone Americas,</b>		
Von Mark Cruz	Professional	Feedstock Development & Production
David Dierig	Key Collaborator	Feedstock Development & Production
Stefan Dittmar	Professional	Feedstock Development & Production
Chloe Gonzalez	Intern	Feedstock Development & Production
Amber Lynch	Professional	Feedstock Development & Production
Russell Prock	Professional	Feedstock Development & Production
Theresa Sullivan	Professional	Feedstock Development & Production
Sam Wang	Professional	Feedstock Development & Production
Jocelyn Zhu	Intern	Feedstock Development & Production
<b>Colorado School of Mines</b>		
Pragnya Eranki	Post-doc	System Performance & Sustainability
Amy Landis	Key Collaborator	System Performance & Sustainability
VeeAnder Mealing	Graduate Student	System Performance & Sustainability
<b>Colorado State University</b>		
Austin Banks	Undergrad Student	System Performance & Sustainability
Jack Johnson	Undergrad Student	System Performance & Sustainability
Jason Quinn	Key Collaborator	System Performance & Sustainability
Evan Sproul	Graduate Student	System Performance & Sustainability
Hailey Summers	Graduate Student	System Performance & Sustainability
<b>New Mexico State University</b>		
Ram Acharya	Professional	System Performance & Sustainability
Sarah Acquah	Post-doc	Extension & Outreach System Performance & Sustainability
Rowen Allen	Undergrad Student	Extension & Outreach
Sangu Angadi	Key Collaborator	Extension & Outreach Feedstock Development & Production
Matt Armijo	Undergrad Student	Post-Harvest Logistics & Co-Products
Meshack Audu	Graduate Student Fellow	Education Post-Harvest Logistics & Co-Products
Valerie Bailey	Undergrad Student	Feedstock Development & Production
Hengameh Bayat	Graduate Student	Post-Harvest Logistics & Co-Products
Sultan Begna	Professional	Feedstock Development & Production
Geneva Ben	Undergrad Student	Feedstock Development & Production
Pratima Bhandari	Graduate Student	System Performance & Sustainability
Catherine E. Brewer	Key Collaborator	Education Post-Harvest Logistics & Co-Products
Ken Cazarez	Undergrad Student	Extension & Outreach
Nicolas Carrera-Little	Undergrad Student	Post-Harvest Logistics & Co-Products



Pedro Castillo	Undergrad Student	Feedstock Development & Production
Feng Cheng	Post-doc	Post-Harvest Logistics & Co-Products
Mostafa Dehghanizadeh	Graduate Student Fellow	Education Post-Harvest Logistics & Co-Products
Barry Dungan	Professional	Post-Harvest Logistics & Co-Products
Miguel Flores	Undergrad Student	Extension & Outreach
<i>Sarah Fox</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
Ryan Fullerton	Undergrad Student	Feedstock Development & Production
Alonso Garcia	Graduate Student	Feedstock Development & Production
Adah Gellis	Undergrad Student	Extension & Outreach
Saba Gill	Graduate Student	Post-Harvest Logistics & Co-Products
<i>Thomas Gloria</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Kulbhushan Grover	Key Collaborator	Extension & Outreach Feedstock Development & Production
Erin Gutierrez	Undergrad Student	Post-Harvest Logistics & Co-Products
Paul H Gutierrez	Key Collaborator	Extension & Outreach System Performance & Sustainability
<i>Befekadu Habteyes</i>	<i>Professional</i>	<i>System Performance &amp; Sustainability</i>
F. Omar Holguin	Key Collaborator	Post-Harvest Logistics & Co-Products
John Idowu	Key Collaborator	Extension & Outreach
Jackie Jarvis	Professional	Post-Harvest Logistics & Co-Products
Umakanta Jena	Professional	System Performance & Sustainability
Sita Khanal	Graduate Student	System Performance & Sustainability
Kelly Laje	Graduate Student	Post-Harvest Logistics & Co-Products
<i>Travis Le-Doux</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
<i>Esai Lopez</i>	<i>Undergrad Student</i>	<i>Education</i>
<i>Alberto Lorenzo</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
<i>Sicilee Macklin</i>	<i>Undergrad Student</i>	<i>Education</i> <i>Post-Harvest Logistics &amp; Co-Products</i>
<i>Cesar Martinez-Bejarano</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
Julie Miller	Undergrad Student	Extension & Outreach
<i>Sa'Rae Montoya</i>	<i>Graduate Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
<i>Kyle Moore</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Hasti Mozaffari	Graduate Student	Post-Harvest Logistics & Co-Products
<i>Jasmine Paquin</i>	<i>Graduate Student</i>	<i>Extension &amp; Outreach</i>
<i>Kaavya Polisetti</i>	<i>Graduate Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
<i>Camila Prieto</i>	<i>Undergrad Student</i>	<i>Extension &amp; Outreach</i>
Darien Pruitt	Graduate Student Fellow	Education Extension & Outreach
Lucas Ramirez	Undergrad Student	Feedstock Development & Production
<i>Joram Robbs</i>	<i>Graduate Student</i>	<i>Extension &amp; Outreach</i> <i>System Performance &amp; Sustainability</i>
Laura Rodriguez-Uribe	Professional	Extension & Outreach Post-Harvest Logistics & Co-Products
Rodrigo Rosalez	Graduate Student Fellow	Education Post-Harvest Logistic & Co-Products
<i>Kimberly Salinas</i>	<i>Undergrad Student</i>	<i>Extension &amp; Outreach</i>
<i>Nathan Schavz</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
<i>Tarah Schuman</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
Ujala Sehar	Graduate Student	Post-Harvest Logistics & Co-Products
Parambeer Singh	Graduate Student Fellow	Education
Jagdeep Singh	Graduate Student	Education Feedstock Development & Production

<i>Peter Skelton</i>	<i>Professional</i>	<i>Extension &amp; Outreach</i>
Nicolas Soliz	Undergrad Student	Post-Harvest Logistics & Co-Products
<i>Stephen Taylor</i>	<i>Undergrad Student</i>	<i>Education</i>
<i>Brian Treftz</i>	<i>Graduate Student</i>	<i>Education</i> <i>Post-Harvest Logistics &amp; Co-Products</i>
Jacob Usrey	Graduate Student Fellow	Education Post-Harvest Logistics & Co-Products
<i>Justin Valdez</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
Victoria Valenzuela	Undergrad Student	Feedstock Development & Production
<i>Stephanie Willette</i>	<i>Graduate Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
April Wright	Undergrad Student	Post-Harvest Logistics & Co-Products
<i>Scott Woolf</i>	<i>Undergrad Student</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
<b>Other</b>		
Jennifer Fields	Professional	Education Extension & Outreach
Clark Seavert	Professional	System Performance & Sustainability Extension & Outreach
<b>University of Arizona</b>		
Torran Anderson	Professional	Education Extension & Outreach
<i>Nick Ashley</i>	<i>Graduate Student</i>	<i>Feedstock Development &amp; Production</i>
<i>Craig Bal</i>	<i>Graduate Student</i>	<i>Education</i> <i>Extension &amp; Outreach</i>
<i>Gloria Vill Barbosa</i>	<i>Undergrad Student</i>	<i>Extension &amp; Outreach</i>
Armando Barreto	Professional	Feedstock Development & Production
<i>Holly Barton</i>	<i>Graduate Student</i> <i>Fellow</i>	<i>Education</i>
Megan Bennett	Undergrad Student	Feedstock Development & Production
Natalie Brassill	Professional	Extension & Outreach
Kyle Brown	Graduate Student	Feedstock Development & Production
<i>Daniela Cabrera</i>	<i>Professional</i>	<i>Extension &amp; Outreach</i>
Madasu Chandrashekar	Professional	Post-Harvest Logistics & Co-Products
Connor Chaney	Undergrad Student	Feedstock Development & Production
Sara Chavarria	Key Collaborator	Education
Yongjian Chen	Post-doc	Feedstock Development & Production
<i>German Coronado</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Kamel Didan	Professional	Feedstock Development & Production
Cara Duncan	Professional	Education Extension & Outreach
Diaa El-Shikha	Post-doc	Feedstock Development & Production
Blase Evancho	Key Collaborator Graduate Student	Extension & Outreach Feedstock Development & Production
Neng Fan	Key Collaborator	Post-Harvest Logistics & Co-Products
<i>Krista Farmer</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Charles Ferini	Undergrad Student	Feedstock Development & Production
<i>Daryan Godfrey</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Leslie Gunatilaka	Key Collaborator	Post-Harvest Logistics & Co-Products
Wolfgang Grunberg	Professional	ALL AREAS
Matthew Harmon	Undergrad Student	Feedstock Development & Production
Danielle Hoare	Graduate Student	Feedstock Development & Production
<i>Stephanie Honeker</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Arisbeth Ibarra Nieblas	Graduate Student	Education

	Fellow	
Aaron Judkins	Undergrad Student	Feedstock Development & Production
<i>Pujan Kafle</i>	<i>Graduate Student</i>	<i>System Performance &amp; Sustainability</i>
Matthew Katterman	Graduate Student Fellow	Education Feedstock Development & Production
<i>C. Kasia Kiela</i>	<i>Undergrad Student</i>	<i>ALL AREAS</i>
Corey Knox	Professional	Education
Jessica Ledesma	Undergrad Student	Feedstock Development & Production
<i>Ashton Leo</i>	<i>Graduate Student</i> <i>Fellow</i>	<i>Education</i>
Taylor Levy	Intern	Extension & Outreach
Myles Lewis	Professional	Feedstock Development & Production
Manping Liu	Professional	Post-Harvest Logistics & Co-Products
Patrick Lohr	Graduate Student	Feedstock Development & Production
<i>Gerardo Lopez</i>	<i>Key Collaborator</i>	<i>Extension &amp; Outreach</i>
<i>Jasmine Lopez</i>	<i>Undergrad Student</i>	<i>Extension &amp; Outreach</i>
Raina Maier	Key Collaborator	Feedstock Development & Production
Hadiqa Maqsood	Graduate Student	Feedstock Development & Production
Celestina Marinez	Intern	Extension & Outreach
William McCloskey	Key Collaborator	Feedstock Development & Production
<i>Wenzhe Mi</i>	<i>Intern</i>	<i>Feedstock Development &amp; Production</i>
<i>Istvan Molnar</i>	<i>Key Collaborator</i>	<i>Education</i>
<i>Madison Montes</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Leobardo Moreno	Undergrad Student	Feedstock Development & Production
Madison Morris	Undergrad Student	Feedstock Development & Production
Julie Neilson	Professional	Feedstock Development & Production
<i>Andrew Nelson</i>	<i>Post-doc</i>	<i>Feedstock Development &amp; Production</i>
Kim Ogden	Key Collaborator	ALL AREAS
Huitzilin Ortiz	Graduate Student Fellow	Education
Lia Ossanna	Professional	Feedstock Development & Production
Alexandra Peck	Undergrad Student	Feedstock Development & Production
Bryan Pastor	Professional	Feedstock Development & Production
<i>Duke Pauli</i>	<i>Key Collaborator</i>	<i>Feedstock Development &amp; Production</i>
Alexandra Peck	Undergrad Student	Feedstock Development & Production
Livvi Pearson	Undergrad Student	Feedstock Development & Production
<i>Shaira Perez</i>	<i>Undergrad Student</i>	<i>Extension &amp; Outreach</i>
Sam Pernu	Undergrad Student	Feedstock Development & Production
Tenzin Phakdon	Graduate Student Fellow	Education
Sarocho Pradyawong	Post-doc	Feedstock Development & Production
Dennis Ray	Key Collaborator	Feedstock Development & Production
<i>Jaspreet Rekhi</i>	<i>Professional</i>	<i>Post-Harvest Logistics &amp; Co-Products</i>
Channah Rock	Key Collaborator	Extension & Outreach
Alix Rogstad	Professional	ALL AREAS
Juan Salas	Undergrad Student	Feedstock Development & Production
Luis Anguiano Sanchez	Professional	Feedstock Development & Production
Carl Schmalzel	Professional	Feedstock Development & Production
Stephanie Sikora	Professional	Education
Andrew Smith	Graduate Student	Feedstock Development & Production
Ana Lucia Soto	Undergrad Student Intern	Feedstock Development & Production
Seth Steichen	Graduate Student Fellow	Education

<i>Ou Sun</i>	<i>Graduate Student</i>	<i>System Performance &amp; Sustainability</i>
Trent Teegerstrom	Key Collaborator	Extension & Outreach System Performance & Sustainability
Valerie Teetor	Professional	Feedstock Development & Production
<i>Mira Theilmann</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
<i>Christine Toering</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Gianni Velasco	Undergrad Student	Feedstock Development & Production
Peter Waller	Key Collaborator	Feedstock Development & Production
<i>Quinn Waltz</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
<i>John Willmon</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Ya-ming Xu	Post-doc	Post-Harvest Logistics & Co-Products
Ali Yaylali	Graduate Student Fellow	Education
Stevi Zozaya	Undergrad Student	Extension & Outreach
Daniel Zuniga-Vazquez	Graduate Student	Post-Harvest Logistics & Co-Products System Performance & Sustainability
<b>USDA Agriculture Research Service – US Arid Lands Research Center, Maricopa AZ</b>		
Hussein Abdel-Haleem	Key Collaborator	Feedstock Development & Production
<i>Adrianna Chambers</i>	<i>Undergrad Student</i>	<i>Feedstock Development &amp; Production</i>
Amber Dearstyne	Undergrad Student	Feedstock Development & Production
Tristan Dunton	Professional	Feedstock Development & Production
<i>Greg Leake</i>	<i>Professional</i>	<i>Feedstock Development &amp; Production</i>
Aaron Szczepanek	Professional	Feedstock Development & Production
Brandon Vera	Undergrad Student	Feedstock Development & Production
<b>USDA Agriculture Research Service – Western Regional Research Center, Albany CA</b>		
Milagro Adom	Student (SEED)	Feedstock Development & Production
<i>Sheyla Aucar</i>	<i>Professional</i>	<i>Feedstock Development &amp; Production</i>
<i>Matthew Canonizado</i>	<i>Professional</i>	<i>Feedstock Development &amp; Production</i>
<i>George Chong</i>	<i>Professional</i>	<i>Feedstock Development &amp; Production</i>
Chen Dong	Professional	Feedstock Development & Production
Niu Dong	Professional	Feedstock Development & Production
Trinh Huynh	Professional	Feedstock Development & Production
Colleen McMahan	Key Collaborator	Feedstock Development & Production
Grisel Ponciano	Professional	Feedstock Development & Production
Dante Placido	Post-doc	Feedstock Development & Production
Mariano Resendiz	Professional	Feedstock Development & Production

\* *Individuals no longer actively working on the SBAR project appear in italic.*

**Total Active Key Collaborators: 22**

**Total Active Professional Staff: 38**

**Total Active Postdoctoral Researchers: 6**

**Total Active Graduate Students: 27**

**Total Active Undergraduate Students: 35**

**Total Active Fellows: 11**

**Total Active /Interns: 4**

**Total Past Participants (no longer active): 61**

## COLLABORATIONS AND OTHER CONTACTS

### Collaborations:

<i>Academic Institutions:</i>	<p>CSM (Colorado School of Mines)</p> <ul style="list-style-type: none"> <li>- Dept. of Civil and Environmental Engineering</li> </ul> <p>CSU (Colorado State University)</p> <ul style="list-style-type: none"> <li>- Dept. of Mechanical Engineering</li> </ul> <p>FSU (Florida State University)</p> <ul style="list-style-type: none"> <li>- National High Magnetic Field Laboratory</li> </ul> <p>NMSU (New Mexico State University)</p> <ul style="list-style-type: none"> <li>- Cooperative Extension</li> <li>- Dept. of Agricultural Economics and Agricultural Business</li> <li>- Dept. of Chemical Engineering</li> <li>- Dept. of Plant and Environmental Sciences</li> </ul> <p>UA (University of Arizona)</p> <ul style="list-style-type: none"> <li>- Agricultural and Biosystems Engineering</li> <li>- College of Agriculture and Life Sciences</li> <li>- College of Education</li> <li>- College of Engineering</li> <li>- Cooperative Extension</li> <li>- Dept. of Agriculture and Resource Economics</li> <li>- Dept. of Chemical and Environmental Engineering</li> <li>- Dept. of Soil, Water and Environmental Sciences</li> <li>- Dept. of Systems and Industrial Engineering</li> <li>- Institute of Energy Solutions</li> <li>- Natural Products Center</li> <li>- School of Natural Resources and the Environment</li> <li>- School of Plant Sciences</li> </ul> <p>University of New Mexico – Gallup</p> <ul style="list-style-type: none"> <li>- Dept. of Mathematics, Physical and Natural Science</li> </ul>
<i>Nonprofits:</i>	
<i>Industrial or Commercial Firms:</i>	<p>BASF</p> <p>Bridgestone Americas, Inc.</p> <p>Central Arizona Project (CAP)</p> <p>FMC</p> <p>Guar Resources</p> <p>Syngenta</p>
<i>Federal Government</i>	<p>Saguaro National Park (West), Tucson AZ</p> <ul style="list-style-type: none"> <li>- Environmental Education Department</li> </ul>

	<p>USDA – Agricultural Research Service, Western Regional Research Center, Albany CA</p> <ul style="list-style-type: none"> <li>- Chemistry (Bioproducts)</li> <li>- Plant Genetics</li> </ul> <p>USDA – Agricultural Research Service, Grassland Soil and Water Research Laboratory, Temple TX</p> <ul style="list-style-type: none"> <li>- Crop Modeling</li> </ul>
<i>State or Local Governments:</i>	Arizona Department of Agriculture, Environmental Services Division
<i>Tribal Governments:</i>	
<i>Schools or School Systems:</i>	<p><b>BASIS Charter Schools</b>, BASIS Tucson North (high school), Tucson, Arizona</p> <p><b>Flowing Wells Unified District</b>, Walter Douglas Elementary School, Tucson, Arizona</p> <p><b>Las Cruces Public Schools</b>, Camino Real Middle School, Mesa Middle School, Mesilla Valley Leadership Academy, and Sierra Middle School, Las Cruces, New Mexico</p> <p><b>Marana Unified School District</b>, Quail Run Elementary School, Marana, Arizona</p> <p><b>Tucson Unified School District</b>, Pueblo High School, and Valencia Middle School, Tucson, Arizona</p> <p><b>Santa Rosa Ranch School District</b>, Santa Rosa Ranch School, Sells, Arizona</p> <p><b>Sunnyside Unified School District</b>, Apollo Middle School, Tucson, Arizona</p>
<i>Other Organizations (foreign or domestic):</i>	

Other Contacts:

<i>Contacts with others within recipient's organization (interdepartmental or interdisciplinary collaborations):</i>	<p>UA (University of Arizona)</p> <ul style="list-style-type: none"> <li>- Applied Biosciences</li> <li>- Arid Lands Resource Sciences</li> <li>- College of Agriculture and Life Sciences</li> <li>- College of Architecture, Planning and Landscape Architecture</li> <li>- College of Science</li> <li>- Institute of the Environment</li> <li>- Water Resources Research Center</li> </ul>
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<i>Contacts with others outside the organization:</i>	<p>Denver Museum of Nature and Science, Denver Colorado</p> <p>Central Arizona College</p>
<i>Contacts with others outside the United States or with an international organization:</i>	



## APPENDICES

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### APPENDIX 1. 2019 SBAR ANNUAL RETREAT AGENDA

#### *Documents Included*

1. **SBAR Annual Retreat Agenda** – Final SBAR annual retreat agenda including pre-retreat sessions and plenary and working session descriptions. (4pgs)

## 2019 SBAR Retreat

## University of Arizona; Tucson, AZ

Wednesday, 11 September 2019		AAIC
0800 – 1900	<b>Association for the Advancement of Industrial Crops (AAIC)</b> <a href="http://www.aaic.org/2019-conference">www.aaic.org/2019-conference</a> “General Crops” (including guar) and “Rubber and Resin” (including guayule) Sessions El Conquistador Resort and Conference Center, Tucson, AZ (Coronado Ballroom) *registration fees inclusive of business lunch and dinner banquet *opportunity for scholarly presentations and poster contest	
Wednesday, 11 September 2019		PRE-RETREAT SESSION
0900 – 1200	SBAR Project Component Working Sessions, University of Arizona <i>(Scheduled and facilitated by Component LEADS or others, as desired)</i>  System Performance & Sustainability – <b>ENR2 S215</b> Education – <b>ENR2 S120A</b> Extension & Outreach – <b>ENR2 S120B</b>	
1200-1330	Lunch ( <i>on your own</i> )	
1330-1630	SBAR Project Component Working Sessions <i>cont.</i>	
1330-1530	SBAR InFO Facilitator Orientation – <b>Catalina Room, ENR 251</b>	
1330-1430	SBAR Poster Set-up – <b>ENR2 S225</b>	
Thursday, 12 September 2019		RETREAT SESSION – DAY 1
0730 – 0815	<b>SBAR Check-in &amp; Continental Breakfast</b> with coffee/tea ( <i>provided on site</i> )	
0815 – 0830	<b>Welcome and Intro ~ Kim Ogden</b> - Setting the stage and introductory remarks - Overview of schedule; intended retreat outcomes	
0830 – 0930	<b>Component Status Updates...</b> lightning-round <u>Accomplishments Overview</u> per Team (~30min report of what was completed in 2018-2019)	
0830 – 0900	Feedstock Development & Production ~ <i>Dennis Ray</i>	
0900 – 0930	Post-Harvest Logistics & Co-Products ~ <i>Catie Brewer</i>	
0930 – 1000	~BREAK~	
1000 – 1130	<b>Component Status Updates, cont....</b> lightning-round <u>Accomplishments Overview</u> per Team (~30min report of what was completed in 2018-2019)	
1000 – 1030	System Performance & Sustainability ~ <i>Jason Quinn</i>	
1030 – 1100	Extension & Outreach ~ <i>John Idowu</i>	
1100 – 1130	Education ~ <i>Sara Chavarria</i>	
1130 – 1215	Lunch ( <i>provided on site</i> )	

1215 – 1230	<b>Introduction: SBAR Interdisciplinary Face-Off (SBAR InFO) ~Stephanie Sikora</b> - Challenge Task - Team Assignments and Meeting Room Locations	
1230 – 1400	<b>Student Poster Lightning Round Session ...</b> - Quick Student presentation on their project and results obtained - What was the most exciting part of your work? - Why should people come by your poster?  <b>Student Poster Session I ...</b> Visit the student posters; review accomplishments; Q&A  Room: <b>S225</b>	
1400 – 1415	~BREAK~	
<b>BREAKOUTS</b>	<b>SBAR Students</b>	<b>SBAR Project Team (4 small pre-assigned groups)</b>
1415 – 1420	<b>Working Session I</b>  - SBAR InFO Task Teams - Identify and select desired deliverable - Identify ways to address the task - How does YOUR work fit into the deliverable?  Rooms: <b>See packet insert</b>	<b>Breakout Task Overview ~ Tahnee Robertson, Lead Facilitator</b> Room: <b>S107 (Haury)</b>
1420 - 1500		<b>Interdisciplinary Working Session I</b> <u>Purpose:</u> Identify opportunities and methods to better integrate all aspects of the SBAR project across components. <u>Method:</u> Groups are pre-assigned and color-coded; travel with your assigned group/color to each room; address/add to materials generated prior to your group's arrival.  - Education - Sustainability - Student Engagement - Extension & Outreach  Rooms: <b>See packet insert</b>
1500 - 1530		<b>Interdisciplinary Working Session II</b> <i>See Interdisciplinary Working Session I for instructions.</i>
1530 - 1600		<b>Interdisciplinary Working Session III</b> <i>See Interdisciplinary Working Session I for instructions.</i>
1600 - 1630		<b>Interdisciplinary Working Session IV</b> <i>See Interdisciplinary Working Session I for instructions.</i>
1630 – 1715	<b>Student Poster Session II ...</b> Visit the student posters; review accomplishments; Q&A (poster judging) Room: <b>S225</b>	
1715 – 1745	~BREAK~	
1745 - ??	<b>Group Reception &amp; Further Business Discussions (off-site location)</b>  <u>Discussion Topics</u> - Strategies for Year 3 project implementation; project component integration - New concepts/revision of research questions to address present conditions	

0745 – 0815	<b>Continental Breakfast</b> with coffee/tea ( <i>provided on site</i> )		
0815 – 0830	<b>Introduction to Day 2 :: Setting the Stage for Success</b> ~ <i>Tahnee Robertson, Lead Facilitator</i> <ul style="list-style-type: none"> <li>- Brief review of yesterday's breakout discussions</li> <li>- Outline for today's working sessions</li> </ul>		
<i>BREAKOUTS</i>	<b>SBAR Students</b>	<b>SBAR Project Team (4 small pre-assigned groups)</b>	
0830 – 0945	<b>Working Session II</b> <ul style="list-style-type: none"> <li>- SBAR InFO Task Teams</li> <li>- Identify ways to address the task</li> <li>- Using interdisciplinary concepts, think outside the box</li> </ul>	<b>Report Out from Working Sessions I-IV (Combined)</b> <ul style="list-style-type: none"> <li>- Key points</li> <li>- Opportunities identified</li> <li>- Prioritize</li> </ul> Room: <b>S107 [Haury]</b>	
0945 – 1000	Rooms: <b>See packet insert</b>  <b>Same rooms as yesterday</b>	~BREAK~	
1000 – 1200		<b>Working Session V (Component Teams)</b> Thoughts, ideas, concerns, questions generated from previous working sessions <ul style="list-style-type: none"> <li>- How can what was discussed be integrated into our work?</li> <li>- What do our team partners need from us?</li> <li>- Are there new opportunities that could benefit the project outcomes?</li> </ul> Rooms: FD – <b>N595</b> LOG – <b>N595</b> SUS – <b>S120B</b> EO – <b>S120A</b> E – <b>N572</b>  Facilitators: Component Leads	<b>ADVISORY BOARD</b> SBAR Advisory Board will conduct a working session for evaluating and advising project implementation <ul style="list-style-type: none"> <li>- Are the challenges being addressed still relevant today?</li> <li>- Evaluation discussion for all components</li> <li>- Are there new challenges to consider that could be addressed?</li> <li>- Develop recommendations for future study/action</li> </ul> Room: <b>N604</b>  Facilitator: Advisory Board Chair
1200 – 1330	<b>Working Lunch ...</b> ( <i>provided on site</i> ) Room: <b>S107 Haury</b>		
1200 – 1330	<b>SBAR Interdisciplinary Face-Off Report Out – Solutions</b> <ul style="list-style-type: none"> <li>- Student Team Presentations</li> <li>- Key points &amp; Opportunities identified</li> </ul>		
1330 – 1350	<b>Student Poster &amp; SBAR InFO Results</b> ~ <i>Kim Ogden and Bridgestone (facilitates)</i> <ul style="list-style-type: none"> <li>- Prizes awarded to top 2 posters in three categories (as scored/ranked by Judging Teams)</li> <li>- Prizes awarded to Face-Off winners (as scored by Judging Team)</li> </ul>		
1350 – 1400	<b>Photo Session – Winners of Student Poster &amp; SBAR InFO</b> <ul style="list-style-type: none"> <li>- Poster and SBAR InFO team winners take group photos</li> </ul> Location: <b>ENR2 Courtyard</b>		

1400 – 1430	<b>Reflections ~ SBAR Advisory Board</b> <ul style="list-style-type: none"> <li>- General Thoughts (overall picture)</li> <li>- Areas of Excellence (achieving project objectives)</li> <li>- Suggestions for Improvement</li> <li>- Outlook – adjustments to overall mission/goals to meet current conditions and expectations (in industry, government, or public perception)</li> </ul>
1430 – 1445	<b>Project Team Discussion ~ Kim Ogden (facilitates)</b> <ul style="list-style-type: none"> <li>- Feedback Loop ... scope :: do we need to make adjustments in specific areas, direction or process? Overall thoughts?</li> <li>- Looking Forward ... Areas missed that should be hit next time?</li> </ul> <b>Next Steps &amp; Assignments</b> <ul style="list-style-type: none"> <li>- Key Questions per Component for Year 3</li> <li>- Revisit Parking Lot</li> </ul>
1445 – 1500	Meeting Evaluation ( <b><i>Please complete before you leave!</i></b> ) See link.
1500	~ Safe Travels; Safe Home ~

*The Sustainable Bioeconomy for Arid Regions (SBAR) Center is funded through a research and education/extension grant provided by the USDA National Institute of Food and Agriculture (NIFA) – Agriculture and Food Research Initiative.*  
**Grant # 2017-68005-26867**

*Any opinions, findings, conclusions, or recommendations expressed in this meeting are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.*

## APPENDIX 2. 2019 SBAR ANNUAL RETREAT EVALUATION RESULTS

### *Documents Included*

1. **Results from the SBAR Interdisciplinary Working Sessions** – Summarized notes from the discussions and prioritization (dot process) occurring in the Interdisciplinary Working Sessions at the 2019 SBAR Annual Retreat, September 2019. (21pgs)
2. **Evaluation Results of 2019 SBAR Retreat** – Executive Summary and question breakdown from the SBAR Annual Retreat hosted by the University of Arizona from 11-13 September 2019 in Tucson, Arizona. (43pgs)

## Executive Summary

The second Sustainable Bio-economy for Arid Regions Center Retreat was hosted by the University of Arizona from 11-13 September 2019 in Tucson, Arizona. One-hundred-five (105) project colleagues participated in the event's scheduled discussions and breakouts, pre-sessions, poster sessions, and evaluation.

- 48% (49:105) of attendees completed the event evaluation (specifically addressing logistics and day-of activities)
- 49% (51:105) of attendees provided feedback through the online form
- Overall, the second retreat did not meet the very high marks of the first retreat, though most responders expressed positive feedback.
- In general, most attendees felt that the retreat was well organized and ran very smoothly.
- Most negative comments received were related to the parking, food, and welcome reception. 15% expressed negative feelings about the lack of "free" time available for discussion/networking.
- 98% of responders either Agree or Strongly Agree that they look forward to next year's SBAR Retreat.
- Online Responder breakdown: 28% PIs/Co-PIs; 20% Tech Staff; 18% Graduate Students; 10% Key Personnel/Researcher; 8% Advisory Board Member; 6% Teacher Mentors; 6% Interns; 2% Undergraduate Students; 2% Others
- 35% of responders also attended the AAIC meeting (18 total responders); of those, 11 had not attended AAIC meetings previously; most who attended felt it was a good use of their time
- The pre-meeting sessions were very helpful for those who were able to attend/participate. It is recommended that pre-session meetings be scheduled in the future for all components AND for cross-pollination opportunities across components. Suggestion for allowing time for post-session component meetings at the end of the Retreat next year.
- For the most part, component presentations were considered "good", and there is a moderate level of confidence that responders can discuss the broader picture of SBAR because of the presentations given.
- Student poster lightning round was well-received, and should be repeated.
- Advisory Board feedback was useful for most responders who felt that they can incorporate suggestions into their work. It is important to note however, that some responders indicated that the Advisory Board comments were not relevant to their study area but that they saw the value of their comments to the overall project.
- Attendees felt that they had time to ask questions and to interact with colleagues, though some suggested more "free" networking time to allow for deeper conversations.
- 88% of responders feel that the SBAR Team is working effectively together.
- The SBAR InFO received mixed reviews. Some really liked it; others really disliked it. Most of the responders suggested that they did not fully understand the task and/or what was expected of them during the process.
- SBAR InFO participants did not feel that adequate preparation materials were provided prior to the event. (Although it is relevant to point out that multiple reading materials and informational



links were available on the SBAR website for at least 3 weeks prior to the event; not a single student read the materials prior to the meeting.)

- The interdisciplinary working sessions were somewhat well received, though passionate responses occurred on both ends. The majority of respondents felt that the breakouts were a good use of time.
- 18% of respondents did not feel that the interdisciplinary working sessions (breakouts) were relevant to their SBAR research (though 71% agreed or strongly agreed that they were relevant).
- 21% of respondents suggest that the interdisciplinary working sessions (breakouts) not be repeated in future meetings. (62% would like to see this format again with different topics.)
- Retreat Strengths: diverse/small group work; interdisciplinary teams; interactions with others; diversity of attendants; well organized and managed (timely)
- Suggested Changes: define shared vision at the onset (timeline, must haves, etc.); more time for poster sessions; don't serve breakfast; different student session options to accommodate different student levels; Advisory Board working session following Retreat; Advisory Board comments provided in written (ppt) format instead of just oral; Advisory Board panel with Q&A (instead of just presentation); more research team discussion/presentation time; concurrent research sessions; get Advisory Board/Bridgestone feedback before the meeting so that a response can be made during the meeting; add a project review session with just PIs/Co-PIs to discuss status of goals, key findings, challenges, and work plans
- Future Topics: guest presenter (group/farmer/Native American) regarding their interest/non-interest in growing guayule/guar and why; relationship to Native communities; possibility of government incentives; guayule/guar production and farm-level costs from growers; guest presenter on new ideas for technology integration; more emphasis on co-products and resin
- The implementation of Sustainability modeling is the "stand-out" innovation presented in Year 1. (With runner up: Retreat SBAR InFO session.)
- Key Learning Concept: Bridgestone's timeline to commercialization.

#### **Suggestions for LEADS:**

- Develop a clear flowchart or schematic for ongoing research and how everything fits together (including targets)
- Define the purpose for each component team (and why it's critical to the overall); big picture vision
- Share a clearly defined process and timeline for budget reallocations

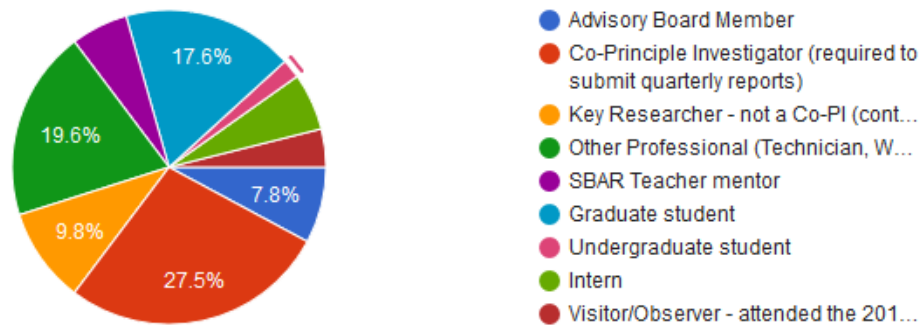
Good additional feedback was gathered through open-ended questions at the end of the survey. All comments are provided in the following pages.

## General

Likert Scale used throughout: Strongly Disagree (1) – Strongly Agree (5)

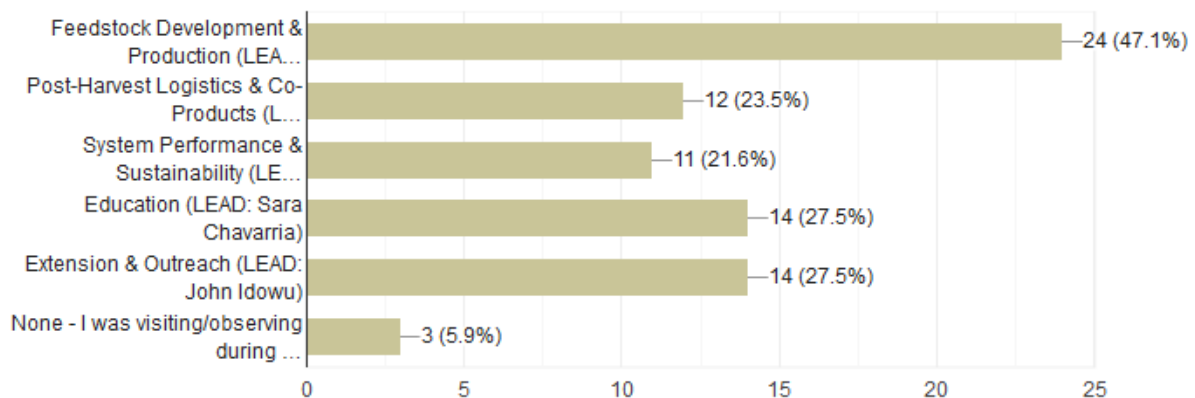
### What is your role in SBAR?

51 responses



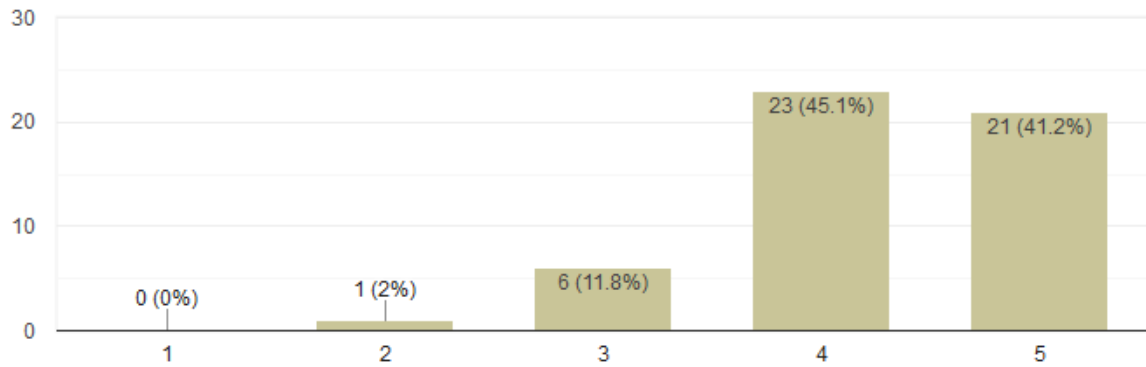
### In which SBAR Component(s) do you participate? (check all that apply)

51 responses



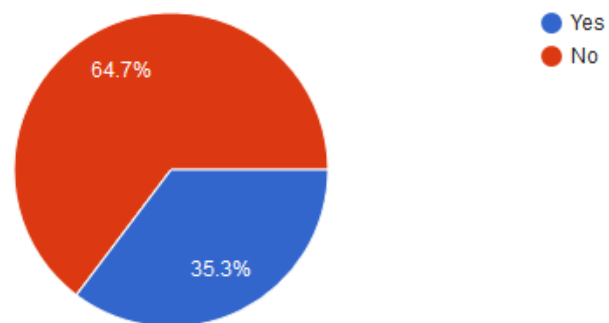
### Rate your overall experience at the SBAR 2018 Retreat

51 responses



### Did you attend the Association for the Advancement of Industrial Crops (AAIC) Annual Meeting hosted at the El Conquistador Hotel/Resort?

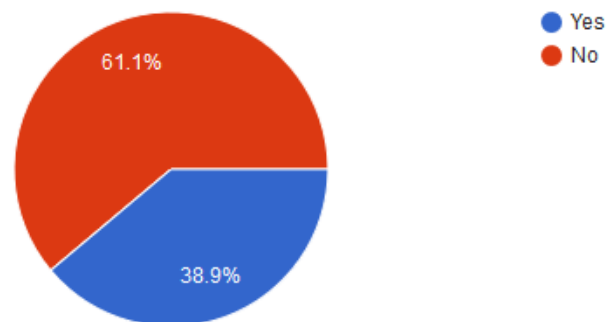
51 responses



## Joint Meeting Attendance – Association for the Advancement of Industrial Crops (AAIC)

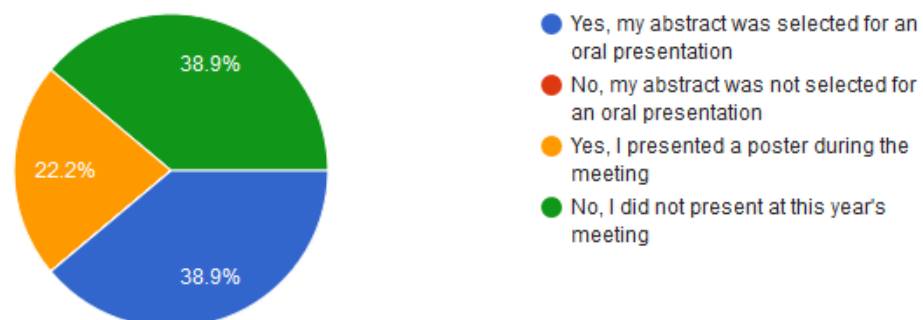
Prior to this year, had you participated with AAIC activities in the past?

18 responses



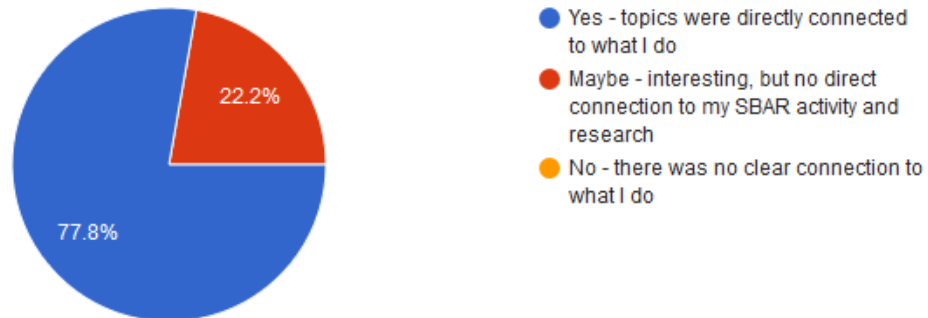
Did you present SBAR-related research at the AAIC meeting (either oral or poster)?

18 responses



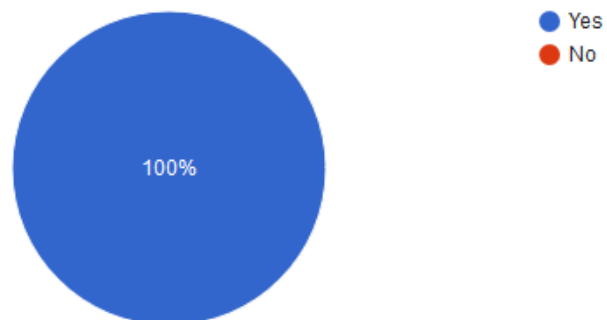
Do you feel that the AAIC meeting you attended was helpful for your future SBAR activity and research?

18 responses



Do you feel that relevant topics (to SBAR research) were addressed during the AAIC meeting you attended?

18 responses



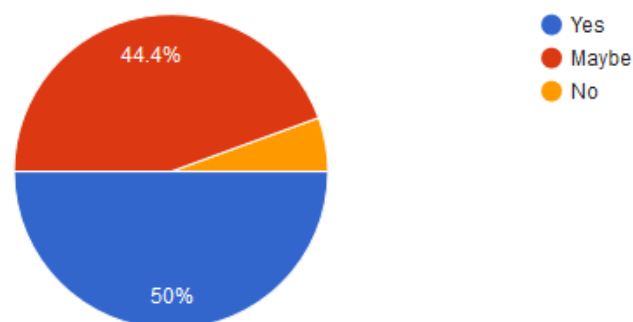
## To what extent did the AAIC meeting produce unintended outcomes (positive and negative)?

8 responses

It was great to hear all the presentations from SBAR
Positive
Good meeting, nothing unexpected.
I learned a lot more about the guayule research collaborative at AAIC than I did at SBAR.
To a small extent and positive.
Networking opportunity to ther countries
It gave me the chance to hear some detail about guayule research that I did not hear about at SBAR.
no unintended outcomes

## Based on your experience this year, will you attend an AAIC meeting in the future?

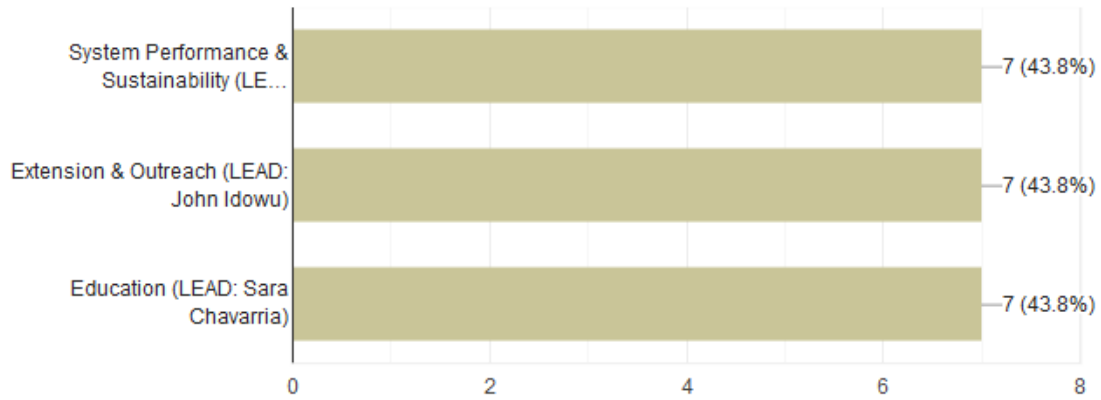
18 responses



## SBAR Pre-Retreat Sessions

In which session did you participate? (check all that apply)

16 responses





## What topics were discussed during the pre-meeting(s) you attended?

13 responses

A general review of everyone's research	^
digital efforts, recruiting participants - strategies and planning	
future research; future education work; future extension plans; ways to combine efforts with others	
Year 2 accomplishments and year 3 goals specifically data collection and model integration efforts.	
data collection, publications, updates from team	
objectives for yr 3, summer training, tech connectivity for teachers,	
year 2 accomplishments, year 3 plans	
We met with Catie to plan our objectives for the year and the plan for NM fellows and the 2020 Summer PD	
Extension goals and accomplishments	
Education, messaging, recruitment	
News Letter, Field Demonstration, Guar Workshop,	
project progress, next years goals, team member connection opportunities and needs	▼
Accomplishments of year 2 and plans for year 3	▼

## Do you feel that the pre-meeting you attended was helpful for planning your SBAR activity for next year?

16 responses



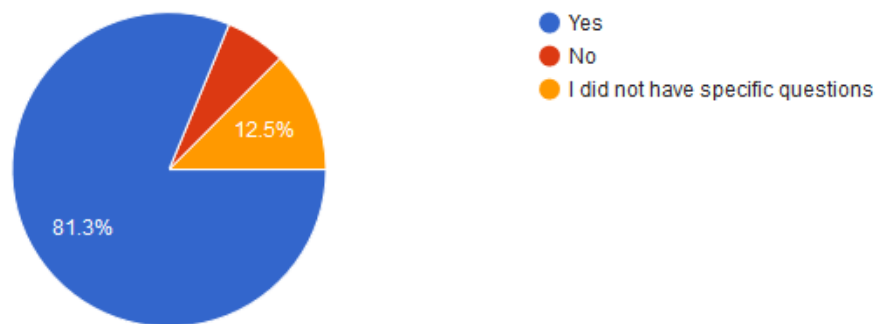
Do you feel that relevant topics were addressed during the pre-meeting you attended?

16 responses



Do you feel that your questions were answered during the pre-meeting you attended?

16 responses



## To what extent did the pre-meetings produce unintended outcomes (positive and negative)?

10 responses

I think the outcome was extremely positive, specially for me since I'm a new member.

all outcomes were positive. We got things ironed out.

face-to-face interactions are always beneficial for project performance. it would be great to be able to have more of these meetings... though budgets are limited.

From what I could tell there were a few (positive) new topics that arose.

potential hemp research

still need a more solid plan around the UA & NMSU 4H moving ahead; overall very good use of time and opportunity for open discussion.

I run the meeting so I have bias. I think to date they have been critical to our success. That said, not sure we will do one before next year. I would prefer to do a 3 hour meeting pre and then a 3 hour post.

Very helpful to meet with Catie in person and we've set up bi-monthly meetings with her.

Positive outcomes

Overall it was positive and good productive discussion..

## How can the pre-meeting sessions be improved to address your concerns or questions?

9 responses

I would love to have a summary of the actions to be taken available for students. I'm not sure if they were discussed in other sessions.

It would be good to know clearly ahead of time if advisory board or industry partners will or will not be in the room. The first year they were, the second year they weren't. Their presence changes the materials we prepare and bring into these meetings. Knowing what to expect would be helpful.

I think if we all review slides that highlight prior year objectives and outcomes before the meeting and save our time for (moving ahead) 1. next year objectives 2. what challenges/obstacles need to be addressed and possible solutions.

better attendance - avoid conflict of other meetings for PI's and personnel who are more than one team

see above, 3 hour pre and 3 hour post. Want to have time after advisory board feedback.

We sent out an agenda and a list of topics to discuss which helped. The only improvement that comes would be having a longer time to meet. Since we won't be traveling to NM in Dec perhaps we could explore having Catie come here for a day during the year—we were able to get a lot done with her in person.

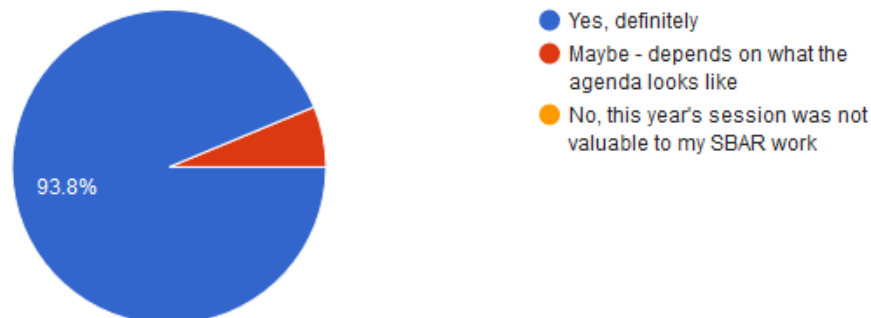
The pre-meeting seems to be the best time to have interdisciplinary conversations, but if we are with the same people all day discussing a single topic those opportunities are missed out on.

They were fine. Sessions that included fellows and teachers.

Individual group agenda in advance...

## Based solely on your experience this year, will you attend a pre-meeting session next year?

16 responses

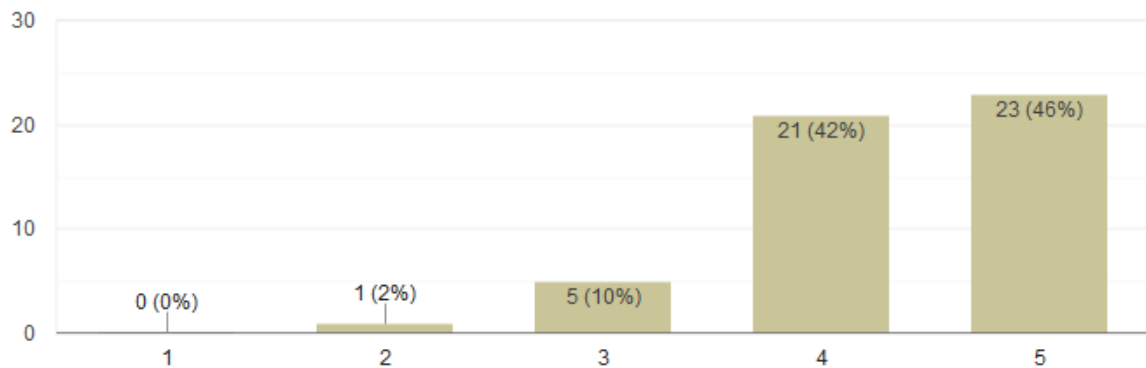


## SBAR Retreat Sessions

Likert Scale used throughout: Strongly Disagree (1) – Strongly Agree (5)

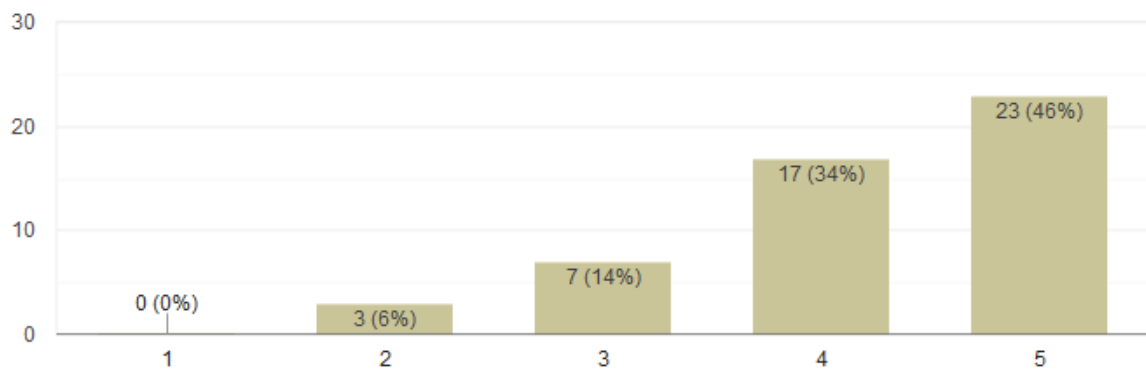
The objectives for the Retreat Plenary Session (Thursday morning) were clearly defined.

50 responses



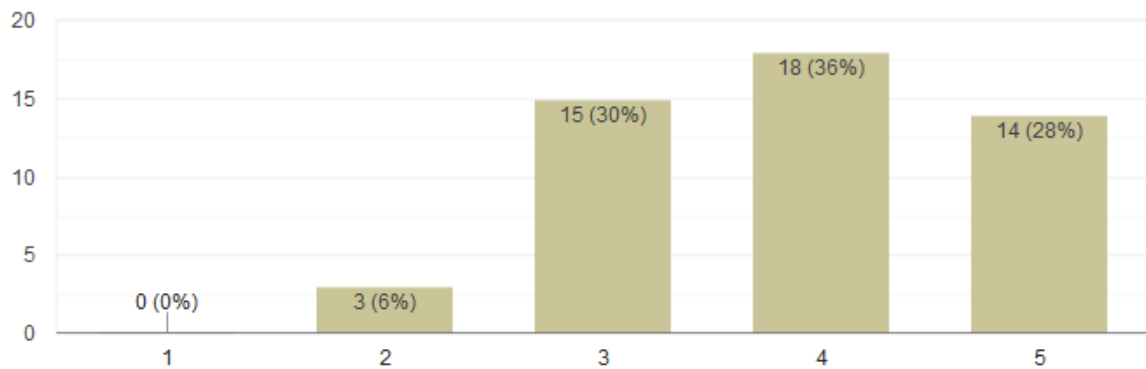
Component updates and accomplishments were clear from the presentations.

50 responses



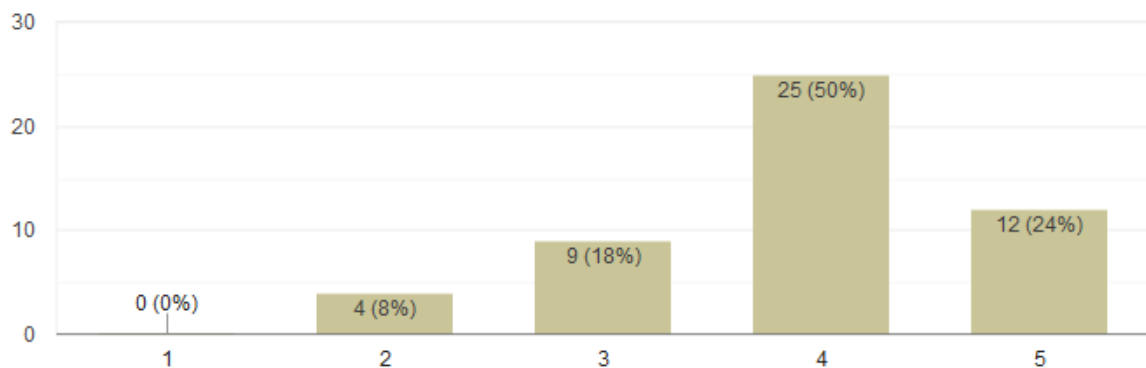
I can confidently discuss the multiple facets of SBAR because of the information provided in the component updates.

50 responses



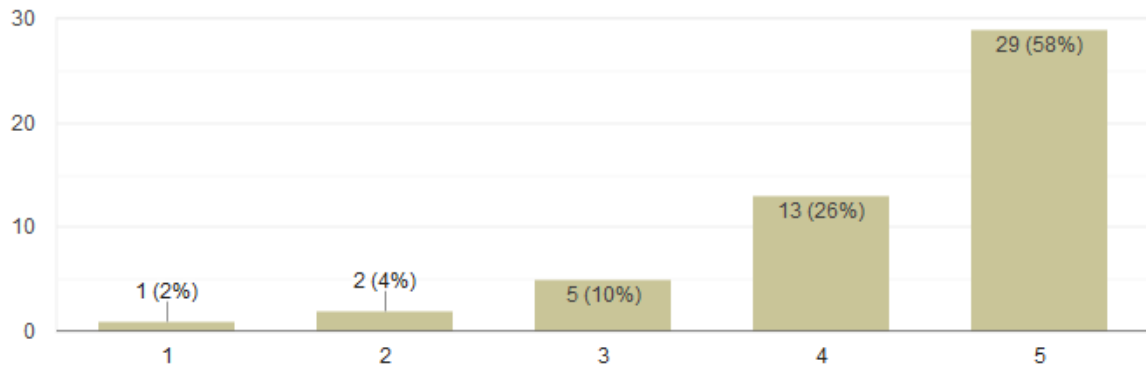
I understand the next questions to be tackled by SBAR project researchers.

50 responses



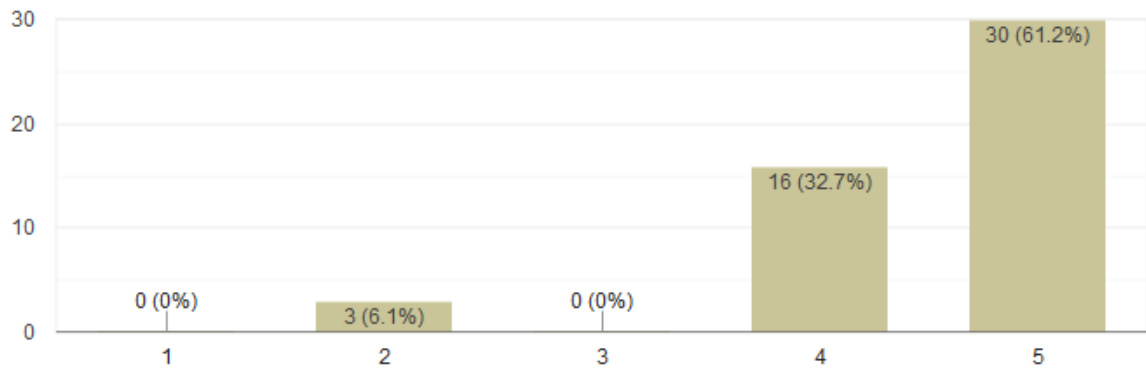
The student lightning round was a good way to introduce the research posters.

50 responses



The student poster session was relevant to the SBAR objectives.

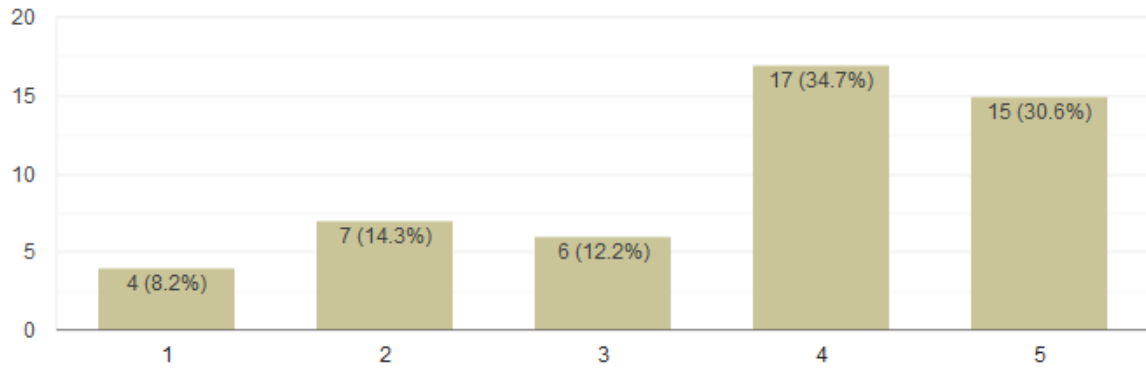
49 responses





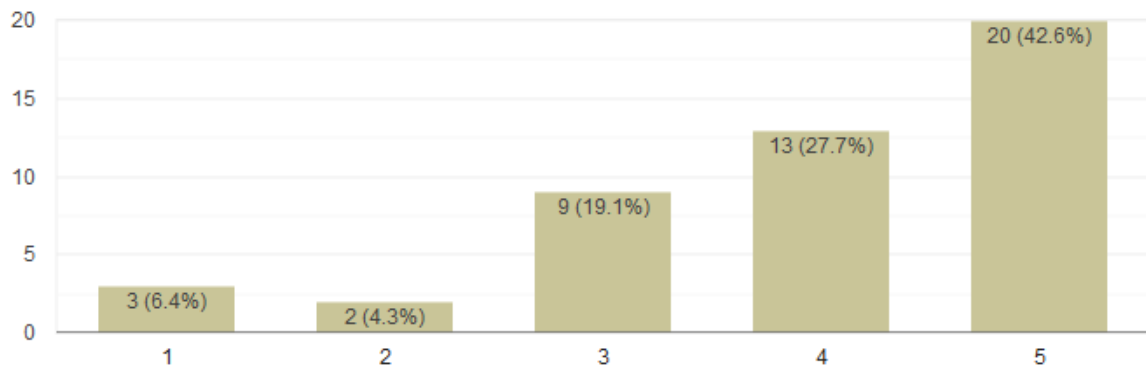
### The student Face Off was a good addition to the agenda.

49 responses



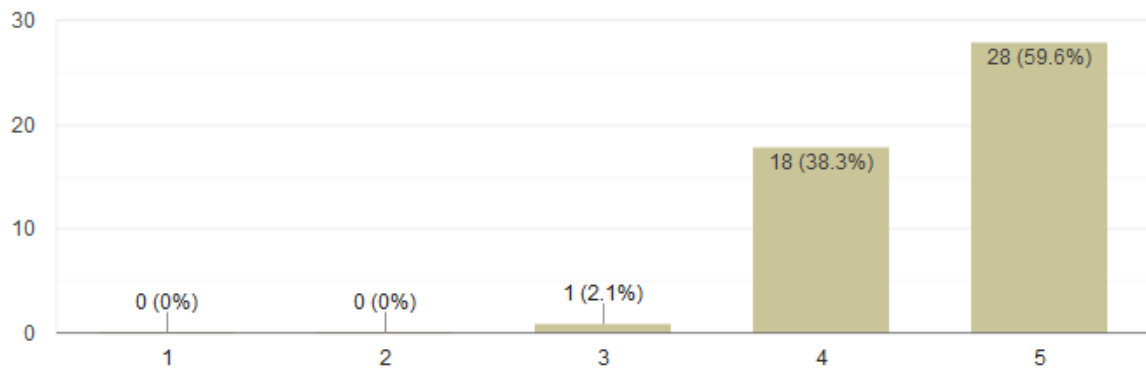
### Comments/Suggestions made by the Advisory Board were directly relevant to my specific part of the SBAR project.

47 responses



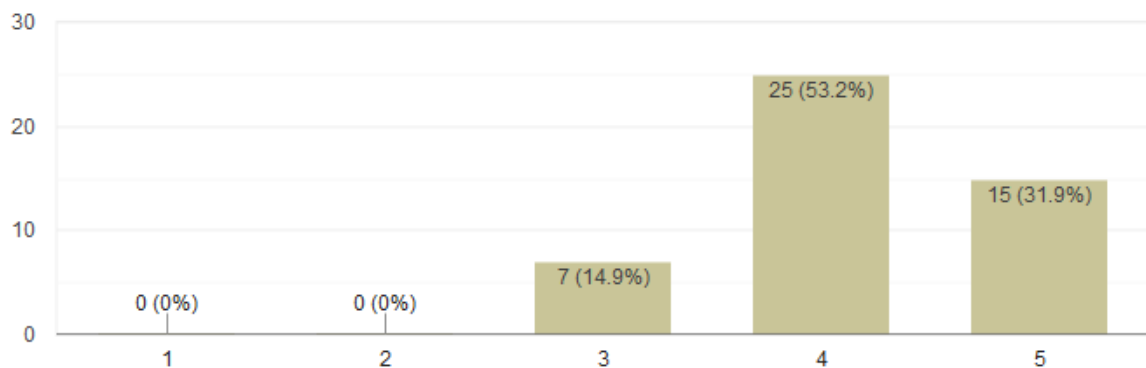
Comments/Suggestions made by the Advisory Board were relevant to the project as a whole.

47 responses



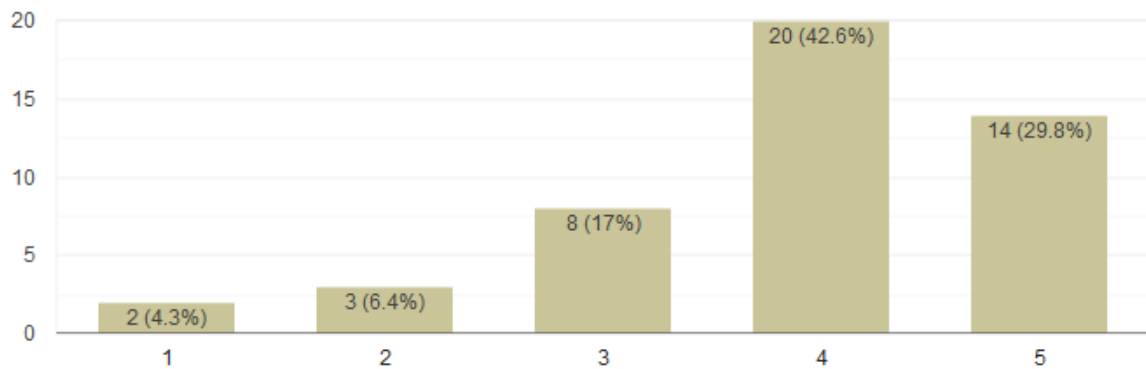
Comments/Suggestions made by the Advisory Board were clear and understandable

47 responses



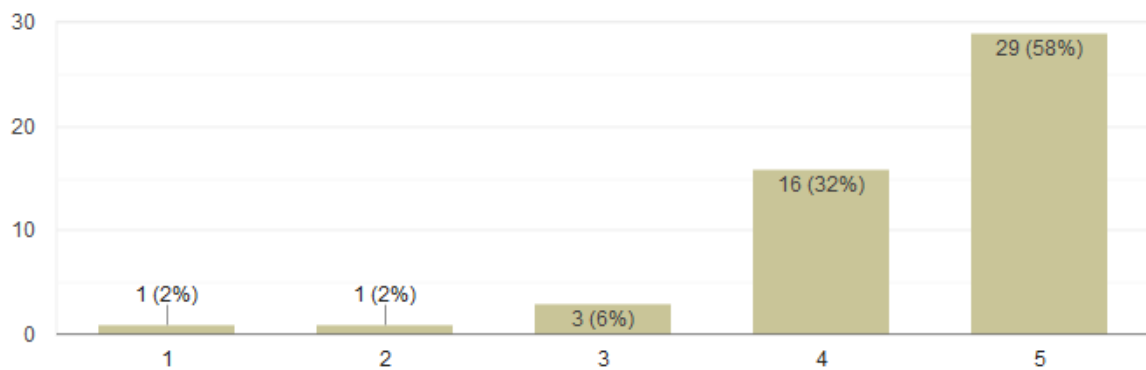
### Advisory Board suggestions will be easily incorporated into my SBAR activities.

47 responses



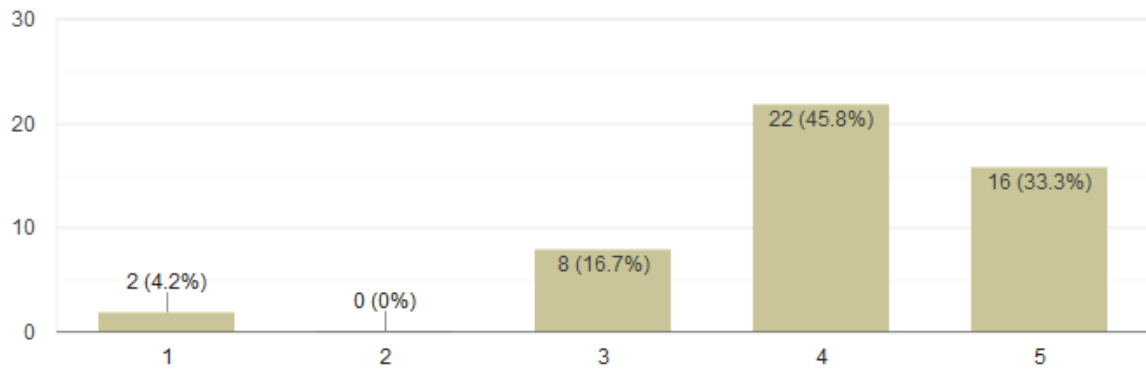
### The information I learned by attending the Retreat will be useful in my future SBAR work.

50 responses



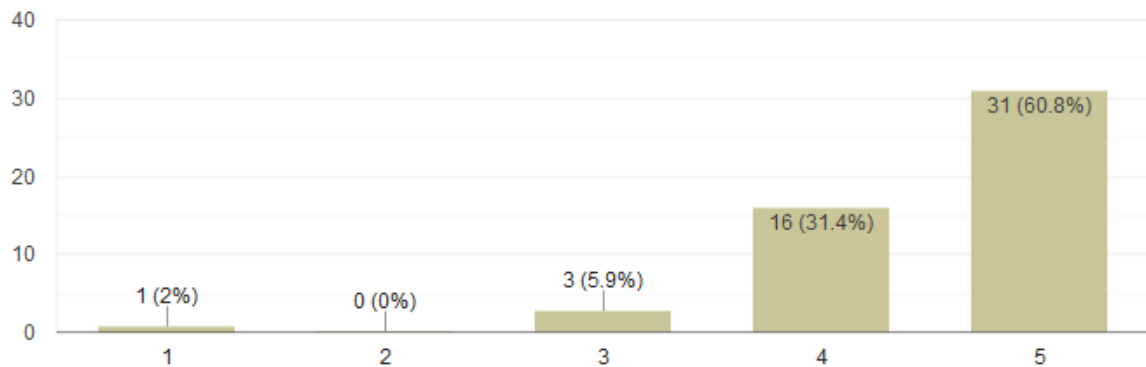
### My questions were answered during the meetings.

48 responses



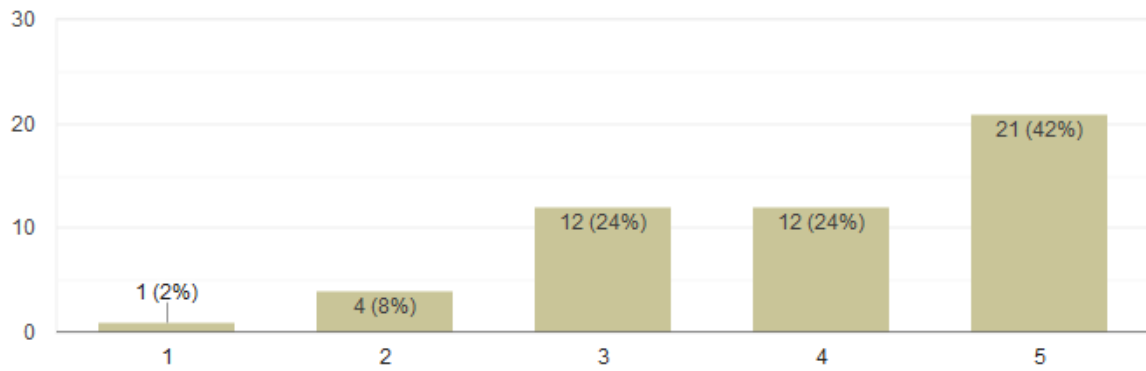
### Participants and interactions were encouraged.

51 responses



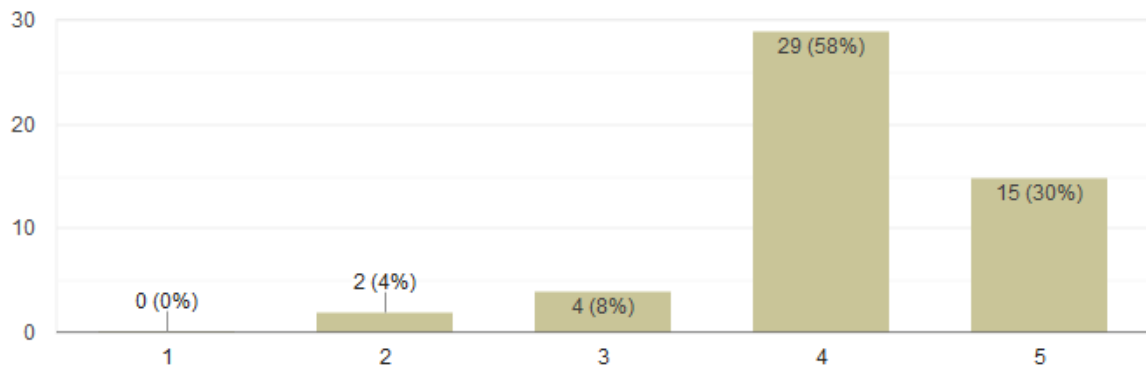
### The time allotted for the SBAR Retreat was sufficient.

50 responses



### I believe the whole SBAR project team is working effectively together.

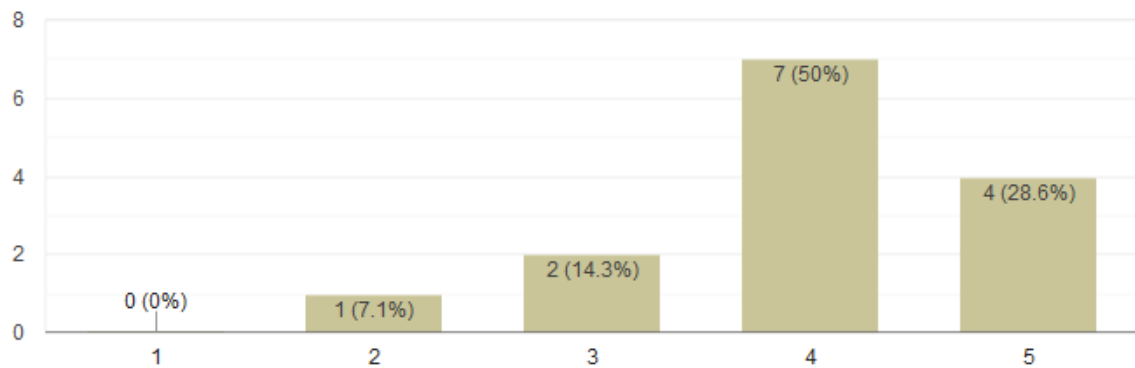
50 responses



## SBAR Interdisciplinary Face-Off

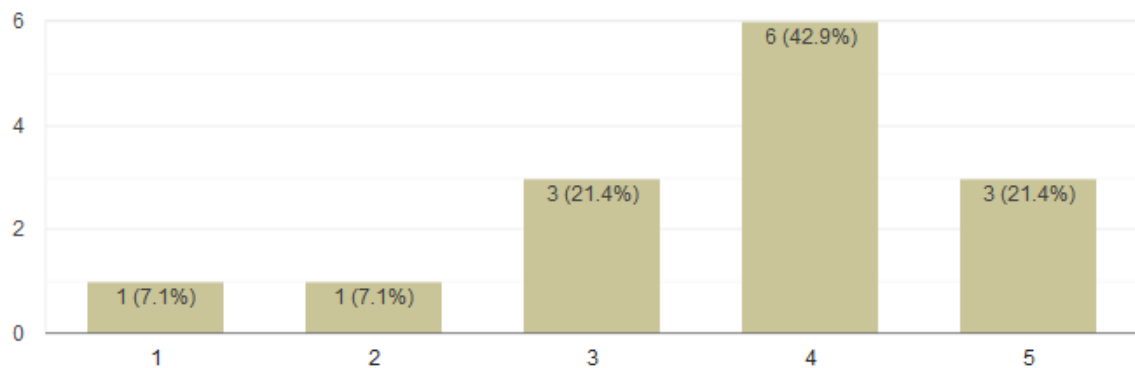
Participating in the SBAR InFO was exciting and fun.

14 responses



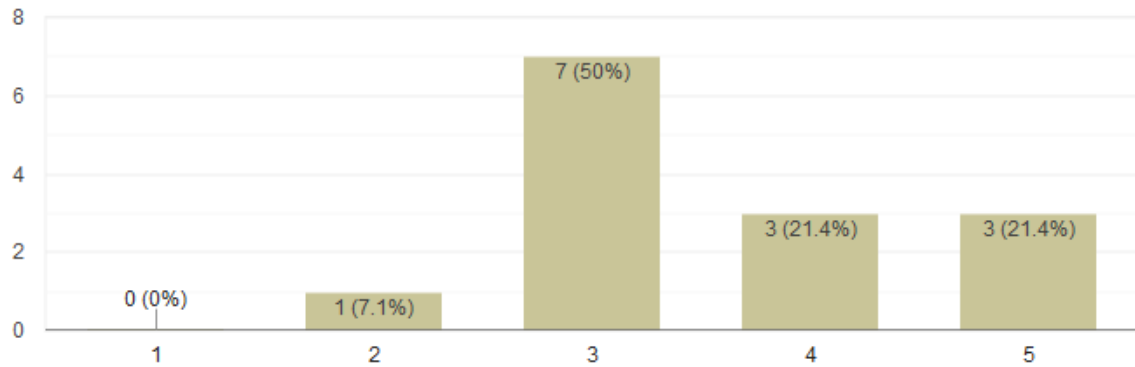
The Challenge presented was clear and achievable.

14 responses



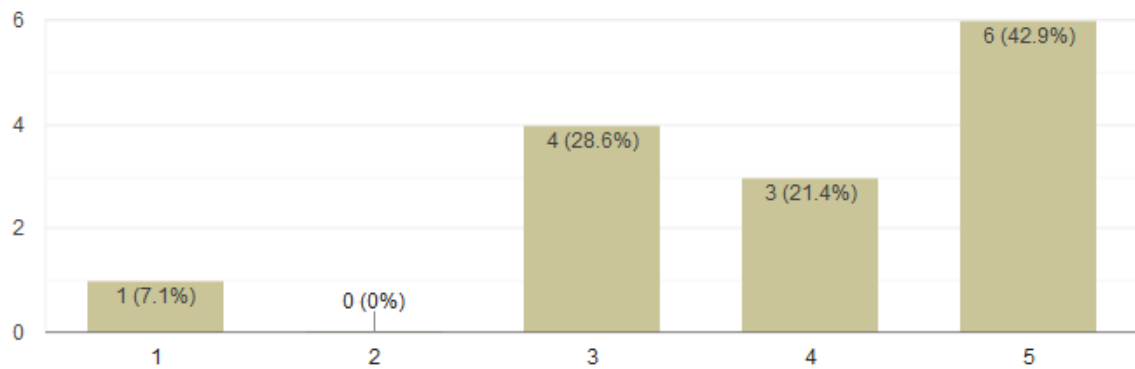
### I understood what was expected of me during the sessions.

14 responses



### Designated student roles were useful in keeping our team members engaged.

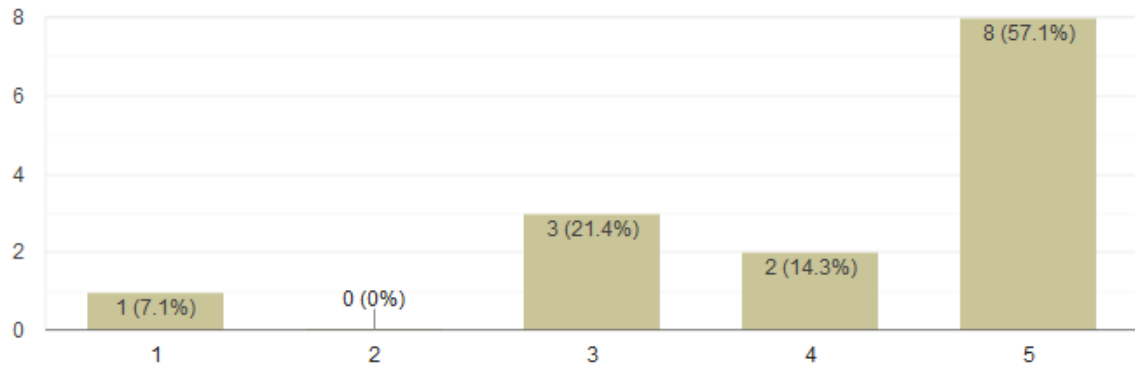
14 responses





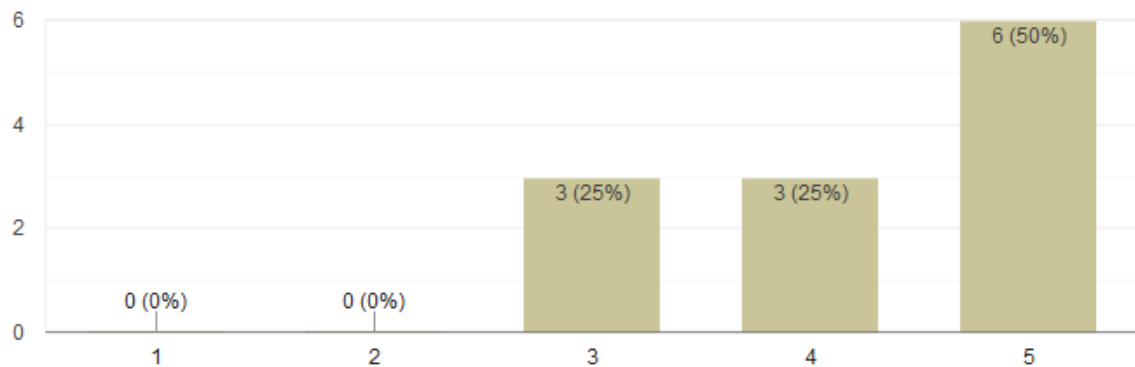
### I liked that the teams were pre-assigned.

14 responses



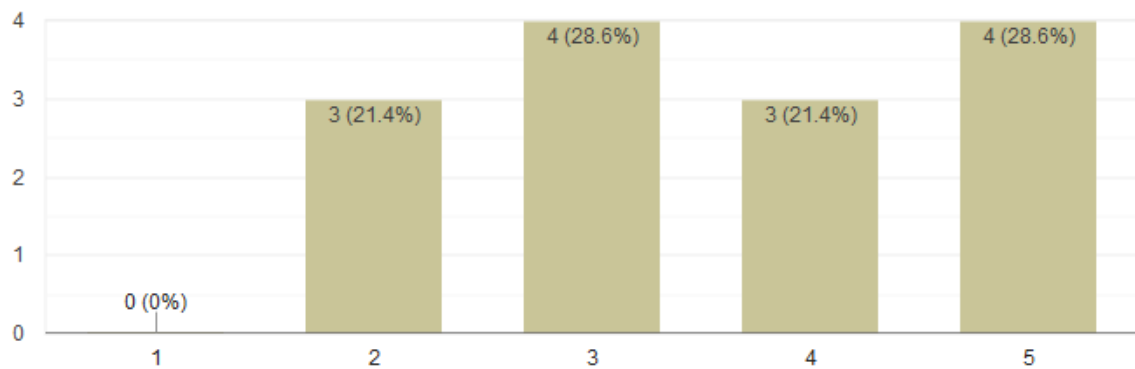
### The interdisciplinary nature of the group was conducive for collaboration.

12 responses



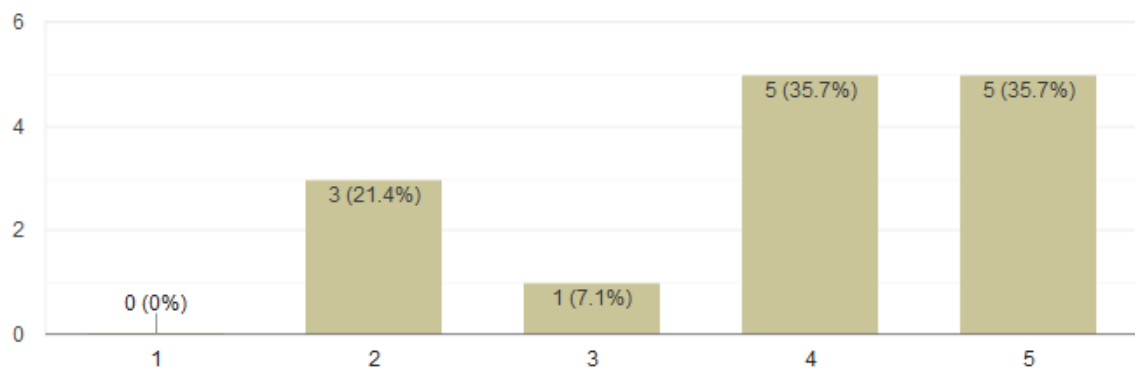
Information provided before the meeting was sufficient for my preparations for the teamwork and discussions.

14 responses



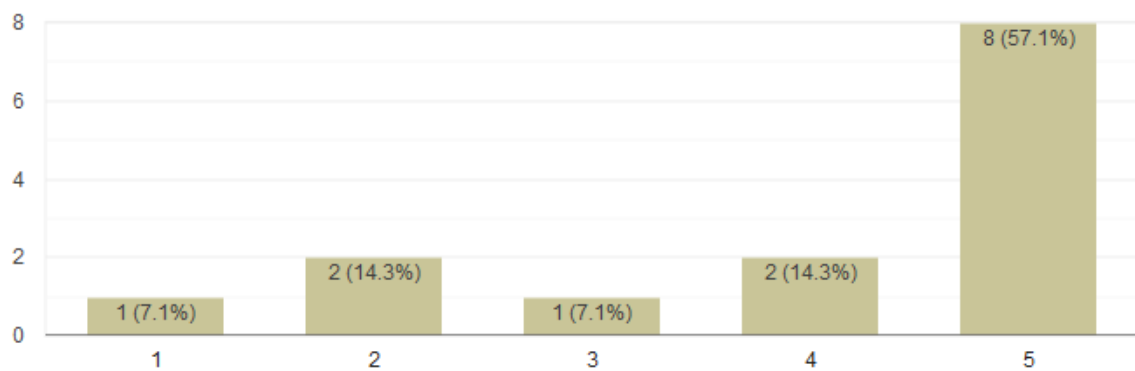
There was sufficient time provided to complete the task with my team.

14 responses



I would like the SBAR InFO to be repeated next year with a different topic.

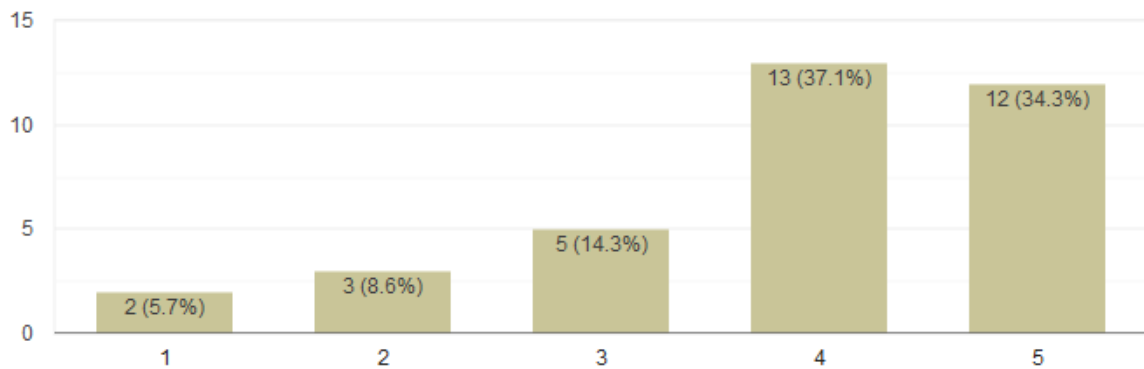
14 responses



## Interdisciplinary Working Sessions

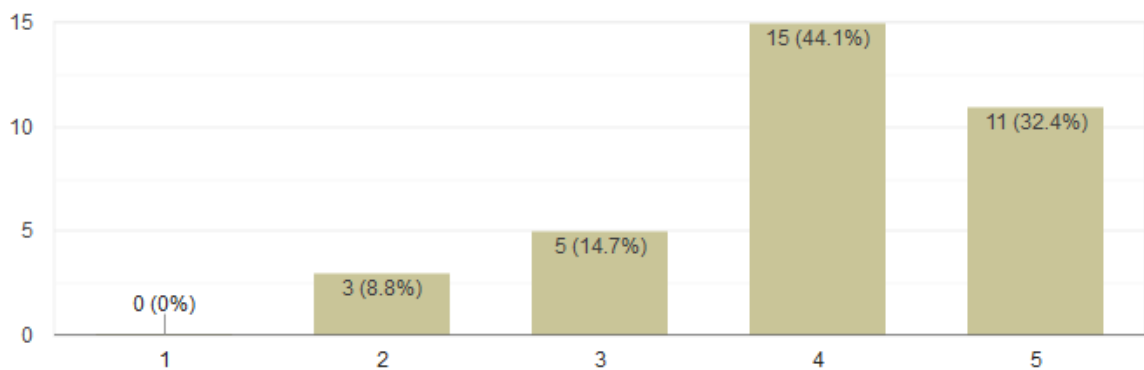
The Project Team Working Sessions were a good use of time.

35 responses



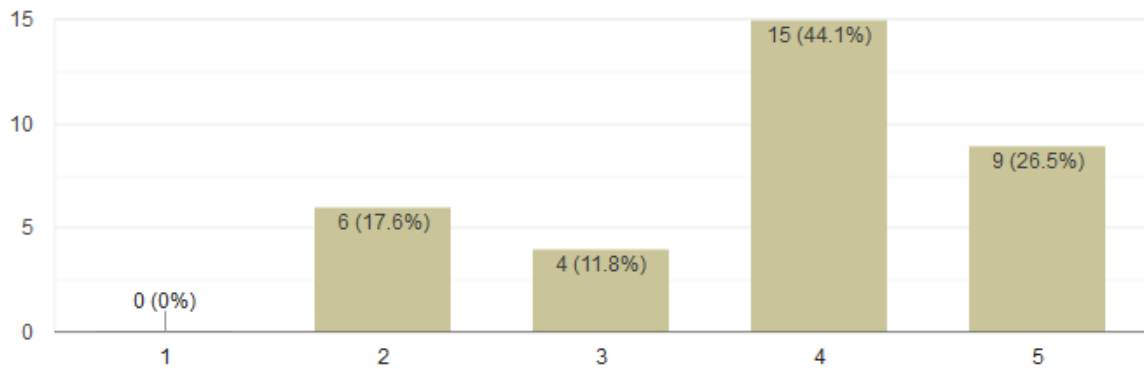
The Project Team Working Sessions were well organized and logical.

34 responses



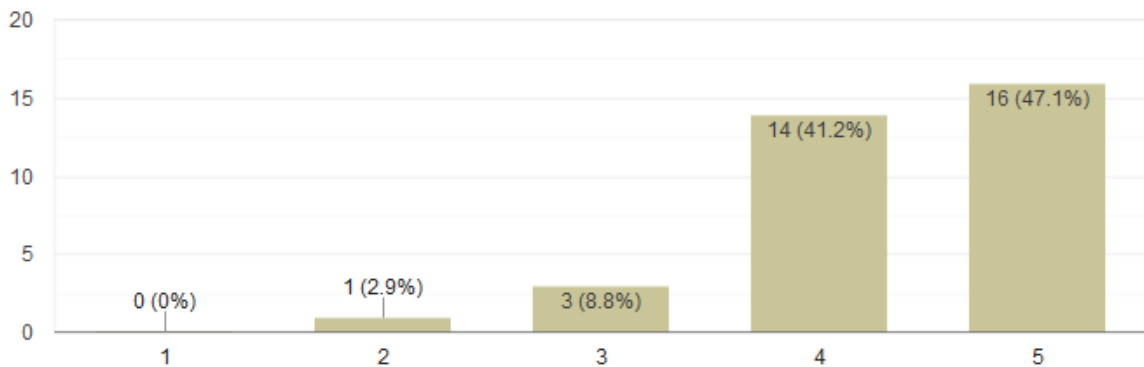
### The topics discussed were interesting and relevant to my SBAR work.

34 responses



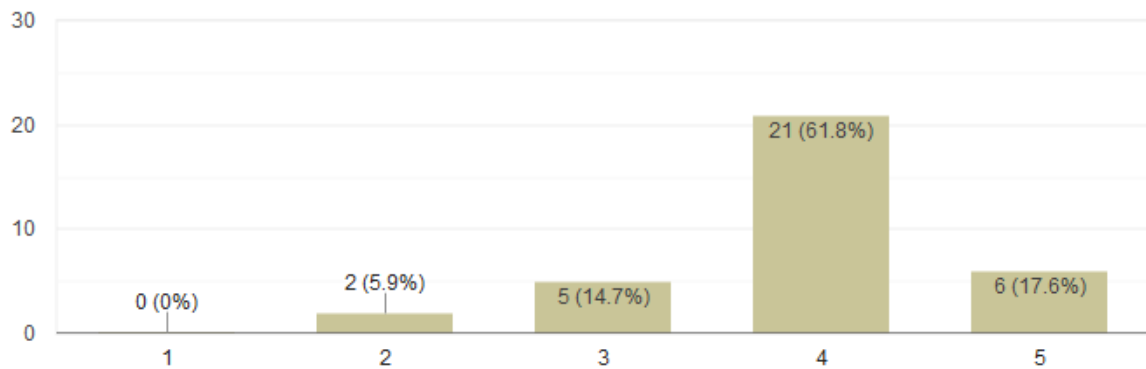
### The interdisciplinary nature of the group was conducive to collaboration.

34 responses



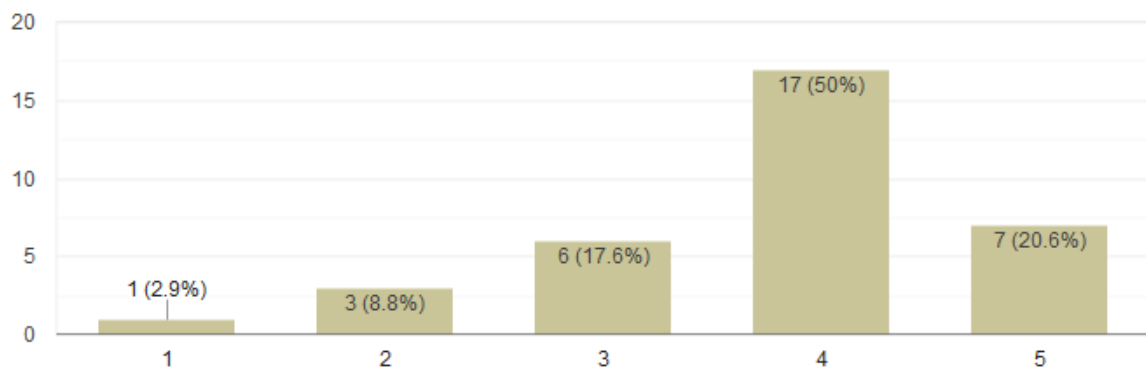
I believe the information generated during the Project Team Working Sessions will be utilized by Component teams.

34 responses



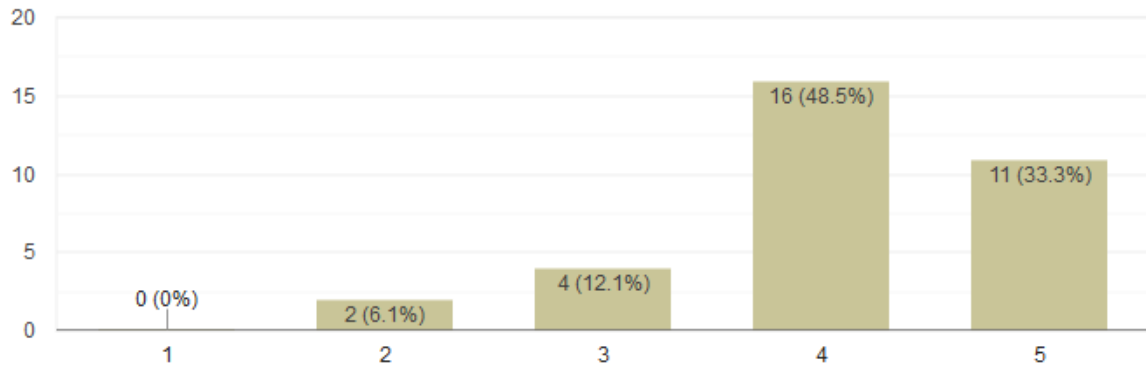
I believe the topics discussed during the Working Sessions will address existing gaps in delivery of SBAR-related information to target audiences.

34 responses



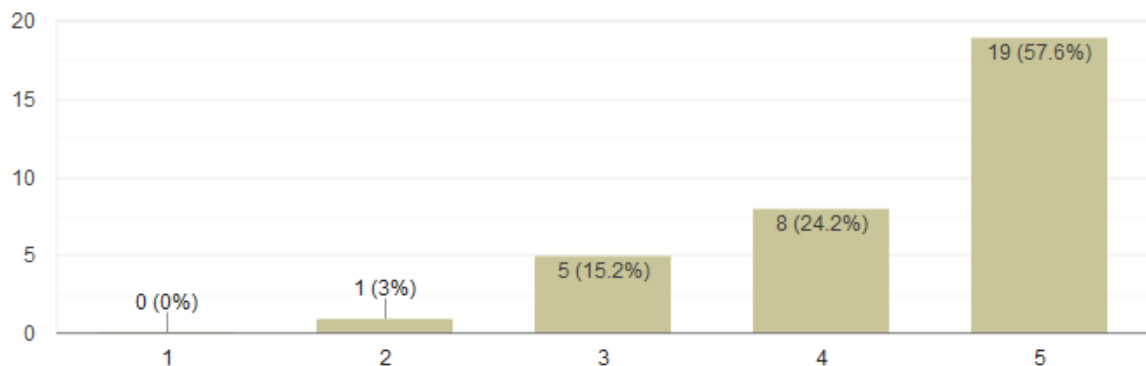
The synthesizing discussion by Component Teams (after opportunities were prioritized; Friday) helped identify how the concepts will be incorporated in future SBAR work.

33 responses



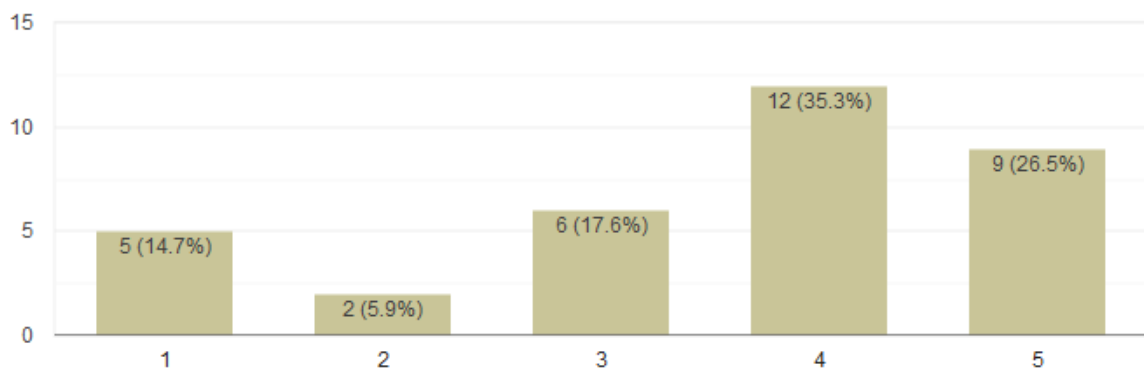
Having facilitators in the room during the discussions was helpful.

33 responses



I would like these types of breakout sessions to be repeated at future SBAR meetings covering different topics.

34 responses





## Other Thoughts for Consideration

### What SBAR project task has been done in an innovative way?

21 responses

Sure. I loved the face-off in particular.	^
All tasks were strong, but none stand out as being exceptionally innovative.	
Sustainability teams initial work is fascinating	
Extension Outreach program	
Sustainability	
sustainability but I have bias.	
breakout sessions	
Irrigation	
Resin characterization by Omar's group is completely new.	
The sustainability team appears to be working on innovative modeling, but this may just appear this way as I have no knowledge of this process.	
Value added coproducts	
Collaborative lesson plan development teachers/fellows	
They are all in different level... I am happy with achievement in Feedstock Development	
I think that involving a Native American school/community is helpful.	
Bringing diverse team together.	
Don't know.	
The student break out sessions gave the students a chance to interact and get to know one another. I think that facilitated student interaction is a positive outcome of the meeting.	
face off	
Not real sure	
The cross discipline collaboration	
The bioproducts teams efforts on coming up with new products to make.	v

## What was one thing you learned by attending the SBAR Retreat that you didn't know before?

23 responses

Almost everything. I know have a better understanding of Guar and Guayule, as well as the SBAR objectives.	^
Bridgestone's timeline.	
Reinforced the role of irrigation and water as an important driver	
Team as a whole	
Work and achievements from other labs and objectives of the project	
Bridgestone's time frame	
There is progress on water stress studies that looks promising.	
continue to learn about what others are doing. Specifically, bridgestones interests	
algae research	
Results of TEA so far.	
Committee on thought and innovation	
Urgency/centrality of financial viability of this venture	▼
Water is the most important thing for guar production from sustainability perspective	
I didn't know about all the stakeholders included in the project.	
Advisory board's view about 'what needs to be done' vs 'what is interesting'.	
Not sure.	
Rubber production costs from guayule are currently at least twice the cost of synthetic rubber production. Resins may provide an important economic component of guayule production.	
I learned more about project efforts related to connecting with native nations	
i didnt know much about guar. now i do.	
actually still have more questions than anwsers	
The specific focus of research and processing challenges	
How extensive the feedstock development research effort is.	
progress on outreach and educational components of the project	▼

## What were the strengths of the Retreat sessions?

27 responses

To get to know the current status of the project in general.	^
Diverse and small groups.	
Outstanding team leads!!	
getting to interact with multiple facets	
Leaders roles	
organization, time management	
Collaboration	
Breadth of knowledge and advisory/industry support.	
facilitators for Team breakouts	
It was well organized.	
interdisciplinary	
breakout session	v
Organization	
Component updates.	
It was great to work on questions collaboratively with the facilitators.	
The plenary was a great opportunity to see all of the work that is occurring and leads to a better understanding of the project and it's direction overall.	
Diversity of attendees and viewpoints	
Collaboration work	
Discussion of broader topics mission/messaging	
Only concern was that there was very little time to interact with members or leads from other groups..	
Having us work in interdisciplinary teams was a great idea.	
Opportunity to interact.	
Very well organized	v

scheduling

for me the breakout sessions on Thursday afternoon

The multiple perceptions and focused discussions on ideas/solutions

Good ideas came from good students.

If you attended the evening "Welcome Reception" on Thursday night, please share your thoughts and suggestions.

23 responses

Nice but far from the UA so easy to lose people. I felt it was not attended by many folks.

DNA

Was good but did not enjoy as no dinner was served and I never drink.

the room was too loud

Great networking opportunity

Great event! Thank you for putting it on!

it was nice. good place to host; decent food and drink service. Too bad there wasn't more outdoor seating.

It was great. It gave us an opportunity to communicate and talk about our projects because we couldn't get the time to share our experiences during SBAR retreat meetings.

I was late but enjoy the less formal atmosphere to connect. food and drink was perfect!

Attended briefly; it seemed fine except the beer smell. Would have been better if Bridgestone didn't schedule an invitation only dinner at the same time.

Another good location for reception this year. It was nice to have this informal time to network. Even more informal network time could be beneficial

I believe last year was a much more successful reception dinner. There seemed to be a much lower participation this year. I don't know if it was the location or the fact that there wasn't an actual meal included, but everything about the dinner last year seemed to be better than this year.

No

Would like to do again

Had interaction with teacher volunteer and advisory board member...

It was great. Thank you!

Didn't due to unique request to engage in a different activity.

The reception was in a good venue and allowed time for relaxed conversation about research projects

The reception was very enjoyable

did not attend



## What changes would you like to see made to the schedule next year?

33 responses

To make it mandatory to students to bring laptops for the face-off. Otherwise, time isn't used efficiently.	^
Stronger overview and statement of shared vision. Layout Bridgestone timeline and must haves. tee up sessions relevant to the must haves.	
more time for poster judging and student interaction	
Students participation with their leaders	
Researchers really need to know what everyone else in their area is doing. Overview by the leader and quarterly reports are not enough (you cannot ask questions or get explanations). If we are to be more interactive, we need to understand what everyone is doing.	
don't serve breakfast - hotel offers breakfast, so it was too much food.	
Great design.	
A different student session or way of incorporating students into the retreat. There are several different levels of student. For instance, there are both undergrads and senior PhD students at the retreat. These two groups have very different objectives at the retreat. Lumping them into one group limits their options.	
More time to hear from PI's on specific research, findings and future projects.	
Each team highlights at least one top success and it goes on one slide. Face-Off needs to be reconsidered: getting qualified facilitators who are not invested in this project to commit to that many hours is next to impossible. Maybe host the face off working session the weekend prior or days prior but in the evening might solve the problem. I think teams could still present solutions during the Retreat.	^
I would definitely let students, who are doing research in SBAR and not all of them, participate in PIs meeting and other related meeting to those research to share their research with other groups, because those students are directly involved in that topic everyday so this meeting would be the best opportunity to ask their questions to improve their research for the next year.	
post board working sessions	
More time for researchers to present their research and discuss. A guide like the student posters listing each PI's project topics	
More time on the various projects	
More opportunity for Research Teams to talk to each other (across Components).	
The retreat was very well organized and I appreciate all the thought that went into it. The role of growers and indigenous communities is crucial to the success of the larger project. It would enhance our understanding and work to have these groups represented in the retreat as much as possible. The sessions with our work groups to follow up on the facilitated activity was productive. It would be interesting to hear one last share out of what the different work groups took from the facilitated discussions and how they will incorporate the groups ideas.	^

I would like to see some kind of inclusive group event for the pre-retreat. I also think that 5 hours in the break out session was a bit much and took away from our ability to discuss topics that are more important to us individually.

More time for networking

N/A

More time for networking (unstructured); so many good discussions got started then had to stop to move on to next activity

Some free time to interact with outside team members..

I would really like to see more Native American involvement, if possible.

More time to present research results and discussio

I would like to see more detailed presentations of research by the PIs and key collaborators to encourage more understanding and interaction between SBAR members. The breakout session were good to get to know different people, but they limited the people you got to engage with because you were with the same people for most of the time. It would be good to have more interaction with other members after the presentation of research ideas. Potentially switch up groups for breakout sessions or plan for more unstructured time for collaboration. Also, it would be beneficial to see a written summary of the advisory committees recommendations, either as a print out or powerpoint presentation. It was harder to follow just an auditory presentation, especially at the end of the retreat when people are tired and ready to go home.

Give more time for teams to interact.

Please perform the poster judging activity in a different manner.

Too little time was allocated to the Component status updates on Thursday. I would like to have concurrent research sessions where more detailed research presentation (10 min each) could be given by PIs and time could be allotted for discussion of results.

I would like the students to be able to join the rest of the project members in the breakout sessions. I think it will be valuable to have both parties present and able to discuss various project issues, since we do not have many other opportunities to be in the same space as most of the other team members throughout the year. Perhaps having one day with a student breakout and one day with a combined breakout, both are valuable and it would be nice to fit both in if possible.

Would like to see more info from researchers. I enjoyed the student presentation but would like to hear from researchers on their research.

need more info about growing as this is a industry that is not going to replace other crops that are being grown at this time due to economics and the [past history of the crop with attempts over the last 40 years trying to introduce this crop into local production systems.

Like the year before, it would be preferable to have the advisory panel sit up in the front and answer questions or give their comments.

More time for progress reports of the different research components



## What topics would you like to see covered next year that were not covered this year?

24 responses

I would like to see how we can relate to native communities or to include government incentives in the project.	^
communication regarding SBAR outcomes externally	
Guayule Production and it's farm level cost benefits from the actual growers	
Time set aside for teams to discuss.	
A guest presenter on new ideas for technology integration...or team dynamics	
I think most of the topics are focused on the agroeconomic and extension part, and the post harvest and co-product have not been discussed that much in this meeting. Because as I found the co-products (bagasse and resin) are the main concerns of advisory board so it needs to be covered much more.	
none	
The actual research being done and plans for the future (in depth).	
I wonder if there is a way to get the Scientific Advisory Board, and Bridgestone input/feedback, in advance of the meeting. Then we can respond to concerns during the meeting, instead of hearing all the feedback at the end (or in side conversations which is a lot of what I experienced).	^
Example, the resin stuff. This year it would have been great to have an entire session on resin: research, economics, sustainability. And really important to get Bridgestone to speak with data, at least on the technology side.	
The needs, perspectives and viewpoints of growers and indigenous communities.	
I would like to see a presentation from a group/ farmer/ native american representative as to why they aren't interested in growing these crops and the reasons behind it. I think a large portion of the group needs to hear a presentation from real industry individuals, not researchers, about the limitations and concerns they have in their business model.	
Drug discovery	
Media, social media, strategies. Overview of agriculture/economy in SW. Past experiences with Guayule in AZ.	
An update from Bridgestone and from Guar Resources (and other industry partners) beyond the Advisory Board	
Some interaction with non-team members and more interaction	v



Co-authorships/credits for the work.

I would strongly prefer to have project review sessions with the PIs to discuss status to goals, key findings, key challenges, and work plans. I definitely want to see the reverse commercialization plan and discuss remaining needs.

More time for research interactions of relevant groups. SBAR supports a great group of scientists with great opportunities for interdisciplinary research collaborations. I would like time in the annual meeting for group discussion of cross-disciplinary research themes. PIs could suggest research topics in advance.

More focus on our native nation efforts, since it is a key part of our mission statement

n/a

see above

more input about the resin everyone talks about and the growing. seems to me that with advances in technology that this is a crop that genetics should be moving at light speed.

A little more time for review of the projects done during the last year. One session isn't enough time for that.

## What can the SBAR Leadership Team do that will help you achieve your SBAR-related goals?

21 responses

Keep doing the same amazing job.	^
Laser focus on mission critical activities, data, and analyses.	
Find greater opportunities for cross pollination	
Good guidance and passion	
I am getting good leadership from the leasers.	
N/A	
Put together a clear flowchart or schematic of what research is being done where so I can see how they are tied together.	
Communicate	
Get Bridgestone to speak with data.	
I debriefed with the SBAR fellows last night in the seminar. They were glad to attend. One of the takeaways from the conversation is that it would be beneficial for the Leadership Team to connect the dots for the bigger picture, explaining the role of each group and why each one is important. This big picture explanation and vision for where we're going could be helpful even for those returning.	^
Not sure, but I think you might get some more honest responses if this was an anonymous survey.	^
Yes	
Emerging research shared in accessible way with teachers/lesson developers	
Clarify who the leadership is for the 4-H/youth extension/internship components	
I liked some additional support to a few co-pi's.. Knowing the process would have helped me.. because some groups want me involvement, but I do not have funding for those activities... eg. sustainability group wants farmers data..	
Just continue to support and communicate on topics/workshops/trainings that would enhance what we are doing.	
Keeping everyone on the team at the same page.	
My goals are to see the project meets its objective of helping Bridgestone be successful with a commercial launch.	

My goals are to see the project meets its objective of helping Bridgestone be successful with a commercial launch.

n/a. i thought everything was great!

Show me that this can be a financially viable crop with a return on investment that makes sense to me.

Help with collaborative efforts

## Do you have any final thoughts that you would like to share?

19 responses

I would like to thank the SBAR team for the opportunity to be a member and share this great experience.	^
Awesome project!!!!!!!	
Team work is ever powerful and appreciated by all	
I enjoyed attending the annual retreat	
Nice work, Alix!	
you didn't ask about the food :)	
thanks to all that pulled it together.	
Salad isn't the only gluten free option and flavored coffee is not good. Thanks!	
First time - gave me a "bigger picture" of the efforts put forth.	
Honestly, I didn't get the interdisciplinary exercises or student Grand Challenge from the start. As a researcher the exercise felt like we spent 7.75 hours of the agenda to work out Education, Outreach (and some Sustainability) strategies and tactics. Aren't they better at that than I am? Hours of brainstorming is challenging enough when it's your area. The introverts in the group were exhausted. And the results didn't seem to me to change anything. Then when Sarah presented she was already defensive about the Education results. She's probably right and should do what the educators planned in the first place.	^
Full disclosure- I didn't stay for the Student Challenge report-out so maybe that was a great use of time for them. Or maybe they would have learned a lot from hearing the co-PIs talk.	
My suggestion for next year is to let the co-PIs talk about their stuff. The AAIC SBAR talks were wonderful. Especially for the Feedstock, where there is so much going on. Then the TEA presentation won Best Paper! Would have been great for the SBAR team to have seen it and discussed it.	
Thank you for all of your work on the retreat. It was great to have everyone together in one room and the breakout groups with facilitators was a helpful addition.	
This survey is too long.	
N/A	
At some point, I would like to have my Native students discuss their involvement with the SBAR project.	v

You guys did a great job!

Thank you.

The retreat organization was great!

n/a

As a student I would have liked to have heard more from the research groups instead of spending as much time on the Face off Challenges.

### APPENDIX 3. NEWSLETTER ARTICLES

#### *Documents Included*

1. **Growing Tires in Pinal County** – Newsletter briefing for SBAR research on guayule published in the University of Arizona Cooperative Extension – Pinal County Quarterly Newsletter (Vol. 6, Issue 1). April 2019. (1p)

# FIELD CROPS

## GROWING TIRES IN PINAL COUNTY

*Submitted by Blase Evancho, Assistant in Extension, Field Crops Systems*

Guayule (*Parthenium argentatum*) is woody shrub that is native to the Chihuahuan Desert and has been periodically utilized for its natural rubber production for over 100 years. Large scale rubber extraction from guayule began in the late 1800's and has continued to be utilized when rubber from the Hevea rubber tree is in short supply. Two important examples of this were WWII and the OPEC oil embargo. These shortages demanded the research and production of a secondary source of rubber, which largely fell on guayule .

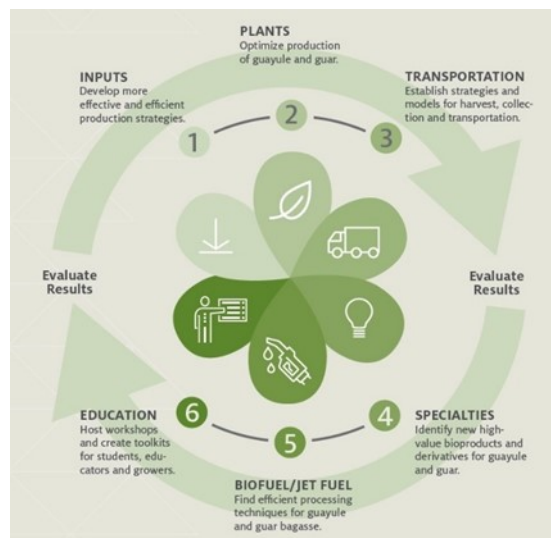
This research provided us with improved genetic lines of guayule, as well as a wealth of knowledge on the agronomic demands of this plant. But, in both cases, when the US regained access to Hevea rubber, guayule research and production was halted.

In the last decade guayule rubber has once again increased in popularity. However, this time it is being driven by the private tire industry, because of the recent increase in global tire demand. As global demand for natural rubber is increasing, global natural rubber production is remaining the same or even decreasing. This is creating a market gap that tire industry drivers are hoping to close with rubber from guayule.

The research to fill this gap is happening right here in Pinal County where there is a guayule research facility focused on “growing tires in the desert.” In collaboration with the private tire industry, the University of Arizona has created the Sustainable Bioeconomy for Arid Regions (SBAR) to aid in crop production research and increase the potential to create valuable products from the remaining components of the guayule plant after rubber extraction.

The first component being looked at is the resin that is removed from guayule during the rubber extraction process, which has potential as a commercial adhesive. The second product is bagasse or ground up remains of the plant which can be used for biofuel production. The goal of this project is to create valuable products from all parts of the guayule plant to create a vital source of income for the farming regions of central Arizona.

While there is still a long road ahead, the steps that are being made today to grow guayule as efficiently as possible and to economically utilize the entire plant and have the potential for long term returns in Pinal County and throughout central Arizona.



*Figure Courtesy of SBAR*

## APPENDIX 4. EDUCATION AND EXTENSION & OUTREACH ACTIVITIES – YEAR 2 EVALUATION REPORT

### *Documents Included*

1. **Education and Extension & Outreach Activities: Year 2 Evaluation Report** – A summary of evaluation results obtained from participants within the Education and Extension & Outreach components. (18 pp)



## Sustainable Bioeconomy for Arid Regions (SBAR)

### Evaluation Report for Education, Extension & Outreach

Evaluation conducted by Raise the Bar, LLC

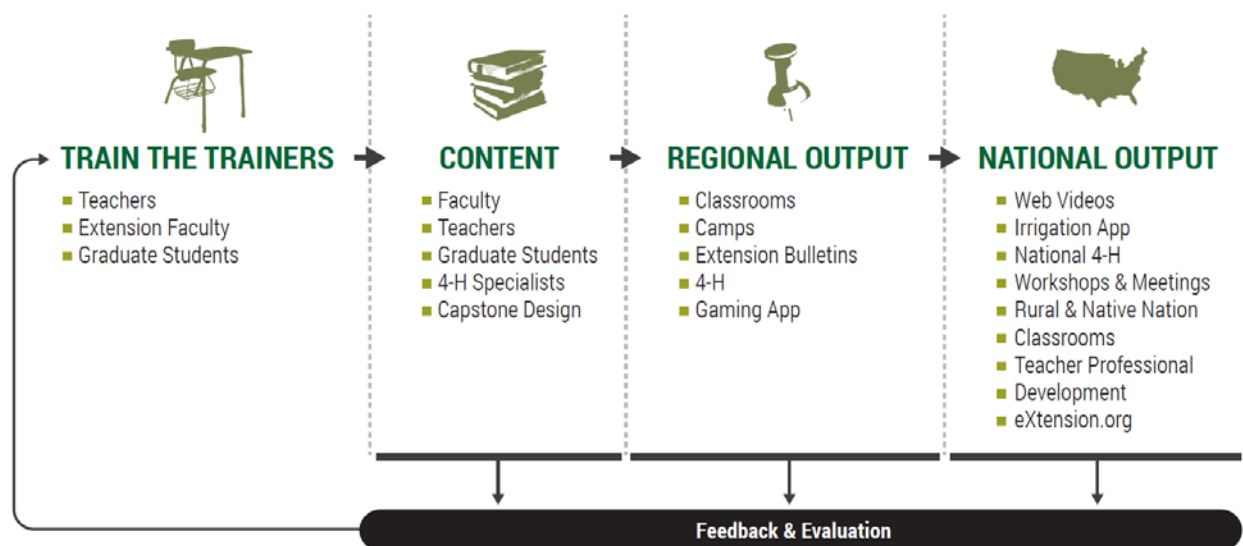
Project evaluator: Jennifer Fields

Period Reported on: Project Year 2, September 1, 2018 – August 31, 2019

Funding for the SBAR Project and Center of Excellence is provided by the USDA National Institute of Food and Agriculture – Agriculture and Food Research Initiative. Grant # 2017-68005-26867.

*The purpose of this evaluation report is to document Education, Extension & Outreach (EEO) activities, processes and products developed and implemented during year one of the project; discuss evaluation tools, methods and findings; communicate needs and concerns of EEO team members; and provide recommendations for programmatic refinements.*

## Extension & Outreach



### Extension – Grower Focused

#### Objectives:

- Produce Extension bulletins and web materials to inform growers of agronomic and irrigation requirements.
- Hold workshops throughout the region on sustainable practices to expand crop production to new rural regions and Native Nation lands.

#### Highlights & Accomplishments:

- ▶ The grower-focused extension team continued building statewide awareness and understanding of the SBAR project through large and small presentations and individual relationship building and knowledge transfer (see attached outreach capture sheets describing events.)
- ▶ Continued to build trust with growers and other stakeholders through transparency in information sharing and informal outreach.
- ▶ Participated in research, especially as related to issues that growers are most interested in (i.e. weed control, irrigation, planting & production, etc.)

- ▶ Extended the visibility of guar and guayule to a variety of audiences and stakeholders through farm trials and demonstration plots and on-site events
- ▶ Acted as liaison between research and education/outreach activities and transferring of project findings

### **Evaluation findings:**

- ▶ Documentation of the true reach of outreach and communication efforts continues to be challenging. While the information gathering tool seemed to work for more formalized, infrequent, large events, it is not the right tool for documenting the myriad of individual touches and subsequent network building among growers and other stakeholders (e.g. Ag professionals), and this is where the majority of authentic communication and relationship/trust building is done. There is much trust to be rebuilt based on past experiences, so this is not a trivial task.
- ▶ Grower-focused extension team members provide a valuable liaison/conduit between researchers and the education and outreach teams. However, much of the information is understandably around the research areas that are most important to growers (i.e. weed control, irrigation, planting, etc.) There still is not enough robust integration of researchers who are directly engaged with the EEO efforts in an authentic way, or in any way. It would be helpful to have more direct messaging from the project leadership to the research team about the important role of this integration.
- ▶ Publications targeted towards growers are one of the expected outcomes/deliverables for the grower-focused extension group; however, there has not yet been much movement in this area. In looking at the stated objectives, the publications are intended to inform growers of agronomic and irrigation requirements. Some publications on Guar should be coming soon from the NM team because they had already been working on Guar prior to the start of the SBAR project, but the expectations from project leadership are not entirely aligned with what the extension team feels is possible at this point. The reality is that the research isn't yet far along enough to produce publications that the team feels will be of value to their stakeholders. While leadership has requested some informational publications in lieu of peer-reviewed, research-based publications, I believe that the team is struggling to understand what type of publication they might produce that would be useful to their stakeholders. More direction from leadership would be helpful in this regard. It would be helpful if researchers were anticipating the type of fact sheet that might be needed and useful to stakeholders and worked more closely with the extension team to be planning for publications and understanding what information can be woven into a useful tool (fact sheet, bound resource guide, online learning module, etc.)
- ▶ Overall, there is a sense that the project leadership is asking for outcomes that the team can't yet deliver on. While they are working to spread information about SBAR and the two crops, there is a common feeling that growers won't really be interested, and most certainly won't commit to growing the crops, until the economic analysis has been completed. The extension team feels that one of the roles they play is to understand the issues that farmers will face. What weed control will be needed? What will deliver good residual rates? There are no combines in NM, so what investment will they need to make for the crop to be profitable for them? Will there be a processing plant close enough to be feasible? Until there are answers about these and other questions, all they can do is continue to spread the word about the project but can't really actively recruit growers.
- ▶ The SBAR budget alone isn't sufficient to support all activities, and additional funds had to be leveraged to complete all work.

### **Looking towards Year 3:**

- ▶ The extension leads and the evaluator have brainstormed ways to document the smaller touches that cumulatively build the network over time. The majority of the relationship and network building work is in small increments, often with individuals in informal and impromptu situations. I encourage the extension team to capture this work in their quarterly reporting even if it is anecdotal, it is legwork that takes time and builds the community of stakeholders incrementally over time.
- ▶ One idea for documenting reach that I believe would be valued by the SBAR leadership would be to visually depict their reach by using a map of AZ or NM (as appropriate to each team) and 'pinning' or marking areas where they have made contacts. For instance (illustrative example), if they made contact with a particular grower who has 1000 acres in the SW corner of the state and who indicated that they would be interested in learning more as the research results emerge, they could indicate that on the map. Over time, the map could represent the POTENTIAL network of growers and other stakeholders with whom they had established contact with or built a relationship with.
- ▶ Several of the team members indicated that they would like to see the monthly meeting format changed. As it currently stands, it is more of a 'report out' structure and the team would like to see more brainstorming of innovative ideas, discussion of challenges and opportunities, etc. Although it is challenging for AZ and NM to work too closely together on individual tasks since they are ultimately working with two different crops and different communities of stakeholders, it would be useful to discuss synergies and strategies that could be used for both crops, in each state.

## Extension – Education & Outreach (4-H and Project Puente)

Objectives:

1. Train teams of students and teachers with a focus on rural and underrepresented groups.
2. Develop and disseminate agricultural bioenergy and bioproduct K-12 modules.
3. Involve youth in 4-H projects and STEM summer camps.

## Project Puente (AZ)

- ▶ **4 Project Puente interns** participated in SBAR specific projects
- ▶ **2 High school** students, **1 community college** student and **1 early college student**
- ▶ Internship placements in research, industry and 4H education/outreach
- ▶ Recruitment area: Tucson, Pima and Pinal counties primarily, but Maricopa as well. The project began through a partnership with Central Arizona College, so historically the overall project recruited about 40 interns from primarily Maricopa and Pinal counties. When SBAR joined, recruitment extended to Tucson to find students who live closer to UA, and also extended beyond high school students into early college.
- ▶ All 4 interns will present posters at the annual meeting as part of the requirement of Project Puente. Interns are required to complete 260 hours of work total and work 4 days per week, 8 hours per day, for 8 weeks
- ▶ Participating interns receive 3 credits at Central Arizona College (credits are transferrable) and a stipend of \$300
- ▶ Participating mentors receive a stipend of \$500 towards items that support interns (i.e. poster and project supplies). It wasn't clear if this is from the SBAR budget or comes from additional resources leveraged.

- ▶ **Mentors:** Channah Rock (UA - extension), Jerry Lopez (UA-extension), Von Mark Cruz (Bridgestone), and Julia Neilson (UA – Research)
- ▶ **Intern's project focus:**
  - One intern placed at Bridgestone examined guayule rubber grown in the desert southwest for tire production;
  - One intern's position was outreach related. They analyzed AZ grower needs assessment data and examined grower's perceptions and comprehension of biofuel, bioproducts, and guar in the SW arid region;
  - One intern assisted with the SBAR Biofuels 4-H summer camp; and
  - One intern conducted scientific research related to guayule's growth, specifically soil parameters that influence natural rubber production in guayule.

### Evaluation Findings:

- ▶ Mentor involvement has improved, with more participation overall this year from both SBAR project researchers and the EEO team. Two faculty at USDA were interested in hosting interns, Dr. Rock would have taken on 2 interns, and there was an interest in placing 4 interns in Tucson, including one with Dr. Ray and one with the Education team.
- ▶ Recruitment efforts were robust. They were aiming to involve 6 interns and ultimately placed 4. Recruitment occurred through reaching out to academic professionals at community colleges and high schools that offer summer internships to students, for example career counselors at every high school at Maricopa and Pima counties. Project staff sent out advertisements of the internship to the career counselors and have them disseminate. Project Puente historically has targeted both STEM and non-STEM focused schools. Pima, South Mountain and Central Arizona are key community college partners.
- ▶ However, placing interns is not as simple as just recruitment. There are a number of challenges to overcome, including logistical issues related to transportation and parking, which are often what makes an internship placement impossible. This is especially true when considering that the interns are working nearly full-time, so having another job to cover these additional expenses is difficult. Because they only earn a \$300 stipend as interns, it is unrealistic to expect them to cover these types of costs. For example, parking at UA can be upwards of \$10 per day, which would cost more for 8-week internship than the entire stipend they are being paid. It is important for the project to set aside funding to support these costs for interns if they expect to have robust participation.
- ▶ The SBAR budget alone isn't sufficient to support all activities, and additional funds had to be leveraged to complete all work.

### Looking towards year 3:

- ▶ During year three, the Project Puente extension team will continue to work to recruit additional SBAR faculty to participate in *Project Puente* for Summer of 2020. This will include resource documents for SBAR faculty on expectations of mentors, expectations of students, timelines, reporting structure, among other topics.
- ▶ The team will create a short PowerPoint presentation directed at recruitment of faculty to participate in the program as well as to be used as an advertisement of the program to the broader campus community. The goal will be to increase participation to a total 6 student interns and 5 SBAR faculty participating in the project in year three.
- ▶ At the culmination of year three, the extension team will also create a short case study video to highlight the success of the program.

- ▶ There has not been data collected to date about the Project Puente interns experience. I would like to work with the team during Year 3 to determine mechanisms for better understanding student outcomes.

#### 4-H Education & Outreach (AZ)

##### SBAR 4-H Biofuels Summer Camp, University of Arizona, June 3-7, 2019

##### Highlights & Accomplishments:

- ▶ During the year, camp curriculum that was developed in 2018 was refined and further tested with high school students at Pueblo High school. Much of the work was done by leveraging UA undergraduate and graduate students through other support mechanisms.
- ▶ A robust camp curriculum and schedule was created, and all logistical components were tackled including recruitment of campers, securing of dorm space, coordination with other 4-H STEM camps.
- ▶ **18** total youth participated
- ▶ **9 female** and **9 male** campers
- ▶ **Campers ages:** 11 (1 camper); 12 (12 campers); 13 (3 campers); 14 (2 campers)
- ▶ **Camper Ethnicity:**
  - **9** Native American,
  - **2** Hispanic/Latino,
  - **2** multi-racial (white/Hispanic and white/black),
  - **2** Asian/Pacific Islander
  - **3** White
- ▶ **8** total staff – 1 Coordinator, 1 lab supervisor/instructor, 3 instructors, 3 counselors
- ▶ **5-day dorm-based residential summer camp** with the theme of Biofuels, presented in the context of the SBAR project content and goals
- ▶ The total cost of the camp was only covered by leveraging significant additional institutional funds and support, largely from UA CALS. The allocated SBAR budget is not enough to implement a camp of this scale without the ability to access and leverage additional resources.

##### Evaluation Findings:

Evaluation data was collected using a number of tools developed by the evaluator and used nationally by 4-H. The camp was observed by the evaluator on two separate occasions, both times during a hands-on activity. A post-camp survey and a 4-H common measures tool were implemented to assess participant satisfaction with various elements of the camp (e.g. staff, camp content, activities and logistics such as food and lodging) and engagement outcomes for the camper. Campers also rated each individual daily camp (biofuels) activity by how much fun they had (science engagement), how much they learned (content knowledge), and how much the activity made them consider being a scientist as a future career (science identity). Data was collected to better understand growth in content knowledge and gains in understanding of SBAR concepts by using pre and post concept mapping, but the data has not been analyzed yet. It will be discussed at the EEO pre-retreat annual meeting on 9/11/19. Median scores for survey responses are reported below, as well as outcomes of activity rankings. Detailed data can be found in the referenced spreadsheet **SBAR 4-H summer camp 2019 evaluation data. xlxs** and completed concept maps attached to this report as a PDF file. This additional data will be discussed with the EEO team at the pre-retreat meeting prior to the general annual meeting.

##### A. Post-Camp Questionnaire

*Evaluation tool developed by evaluator specifically for SBAR project goals*

Q1. Was there enough information about the camp in the recruitment materials to get you excited about participating in the camp? **Median Score: 9**

1 = No, I didn't know what to expect      10 =Yes, I was super excited

Q2. How would you rate the application process? **Median Score: 3**

1= Easy 10=Difficult

Q3. How would you rate the camp instructors' knowledge? **Median Score: 9.5**

1=Not very informative 10=Very informative

Q4. How would you rate the camp instructors' attitude/approach? **Median Score: 10**

1=Not very friendly or engaging 10=Very friendly and engaging

Q5. How would you rate the evening camp staff? **Median Score: 9**

1= Not very friendly or helpful 10=Very friendly and helpful

Q6. How would you rate the evening activities (bowling, the REC center, Funtastiks)? **Median Score: 10**

1=Kind of boring 10=Super fun and a good way to end the day

Q7. How would you rate the food at bear down kitchen (breakfast, lunch, dinner)? **Median Score: 10**

1=Gross, made me want to gag 10=Super delicious and healthy

Q8. How would you rate the dorm accommodations? **Median Score: 9**

1=Not good 10=Fantastic

Q9. How important was it to you that this camp took place on the UA campus? **Median Score: 9**

1=Made no difference 10=Super important, go Cats!

Q10. How likely would you be to attend this camp if it was NOT on a college campus (i.e. was at your local museum or youth center)? **Median Score: 8.5**

1=Wouldn't come, I wanted to experience the college life      10=No problem, I'd still come

Comment: Wanted to experience the college life

Q11. How likely would you be to attend this camp if it was a DAY camp (no overnight stay)? **Median Score: 6**

1=I was only interested in overnight camps      10=I would have preferred just days

Comment: Transportation would have been an issue

Q12. How much do you feel you learned about BIOFUELS in this camp? **Median Score: 10**

1=Not much 10=A whole lot

Q13. How much do you feel you learned about SUSTAINABILITY in this camp? **Median Score: 9**

1=Not much 10=A whole lot

Q14. Did you learn more about conducting scientific research in this camp and get to use cool equipment? **Median Score: 10**

1=Not really 10=Yes, I did some stuff I've never done before

Q15. How much do you feel you learned about possible CAREERS related to biofuels/sustainable bioeconomies in this camp? **Median Score: 9.5**

1=Not much                      10=A whole lot

Q16. Did this camp make you more committed to going to COLLEGE? **Median Score: 10**

1=Not at all                      10=Yes, college is in my future!

Q17. Did this camp make you consider being a scientist as a future career? **Median Score: 8**

1=Not at all                      10=Yes, seems fun & rewarding!

Q18. Did this camp make you consider being an engineer as a future career? **Median Score: 7**

1=Not at all                      10=Yes, seems fun & rewarding!

Q19. Did this camp make you consider being a farmer/grower as a future career?

**Median Score: 6**

1=Not at all                      10=Yes, seems fun & rewarding!

Q20. Would you recommend this camp to a friend? **Median Score: 10**

1=Not at all                      10=Yes, it was great!

*Additional Comments:*

This camp is cool.

This camp was great and I learned a lot

Thank you for a great week! I had so much fun!

#### **B. 4-H Common Measures Survey**

*Evaluation tool developed by 4-H national and responses were analyzed by the evaluator. For more detail, see above referenced excel spreadsheet.)*

Q1. I felt safe while attending camp at the UA campus this week: **100% agree or strongly agree**

Q2. In my camp, I learned to set an achieve goals: **89% agree or strongly agree**

Q3. My camp experience gave me a safe place to make and learn from my mistakes: **94% agree or strongly agree**

Q4. My camp gave me the opportunity to learn a new skill in an area I am interested in: **94% agree or strongly agree**

Q5. Because of my camp, I am interested in a career in Science, Engineering or Food Science: **78% agree or strongly agree**

Q6. Because of my camp, I am interested in attending college: **89% agree or strongly agree**

Q7. Because of my camp, I am interested in teaching what I learned in my county: **67% agree or strongly agree**

Q8. My opinions were valued by my peers and instructors in my camp: **67% agree or strongly agree**

Q9. I am willing to attend future camp experiences in STEM because of my participation this week: **89% agree or strongly agree**

Q10. I made new friends because of this camp experience: **94% agree or strongly agree**

#### **C. Daily Camp Activity Ratings**

*Evaluation tool developed and analyzed by the evaluator. See above referenced excel spreadsheet for more detail and scoring results for all camp activities.*

**The following activities ranked the highest in each category listed:**

**Highest engagement (fun):**

1. Biofuel Blast
2. Burn a Nut
3. Student Presentations

**Highest Learning:**

1. Cellulose Lab Pt 4
2. Photosynthesis
3. Biodiesel Lab

**Highest Science Identity (Career):**

1. Cellulose Lab Pt 4
2. Cellulose Lab Pt 2
3. Biodiesel Lab

**Highest overall ratings:**

1. Cellulose Lab Pt 4
2. Cellulose Lab Pt 2
3. Biodiesel Lab

These rankings remained consistent with 2018 activities for highest in engagement, learning and science identity. (2018 results for Fun: Burn a Nut and Biofuel Blast; Learning: Cellulose Labs 1 & 4 and Biodiesel Lab; Career: Biodiesel Lab & Cellulose Lab)

**The following activities ranked the lowest in each category listed:**

**Lowest engagement (fun):**

18. Careers in Biofuel Bingo
17. Fats, Lipids & Fatty Acids
16. Mixture's Separation

**Lowest Learning:**

17. Mixture's Separation
17. Fats, Lipids & Fatty Acids
16. Mixture's Separation

**Lowest science identity (career):**

18. Careers in Biofuel Bingo
17. Scientific Methods
16. Biofuel Blast

**Lowest overall rankings:**

18. Careers in Biofuel Bingo
17. Fats, Lipids & Fatty Acids
16. Mixture's Separation

The activities with lowest rankings in 2018 were not repeated in 2019, so there is no comparison data for 'lowest' rankings. Also, there is some confusion about the responses for the Mixture's Separation activity. That activity was listed on Day 1 and Day 2 of the ranking rubric (which was edited by the camp coordinator as the schedule shifted.) Some campers had the activity crossed out on Day 1 on their ranking sheet, while others ranked it. All campers ranked the activity on Day 2. The numbers were not combined on the data analysis but instead were kept as two separate activities with distinct scores. Further examination is needed to see if this activity is not actually among the lowest rankings.



#### ***D. Camp Observations***

- ▶ Daniela (the camp coordinator) was an effective leader of the camp, keeping the activities organized and moving as per the schedule. She interacted with the campers quite a bit, even though she was very busy with logistics. The lab manager was great too, often 'suggesting' that supervisory staff change locations or groups or get more involved as needed.
- ▶ There was plenty of supervision in the lab. Daniela was there for overall coordination and help with logistics (i.e. supplies) and her support staff included a lab manager/instructor, three additional instructors who had been training on the activities for months in advance, and three counselors who helped with classroom management and safety. So, in total, there were 8 staff for 18 kids, which may seem like a lot but is very helpful when doing a hands-on science camp with equipment and a variety of supplies/chemicals. The camp seemed very well organized and well planned.
- ▶ The group of campers was very diverse in terms of gender, ethnicity, and the communities from which participants were drawn. Campers were visibly having fun and engaged.
- ▶ The staff was very patient and engaged with campers and their many questions and normal middle-school behavior. They were right beside the campers during experiments and there to assist and ask questions. They were well prepared for the experience as camp instructors.
- ▶ The camp was very effective at modeling a real science research experience including the lab space in Koffler (which was a big improvement over the space last summer), lab equipment, safety equipment including gloves, glasses, and lab coats, and clear lab procedures and rules. Data analysis indicates that the favorite activities of campers (most highly ranked) were those that were titled 'labs' and involved more hands-on experimentation. The lessons taught real lab procedures and used real scientific equipment. The staff was very cognizant of safety and ensured that kids had their safety equipment on.
- ▶ The campers were separated into groups, with group names, which is an effective and evidence-based approach for this type of camp. Active and collaborative learning was happening during every activity.
- ▶ The campers seemed very comfortable asking instructors questions about not only experiments, but also about high school and college. The staff was very responsive to all questions.
- ▶ Procedures were in place to get the campers' attention and re-group when needed (hand raising gesture).
- ▶ Each camper had a binder with activity instructions and worksheets that had been prepared in advance. There was lots of inquiry happening as the campers did their experiments. Campers received lots of guidance from adults. One instructor I noticed specifically encouraged teamwork when a student was 'taking over' the group. Instructors asked lots of follow-up questions to help the student arrive at more understanding of 'why?' rather than just giving answers.
- ▶ The activities involved lots of authentic science, data, and math. In the Biodiesel Lab, even the instructors were struggling a little bit with the math involved and had to ask each other for help. This made me wonder if they were too difficult or would be considered a 'fun' summer activity. The Biodiesel Lab ended up being one of the highest overall ranked activities! The post-surveys indicated that campers overall enjoyed the camp in every category, almost all saying that they would recommend it to a friend. The individual activity ratings support that campers did learn, have fun, and build their science identities. Specifically, the more lab-based activities were the highest ranked overall on all categories.
- ▶ There was little integration with SBAR researchers or specific SBAR research/labs. I know that the team had always planned to include lab tours and talks from SBAR researchers or graduate students as part of the camp. This did not seem to happen as planned, so there remains a

disconnect between the research/researchers and the education components. This same theme shows up across education and outreach activities.

#### **4-H Education & Outreach, NM**

##### **Highlights & Accomplishments:**

- ▶ During project year 2 the NM team worked on developing SBAR related activities/curriculum while also informing and building relationships with a network of 4-H/extension offices throughout the state, especially those in counties serving the targeted audience for SBAR EEO.
- ▶ A 'Train-the-Trainers' workshop was planned for July 1-3, 2019 and related curriculum was developed. The intent for the workshop at this time was that the 4-H target audience would participate, along with the SBAR teachers and graduate fellows as part of their summer PD.
- ▶ While the NM extension team worked to recruit 4-H educators & volunteers, they learned that the summer dates were not ideal or even possible for them, given their heavy summer activity load with other 4-H responsibilities. Some feedback also indicates that the proximity to a holiday was not ideal either. Feedback from the 4-H educators/volunteers was that the best time to host the workshop would be in Jan-March of 2020.
- ▶ Catie Brewer ultimately delivered the workshop to Teachers and Fellows participating in the Education component of SBAR. I am not certain if the curriculum was adapted or was implemented exactly as would have been done if the audience had included 4-H educators & volunteers.

##### **Evaluation Findings**

- ▶ This component doesn't report directly to John, but rather reports to Alix, so he has little direct involvement.
- ▶ Movement has been slow on this aspect of the project, partially because there was a new Director of 4-H hired by NMSU after the proposal was written who is situated in Family & Consumer Sciences. Because they are not formally involved in the project, they are less participatory than would be ideal, and it has been difficult to get robust 4-H participation in the project.
- ▶ John advised that Laura and Paul will need to be proactive with 4-H agents and talk directly to them to motivate participation in the SBAR project. Agents historically are not as responsive to a simple email or phone call. John advised that it will be necessary for the SBAR project team to visit them in person.
- ▶ Without knowledge of the budget allocated for this component, I do not know if it is sufficient to do the travel and legwork necessary to recruit participation from around the state.

##### **Looking Towards Year 3 for AZ and NM 4-H education & outreach activities:**

Moving forward, the model in AZ is changing to follow the 'train-the-trainer' model in NM. The vision is to have SBAR-related, 4-H sponsored education/outreach activities taking place across each state, in rural communities, especially those where farmers/growers are located, as well as communities whose members are largely Hispanic and Native American. This is intended to be accomplished via the two state's extension network of 4-H agents. The activities can take the form that makes the most sense for each community (given their available resources and knowledge of community members) including Saturday clubs, after-school settings, summer camps, family events, local fairs & festivals, etc. Given that NM and AZ are both largely starting the implementation of the 'Train-the-Trainer' model in Year 3, possible programmatic considerations for the coming year include:

- ▶ Two week-long summer camps have been conducted and the activities were assessed by participants/campers for impacts in terms of engagement, learning, and science identity. There is consistency about which of the activities were most highly rated in each category, and overall. The most highly ranked activities are lab-based, indicating that participants like hands-on activities that are experimental, and more inquiry based as opposed to demonstrations or simpler, 'recipe-driven' experiments. These types of activities were ranked especially high for science identity – meaning that participants indicated that they made them think about science as a career.
- ▶ There is real opportunity to utilize material that has already been developed and assessed through prior camps (binders, schedules, agendas, curriculum, supply kits, etc.). Focus on the top 5-6 activities (as assessed by campers) for integration into the Train-the-Trainers experience. The total curriculum can be available as a resource for participating 4-H educators/volunteers. Locate all of the materials in the UA Box account for SBAR 4-H. This is comprehensive of already developed camp schedules, curriculum and activity instructions, supply lists, etc.
- ▶ As the K-12 teachers and fellows finalize and compile their lesson plans in year 3, more activities will be available to fill potential gaps in the topics addressed that are applicable to specific communities/audiences.
- ▶ Begin recruitment of 4-H agents, volunteers, and educators to participate in the training early. Communicate via existing networks with 4-H agents in identified counties (per your target audience) to introduce them to the SBAR project and seek their participation in a 3-day (maximum) 'Train-the-Trainers' workshop to be held in the early spring of 2020. Get people's feedback for the best time to host the workshop and settle on a date quickly so that you can actively seek participation.
- ▶ Questions I have - will they be compensated for their time or will travel be paid for? If so, convey that information early. If not, consider how that will greatly impact participation, especially from people far from where the training will occur or with limited resources.
- ▶ I suggest that the workshop is a combination of the most successful elements from camps and PD activities to date. Choose elements to integrate for the 3-day workshop by reviewing the evaluation data with the evaluator and discussing feedback about the various formats and what participants would have liked to see changed. Through observing and assessing the 2 camps and the 2 summer PD sessions, I think that the best model for the new 'Train-the-Trainers' experience for 4-H educators & volunteers is a hybrid of several elements that have occurred over the two summers – a modified versions of Catie's material to extend content knowledge; integrated into camp activities done in real time, with real children; time for participants to reflect on what they've done and think about what will work in their communities; and supplying participants with the resources they will need to carry out experiments (kits, curriculum.)
- ▶ Examine resources (budget) available to understand if a joint AZ/NM training or two separate trainings will be most efficient and considerate of participant needs and obligations (i.e. cost for them to attend, if not supported by the SBAR budget.) Previous activities have not been fully supported (\$) by the SBAR budget and additional resources had to be identified and leveraged. I don't know what the budget consists of, so can't comment on whether there is adequate money to supports any or all of these activities. i.e. implement the workshop, cover participant costs, provide participants with supplies for conducting activities.
- ▶ Work with evaluator to develop assessment tools and follow up structures to document and determine outcomes and impact following the training.

## Education – Teacher and Graduate Fellow Professional Development and Curriculum Design

### Objectives:

1. Train teams of students and teachers with a focus on rural and under-represented groups.
2. Develop and disseminate agricultural bioenergy and bioproduct K-12 modules.
3. Develop a biofuel certificate program at the university level.

### Highlights & Accomplishments:

- ▶ Participating K-12 teachers (primarily middle school) and graduate students (Cohort 1) were paired as 'co-teachers' throughout 2018-2019 the school year and were asked to develop and integrate SBAR-related content into middle school classrooms in ways that support science standards and teaching requirements
- ▶ Throughout the year, the pairs of Cohort 1 teachers and fellows in each AZ and NM developed, implemented and documented specific lesson plans and other supporting curricular materials. The collection of developed resources is robust and provides material to build on and refine during year 3. It can be accessed via the UA SBAR Box account.
- ▶ Graduate fellows participated in a weekly seminar at the UA (NM fellows participated via zoom) to provide additional mentoring and guidance around their role in the classroom and their partnership with teachers. Insights about the seminar will be discussed in the annual pre-retreat meeting.
- ▶ Some teachers and fellows agreed to continue participating for a second year and are joined by newly recruited teachers and fellows. Efforts have been made to recruit Hispanic and Native American teachers when possible, however, all participating teachers serve large numbers of underrepresented and underserved students.
- ▶ All new and continuing teachers and fellows participated in a 2-week professional development workshop from July 1-12, 2019. The experience was split between NMSU and UA, with July 1-3 being a very content intensive workshop centered around 25 core SBAR concepts. The week of July 8-12 happened at UA and was focused around additional educational support (speakers, field trips, etc.), resource exploration, concept development, curriculum mapping, and lesson development.
- ▶ **6 returning teachers, 4 new teachers** participated in the 2-week training and will continue with the project in Year 3.
- ▶ **5 returning fellows and 7 new fellows** participated in the 2-week training and will continue with the project in Year 3.
- ▶ A needed shift in approach toward curriculum development was made so that SBAR concepts and content can more easily be incorporated into existing school curriculum structures. It would be difficult, if not impossible, to create a stand-alone 'SBAR Curriculum' that teachers would be able to implement IN ADDITION to the required curriculum. Therefore, the team (staff, teachers, fellows) has shifted their approach to contextualizing SBAR themes such as arid lands, sustainability under climate change, bioeconomies, systems thinking, and other themes where SBAR can be used as a case study within existing courses.
- ▶ All teachers and fellows (new and returning) will work collaboratively throughout Year 3 to continue to develop, implement and test lessons that are aligned with middle school courses such as life science, physical science, earth science, and other subject area standards. They will use SBAR concepts (to build a repository of SBAR related curriculum, modules, activities and

other resources **that will ultimately contribute towards the 5-year outcome of a replicable school-based curriculum.**

#### **Evaluation Findings:**

A number of tools were implemented with teachers and fellows to gauge impacts on teachers and fellows and to provide feedback for programmatic improvement moving forward. For the NMSU 'Train-the-Trainers' workshop, a pre and post assessment was done to determine comfort with 25 core SBAR concepts. After the entire 2-week PD experience, a post-survey was given to assess usefulness of activities, time spent on activities, confidence in completing certain tasks, and open-ended feedback about their experience. Data is sorted by teachers and fellows, and further broken down by whether the participant is returning for their 2<sup>nd</sup> year or is new to the project. **complete data can be found in the excel sheet SBAR 2019 Summer PD evaluation data.xlsx.** This more detailed data will be further discussed at the pre-retreat annual meeting. A pre and post concept mapping assessment was also administered but are still being analyzed. An exit interview was also held with fellows during the final seminar session. Highlights from the surveys are below, as well as the complete feedback from the open-ended questions, as those are difficult to read in the excel format.

#### **A. 25 Core Concepts Pre & Post assessments**

The pre and post assessment was administered at the beginning end of the 3-day workshop in NMSU. It provides insight into participant's understanding of and comfort in using content and contexts around 25 core SBAR ideas. By using Likert items and number rankings, we can see areas where teachers and fellows indicated less confidence, and to quantify gains based on post-survey responses. Highlights are below and **complete data can be found in the excel sheet SBAR 2019 Summer PD evaluation data.xlsx.**

*Teachers* indicated the least (median) initial confidence in 4) Polymerization involves initiation, lengthening, termination, and branching. This is also the concept where they showed the most (median) gains in post assessment. They also struggled with the concept(s): 6) Liquid hydrocarbons are good fuels because they have high energy density and are easy to handle; 7) Biofuel production involves depolymerization, decomposition, and removal of oxygen; 8) Combustion has four steps: drying, pyrolysis, flaming pyrolysis, and char combustion; 10) The usefulness of guar gum depends on monomer ratio, chain length, degree of cross-linking, and content of other materials. They showed the next highest incremental gains in these same concepts. Another concept that saw large gains was 20) Most of the work in research happens before the official experiments in the lab or field.

*Fellows* showed less overall initial confidence in their understanding of and comfort with more concepts than the teachers did. They indicated the least initial confidence specifically in the following concepts: 7) Biofuel production involves depolymerization, decomposition, and removal of oxygen; 8) Combustion has four steps: drying, pyrolysis, flaming pyrolysis, and char combustion; 10) The usefulness of guar gum depends on monomer ratio, chain length, degree of cross-linking, and content of other materials; 12) Guayule can be grown from transplants or seeds; the young plants require the most care; 13) Guayule rubber is stored in packets right inside the outer edges; 14) Season of harvest and time from harvest to processing affect guayule rubber yield; 23) Technoeconomic analysis models the economic sustainability of a product or process. They experienced highest median gains in the concept of 13) Guayule rubber is stored in packets right inside the outer edges.

#### **B. Summer PD Post-Survey**

The survey was developed in conjunction with Education team to gather feedback specifically on the 2-week summer PD experience. The data was analyzed by the evaluator. Teachers ranked the usefulness

and the amount of time spent. Responses by teachers and fellows, broken down by their status of first year or returning, are listed below. Data ranking the individual activities is difficult to summarize without discussion and some level of active disaggregation rather than focusing on median values. Complete data can be reviewed in the excel sheet referenced above and will be discussed further at the pre-retreat workshop prior to the annual meeting.

### **Teacher & Fellow Responses to Open Ended Questions**

*How do you feel about the approach taken to split the PD experience between NM and AZ? What would you add to or change about this particular approach of the content intensive 3-day workshop at NMSU combined with the 2nd week at UA to hear from more content experts, have more tours, brainstorm, and work on lesson design?*

#### *1<sup>st</sup> year Teachers:*

- I felt the experiences in NM and AZ were all valuable. I felt most teachers didn't quite understand the 3-day workshop at NMSU was only for their own food for thought and so they expressed their confusion on that.
- I think the split was a good idea, however, I would have preferred it to be other than a holiday. I also think that having daily agendas/itineraries prior to each day would have been very helpful. I enjoyed each field trip and hearing from field experts on the SBAR topics.
- I would have like a tour of Bridgestone to tie everything together

#### *Returning Teachers:*

- A. Loved it. B. More UA development time
- I liked the split time between NM and AZ because I had less stress in taking care of personal issues.
- I really liked to split between NMSU and UA. Increasing opportunities for more brainstorming and lesson design would be helpful in creating more detailed lessons for submission at the end of PD
- I enjoyed the experience but there was A LOT of content provided in the intensive 3-day workshop that left me a little overwhelmed at the end of it. I felt like there were many areas I would like to have incorporated into my teaching, but don't know how.
- I really enjoyed having the opportunity to visit NMSU. It's unfortunate that I wasn't able to make the trip. Hopefully there will be another opportunity
- The NM portion was completely useless through zoom as we could not see anything going on. I also feel it was too high level of science. It's not relevant to my students' ability. I wanted to see experiments I could do. I loved the tours at the UA. I wanted more.
- I think we needed more collaboration as a team to make sure we were not duplicating efforts in lesson planning

#### *1<sup>st</sup> Year Fellows:*

- I did not care for splitting the two weeks, especially with the holiday in between sessions. I did enjoy coming in with the train the trainer information
- I would like to suggest that in the 2nd week in Arizona, the planning for the lesson should begin. That way throughout the tours one could imagine/develop their own ideas for a lesson plan
- More hands-on activities during workshop, especially for middle difficulty concepts
- 3-day workshop at NMSU could be incorporated into a written resource and shortened into a day of presentations. 2nd week hear from more experts of work on lesson design.
- I feel it was good approach to split the experience spending two weeks at one place is kind of a lot and (can't read) becomes boring. 3-day workshop at NMSU was pretty intense. At UA, it was

slightly slower pace. It would have been even better if we could have spent some more time with teachers developing lessons.

- I liked the change of venue to see both places but would encourage a more explicit connection between SBAR and educational goals. It makes sense that SBAR is a broad topic, but specific topics would be helpful
- I liked the split especially the heavy content being covered in the first 3 days. That provided great context for the 2nd week. We could in fact cover more talks from education experts about the pedagogy in AZ

*Returning Fellows:*

- I liked the split, but I felt a lot of time in AZ was wasted/not well managed
- The decision was OK, it gives everybody a 50-50% experience of both worlds or environments
- I find very useful the time we had to work on our lessons. I liked the intensive 3-day workshop at NMSU, it filled gaps I had about SBAR and science behind SBAR
- Having more brainstorm and work on lesson design would be really helpful
- I really thought the training in NM was very valuable for me. I thought I had already known this type of material but quickly learned there were gaps in my understanding. One thing I would change would be to coordinate the SBAR themes that were presented to us during the PD week with the content that is being taught at the NMSU week.

*Do you feel that you were given enough content design guidance during the lesson writing process? Is there additional guidance that would have been helpful?*

*1<sup>st</sup> Year Teachers:*

- I felt good about it.
- I think that having a lesson plan example would have proved a bit more helpful for me.
- Life, physical earth guide of lessons already made
- It would have been helpful to start with the mission statement found on the 2nd part of the P.O paperwork. Super clear and short for (work? - can't read) /teacher's expectations

*Returning Teachers:*

- Yes - time is one thing teachers need. Left to our own devices we do TOO much on unpaid time. It is nice to be respected for our time.
- As teachers, we continue to develop our science concepts for the SBAR lessons (more time needed)
- Yes, I feel I was given enough guidance
- It was very helpful to have the week to collaborate with my fellow as well as getting feedback from others
- Yes
- I personally feel very confident in writing lessons, so this was not an issue for me

*1<sup>st</sup> Year Fellows:*

- Yes, the guidance was sufficient
- yes, the guidance was sufficient
- Yes, the guidance was sufficient
- I feel it was enough to get us through this fellowship responsibility
- I feel that I learned a lot about this from my paired teacher, but little from the workshop. This might be an OK dynamic
- We could add some literary activities that are applicable to multiple themes rather than particular contents

*Returning Fellows:*

- No, I do not. I had no clue what was going on, and ended up bouncing ideas off of my teacher

- More guidance would be helpful during the lesson design process
- There was enough content provided
- I would like to have more connection with the other section, of SBAR project not only educational it helps to understand more the goals of SBAR
- I thought it was very informative to do the exercise where everyone had initial ideas they wrote on stickies to put on the SBAR theme posters. Great idea to have people follow this up by putting stickies on the posters again once a lesson idea was in the formative process of development. It was also a great idea to have us listen to some of the experts in the fields such as climate change, economics and farming. If this were done in all the SBAR theme areas it would have been even that much more effective.

*What additional training do you think that the fellows would benefit from to be most helpful as you design and implement lessons?*

*1<sup>st</sup> Year Teachers:*

- I think that maybe a crash course in lesson design/standards for teaching would have been helpful.
- Not sure, just getting to see what she can do

*Returning Teachers:*

- I really like having the expertise of a grad student in class because I am at a non-traditional school and I am not traditional, it is relatively easy to train them 'on the job.'
- Focus on student facilitated learning strategies and assessments. More student interaction as versus lecturing at.
- Lesson delivery, classroom management
- Understanding the idea of phenomena and inquiry science to go with the new standards
- Classroom management. How to build relationships in the classroom. Science talk.
- Fellows need to know the basic design of a lesson plan, and how to check for understanding as they go

*If you participated last year, how will the second year of support impact what you are able to do?*

*Returning Teachers:*

- I will feel more confident in what I am teaching. Having professional development input & support to say science is a real career path is helpful
- This second year provides more resources & lessons to pull from
- Since I feel I have a better idea of what is expected this year, I'm looking forward to the support of my fellow and being able to support my fellow.
- I have a much broader range of skills to draw upon in the additional teachers & fellows. The presenters will also be valuable resources
- I feel more comfortable with the content and have seen what the teachers did last year to give me more ideas
- I have learned more about the economic aspects of SBAR and how many different people at different professions are involved in making this work. I feel more excited about involving parents who work in these fields.

*Returning Fellows:*

- I feel better prepared to lead a lesson on my own
- It will be a lot more fun. Since I have developed experience during SBAR related stuff
- I do not know
- I may have the opportunity to participate in more lesson planning, development and delivery than what I was doing last year. I feel excited to be able to teach the students these new



lessons. The ability to teach some of the lessons last year I believe will help me be more effective at teaching this year

*Are there any particular pedagogical strategies that you would like to see included in the PD activities?*

*1<sup>st</sup> Year Teachers:*

- If making the connection to indigenous communities is a view SBAR would like to incorporate, having tribal speakers would help
- I think that more math should be in focus/integrated into the lessons.
- Loved how we took a role as a student before we did teacher role. So not really.

*Returning Teachers:*

- Collaboration and group work, working from a phenoma
- Since not all grade levels are implementing the new standards, teachers need more background in the ways to teach inquiry science rather than relying so much on teacher presentations
- The more 'hands-on' we can brainstorm, the better

*1<sup>st</sup> Year Fellows:*

- Maybe for fellows, a teacher share out would be great
- Include activities keeping in mind student demographic and their personal interests. i.e. arts, literature or science/math. Reading/writing exercise (journalism). Experiments. Art
- Maybe a live teaching lesson giving to the middle school children which could have given us real-life experience
- The 5 E's perhaps? This is the only named strategy that I am aware of
- Discussion, collaboration, and presentation activities/strategies would be great

*Returning Fellows:*

- Classroom management techniques
- Effective strategies or incentives to have the students pay attention and show respect

*Are there any particular technologies or lab techniques that you would like to see included in the PD activities?*

*1<sup>st</sup> Year Teachers:*

- It would be cool to hear from someone from Biosphere 2
- I think that technology should also have an emphasis
- Seriously everything was so new and interesting can't imagine what else I would need

*Returning Teachers:*

- Perhaps PCR machine
- We need to think about how do activities with minimal and easily available resources

*Any additional feedback that you would like to share?*

*1<sup>st</sup> Year Teachers:*

- Y'all did great! Thanks for your warm & welcoming inclusion (heart)
- Thanks for a great training!

*Returning Teachers:*

- It was awesome, I feel informed and more competent. I am excited about the real-world science problems that there are people who are working on solving these WICKED problems

*1<sup>st</sup> Year Fellows:*

- I love our SBAR team!!

*Returning Fellows:*

- Could have used more time with teachers developing lessons (maybe on 1st or 2nd day)

- You might want to have more specific milestones in the last three days that partners can present. SO, an objective per day rather than just working with the partner on a lesson plan. It is an open-ended goal and accountability goes down. Great week overall!!
- SBAR to the world!!!
- I really liked the balance between time allotted for developing lesson plans and time that was spent on bringing people in to do presentations and tours.

### Looking towards year 3:

- ▶ Fellows will continue to receive additional training via the weekly seminar. Feedback from fellows via the focus group interview and survey data will be used to define weekly activities and additional training for fellows to maximize their learning and role in classrooms and curriculum development.
- ▶ The focus will shift away from recruitment of new teachers and fellows and towards developing, testing, refining, and ultimately publishing curriculum modules, lessons and units towards a replicable curriculum.
- ▶ The team will discuss ways to continue to collaborate with NMSU. For instance, last year fellows from NM participated in the weekly seminar via zoom, which is not an ideal way to have active participation. The NMSU team is looking for an educational expert to bring onto the team who could conduct similar seminars for graduate fellows in NM. This has proven a challenge so far, but they continue to search for a qualified candidate.
- ▶ Teachers and fellows have indicated that they would like to work more collaboratively so that they are more aware of the types of lessons and content areas that other teacher/fellow pairs are developing so that there is not overlap.
- ▶ Teachers and Fellows have indicated that they feel that additional training for fellows on classroom management, building relationships with students (middle school) in the classroom, and teaching strategies would be useful.
- ▶ Universally, all on the EEO team would like to see more participation and integration by researchers in education activities. While there was some improvement in this area, it largely was due to the liaison role that extension team members played, and the research that they had access to was more related to farming practices and production. They would like to have more opportunities to be exposed to other SBAR researchers and labs.
- ▶ Teachers and fellows also indicated that more hands-on activities during the trainings would help. They felt that the intensive content provided during the NMSU workshop may have been more effective if it could have been paired with a specific activity/lesson to better understand how they relate and how the content can be used specifically with students.