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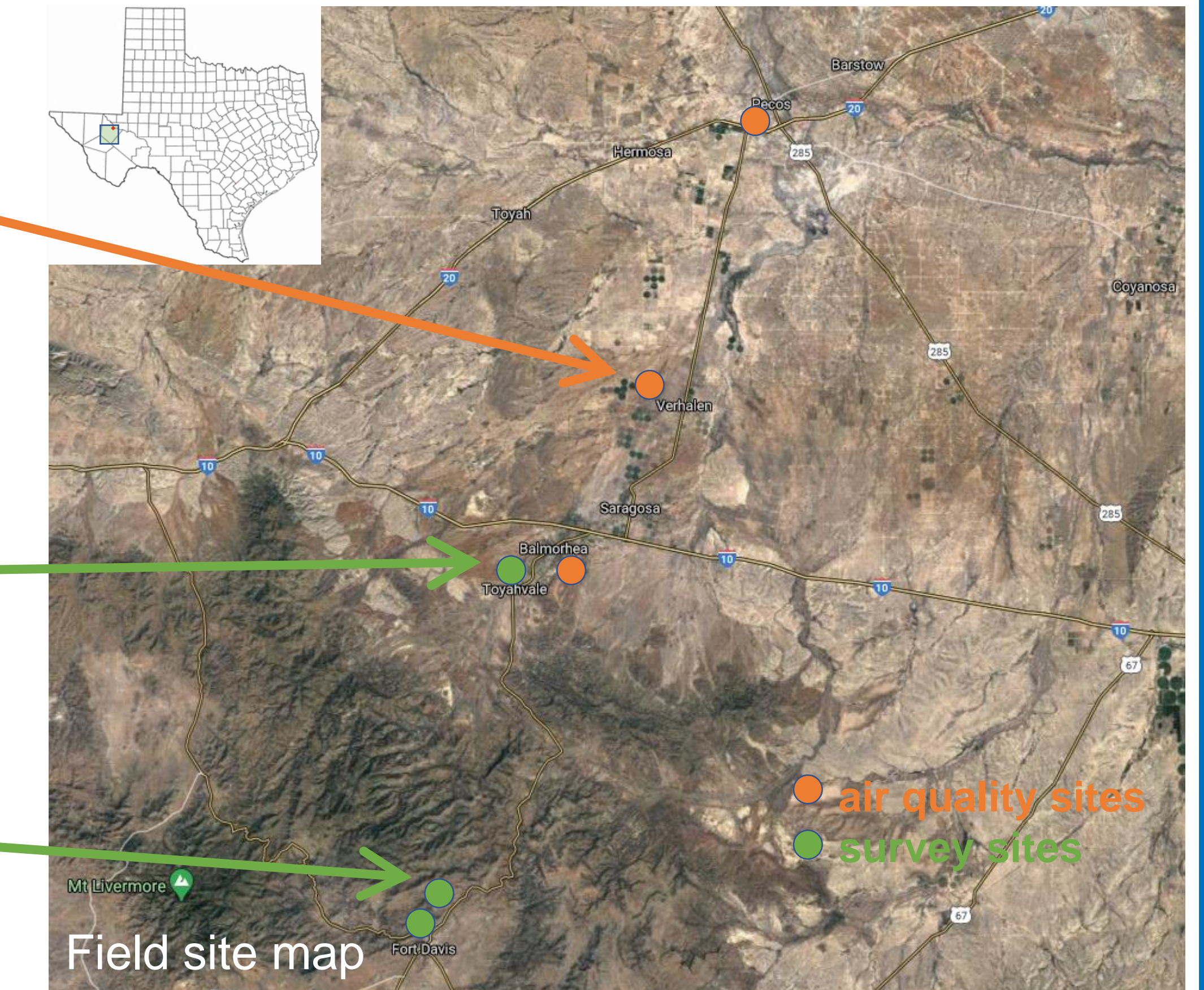
Abstract

Our project field-tested a passive air sampling strategy for hydrocarbons in the Permian basin in northeast Texas in 2019, where oil and gas production rapidly expanded in the 2010s. In recent years this expansion reached closer to popular recreational areas near the Davis Mountains, including the Davis Mountains and Balmorhea State Parks. Our goal was to combine actual air quality measurements with surveys of State Park visitors to evaluate public perceptions of air quality and energy development in the Permian Basin of West Texas. We deployed a weather station with an ozone sensor to Pecos, and recruited citizen scientist volunteers to collect and replace passive samplers weekly. Data was recorded for parts of 2019 and a survey of park visitors was conducted during longer stays in the area. Park visitors were asked a variety of questions including perceptions of air quality, energy development, recreation experiences, and socio-demographics.

Results showed high hydrocarbon and ozone pollution in Pecos, near the center of the region's development, with decreasing hydrocarbon levels toward the edge of the production area in 2019, in Balmorhea. Park visitors were conscious about this development, many considering air quality as very important to them, and stating concern about how oil and gas development is affecting their health and recreational experiences. Additional analysis showed differences with several variables, e.g., gender and political beliefs. Measurements in Pecos are commencing

Survey Findings

- Data collection sites
 - Balmorhea State Park
 - Davis Mountains State Park
 - Fort Davis National Historic Site
- June 21-23 and July 3-6, 2019
- Convenience sample of visitors
- Self-administered questionnaires
 - Perceptions of air quality
 - Energy development
 - Recreation experiences
 - Socio-demographics



Air Quality Findings

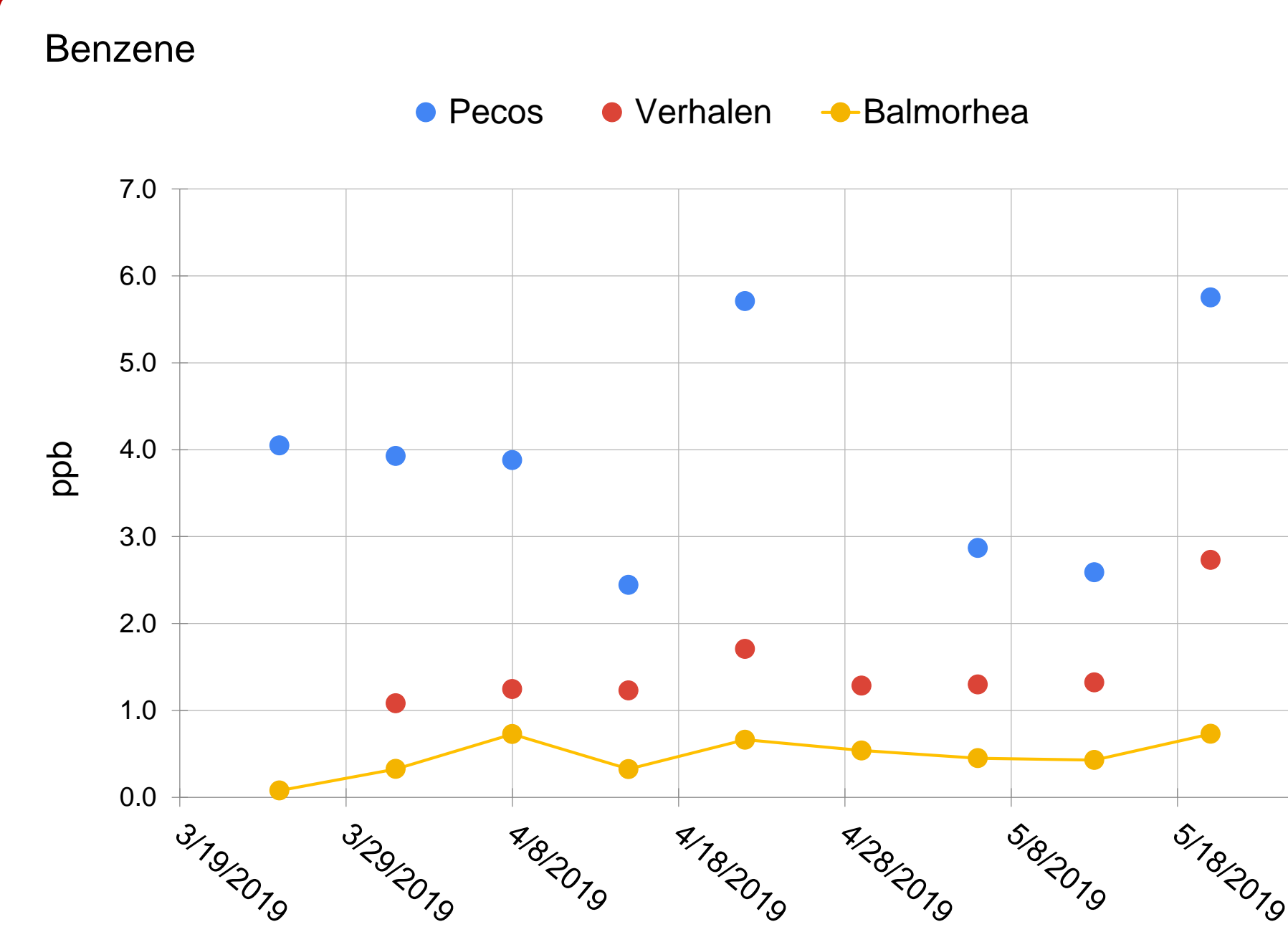
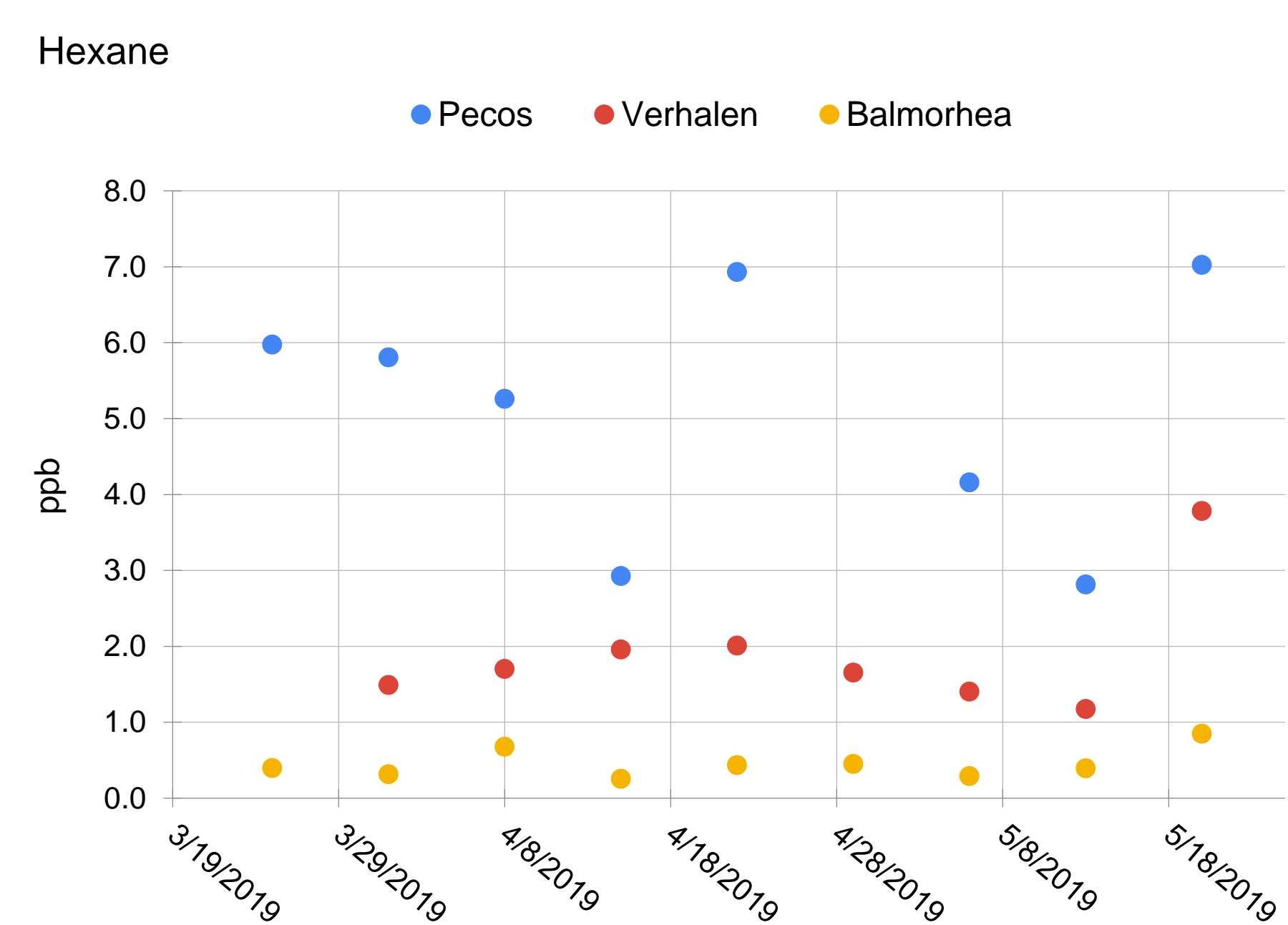


Figure 1: Average weekly hexane (left) and benzene (right) volume mixing ratios in spring 2019. A line is drawn in one graph to guide the eye. A clear concentration gradient exists between values in Pecos (north) towards Balmorhea (south). Both hexane and benzene are air toxics, for which the State of Texas maintains threshold values. Benzene values in Pecos exceeded the state's Air Monitoring Comparison Value of 1.4 ppb, which is cause for concern.

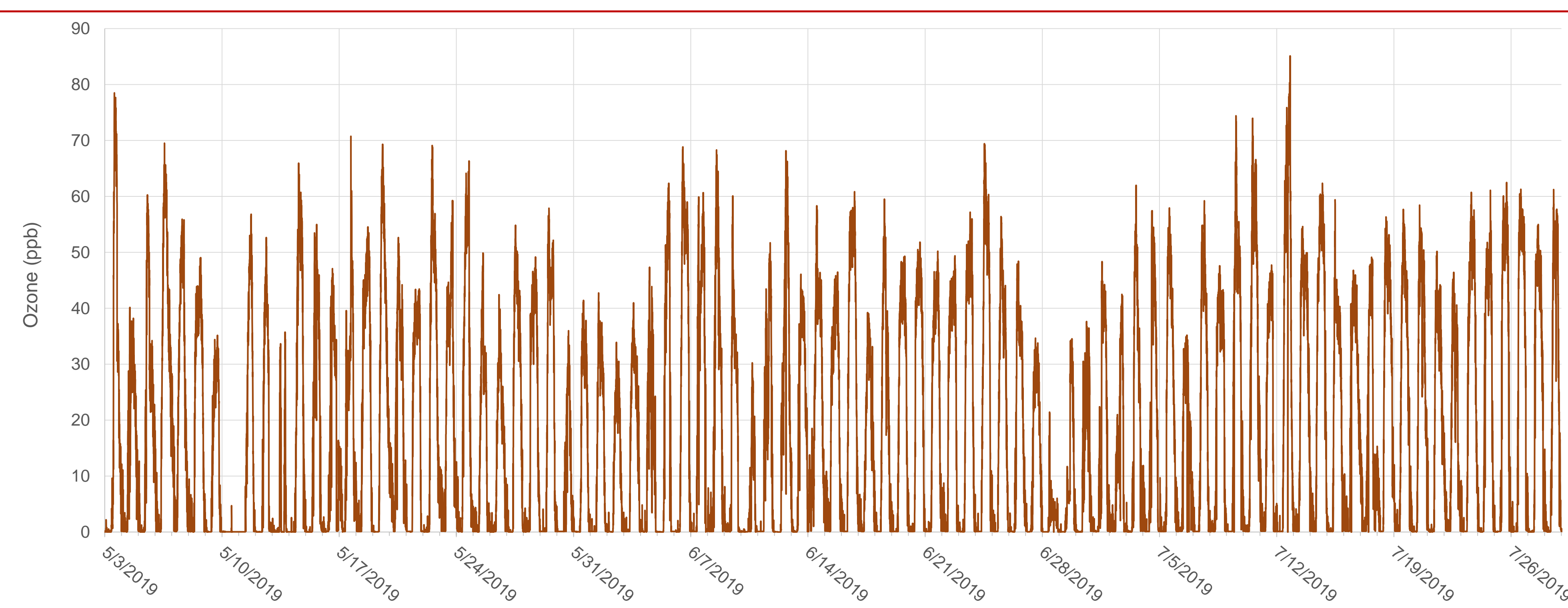


Figure 2: Ozone volume mixing ratios in spring/summer 2019. Two features stand out: (i) ozone exceeded 70 ppb – the ozone NAAQS – on several dates during this period, and (ii) ozone is regularly titrated at night, suggesting high local and regional NO_x emissions, unusual for a rural area. Both suggest significant ozone precursor emissions, most likely due to the industrial oil exploration activity in the region.

Table 1: Respondent demographics (average age = 46, 59% male, 41% female)

Variables	Categories	n	%
Race/ Ethnicity (N=336)	White	227	67.6
	Hispanic	90	26.8
	Other	19	5.7
Education (N=339)	HS graduate or less	27	8.0
	Some college or 4-yr degree	214	63.1
	Graduate work or degree	98	28.9
Household income (N=321)	Less than \$49,999	56	17.4
	\$50,000–\$99,999	134	41.7
	\$100,000 or more	131	40.8
Residency (N=342)	Texas resident	302	88.3
	Non Texas resident	40	11.7

Table 2. Perceptions of Environmental Quality

Items	Mean (x̄)	Std Deviation
Air quality		
Air quality is important when I recreate	4.20	1.08
The air in this region smells like rotten eggs	1.87	0.88
The air quality in this region irritates my eyes and breathing	1.91	0.84
Other qualities		
I am concerned about the water quality around here	3.41	1.26
I prefer natural, undeveloped areas when I participate in recreation activities	3.89	1.03
I like to see a dark sky at night away from city lights	4.45	0.73
Climate change		
I am concerned about the effects of climate change worldwide	3.82	1.31
We must reduce our energy consumption for the welfare of future generations	3.97	1.02

Measured on a 5-point Likert scale ranging from 1="strongly disagree" to 5="strongly agree"

Table 3. Independent Samples t-test Results based on Gender

Items	Male (202)		Female (138)		t value
	Mean	SD	Mean	SD	
1. I am used to seeing oil and gas wells where I recreate	3.10	1.14	2.60	1.26	3.69**
2. Seeing oil and gas wells while I recreate negatively affects my recreation experience	2.99	1.28	3.43	1.30	-2.98*
3. Energy development near recreation areas is a public health problem	3.23	1.18	3.69	1.17	-3.49*
4. I support energy development here because it is important to the Texas economy	3.66	1.09	3.05	1.31	4.41**
5. I am concerned about the effects of climate change worldwide	3.63	1.35	4.11	1.19	-3.39*
6. We must reduce our energy consumption for the welfare of future generations	3.78	1.07	4.30	0.83	-4.95**

Measured on a 5-point Likert scale ranging from 1="strongly disagree" to 5="strongly agree"
*p < 0.01. **p < 0.001

Table 4. Independent Samples t-test Results based on Political Beliefs

Items	Conservative (157)		Liberal (108)		t value
	Mean	SD	Mean	SD	
1. Oil and gas wells ruin the view shed in this area	2.66	1.18	3.75	1.10	-7.41*
2. Seeing oil and gas wells while I recreate negatively affects my recreation experience	2.65	1.28	4.08	0.86	-10.79*
3. I am willing to travel to another area to recreate when I see energy development nearby	2.53	1.16	3.68	0.98	-8.44*
4. I support energy development here because it is important to the Texas economy	3.93	1.04	2.61	1.16	9.32*
5. Energy development near recreation areas is a public health problem	2.88	1.16	4.23	0.77	-11.12*
6. I am concerned about the effects of climate change worldwide	3.05	1.30	4.80	0.47	-15.27*
7. We must reduce our energy consumption for the welfare of future generations	3.49	1.01	4.61	0.66	-10.80*

Measured on a 5-point Likert scale ranging from 1="strongly disagree" to 5="strongly agree"
*p < 0.001

This study has implications for park managers in several areas including awareness toward visitor-related issues on proximate energy development nearby, interpretative programs, and education about climate change. Future research should focus on obtaining data from a larger geographic area, a more diverse sample of visitors, and input from residents and business owners of regional communities.

Other activities. We tested several small form factor air quality sensors (NO₂, H₂S, PM_{2.5}) with undergraduate and graduate students in the laboratory. A H₂S sensor was deployed to the Pecos weather station in January 2020 with results pending.
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