A climate-based method to estimate water use and evaluate water savings

2018 Governor's water Conference

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Outline

- A bit of context
- The question that prompted us to look deeper
- Development of the method
- Application of the method and preliminary results
- Potential future applications and work to be done

- KDA’s vision: …*provide an ideal environment for long-term, sustainable agricultural prosperity and statewide economic growth.*

- Kansas Water Vision: *Provide Kansans with the framework, policy and tools, developed in concert with stakeholders, to manage, secure and protect a reliable, long term statewide water supply while balancing conservation with economic growth.*

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The case that prompted the method

- The impairment of Quivira National Wildlife Refuge
- Potential action to reduce depletion growth rate through pumping cuts
  - 10-year limit on withdrawals
  - Evaluate at five years

But what if the first 5 years are abnormally dry

(or wet for that matter)?

How will we all know if the basin is on track to stay within the withdrawal limits?

Let’s see if irrigators change their behavior

Modeling irrigation behavior

Establishing past behavior

The big idea:

Climate and crop need causes pumping

Establishing past behavior

Cause: Crop Need - data

- Precipitation – PRISM Climate Group, Oregon State University
  - Datasets1895 – present
- Evapotranspiration (ET) – calculated using PRISM temperature data

Effect: Pumping - data

- Water use – metered since early 1990s in KDA-DWR database

Linear Regression

modeling the relationship between a scalar response (or dependent variable) and one or more explanatory variables (or independent variables)

$$y = mx + b \text{ (simple)}$$

Climate based pumping estimators: f(ET,P) and CIR

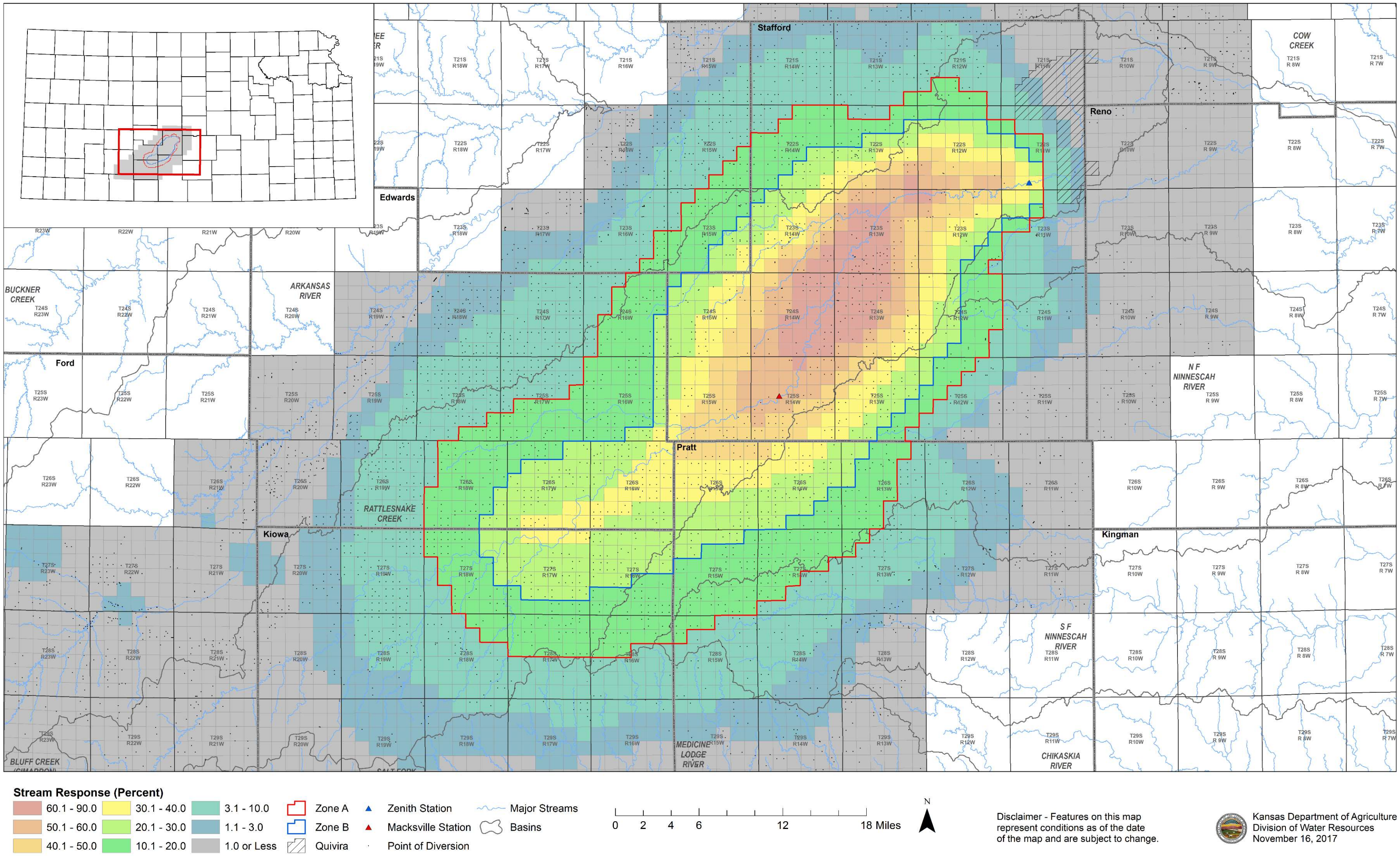
- Sam Perkins
- Regression model (Example):

$$f_5(ET_i, Pi) = c_0 + \sum_{i=1}^{3} a_i \, ET_i + \sum_{i=1}^{3} b_i \, P_i$$

  - c_0 constant coefficient
  - a_i: coefficients for ET (March-May, June-July, August-September)
  - b_i: coefficients for precipitation (March-May, June-July, August-September)

Rattlesnake Creek Streamflow Response Regions, Draft

1998 - 2007 average streamflow response (pct) at Zenith gage evaluated in 110 townships and 823 sections and kriged to 3,960 sections in and near Rattlesnake Creek basin and groundwater points of diversion junior to Quivira



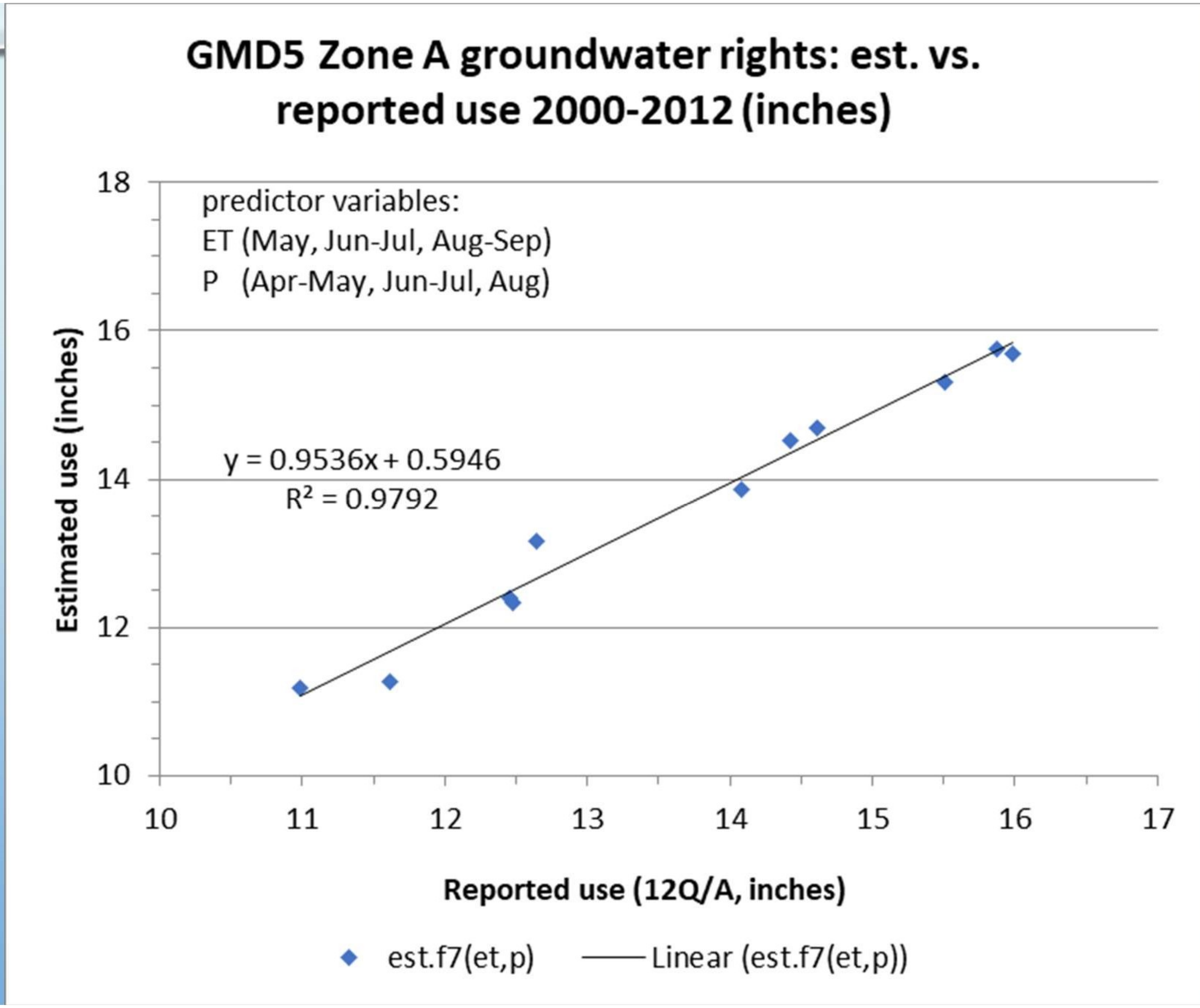
Variable selection: water use estimators tested for Zone A

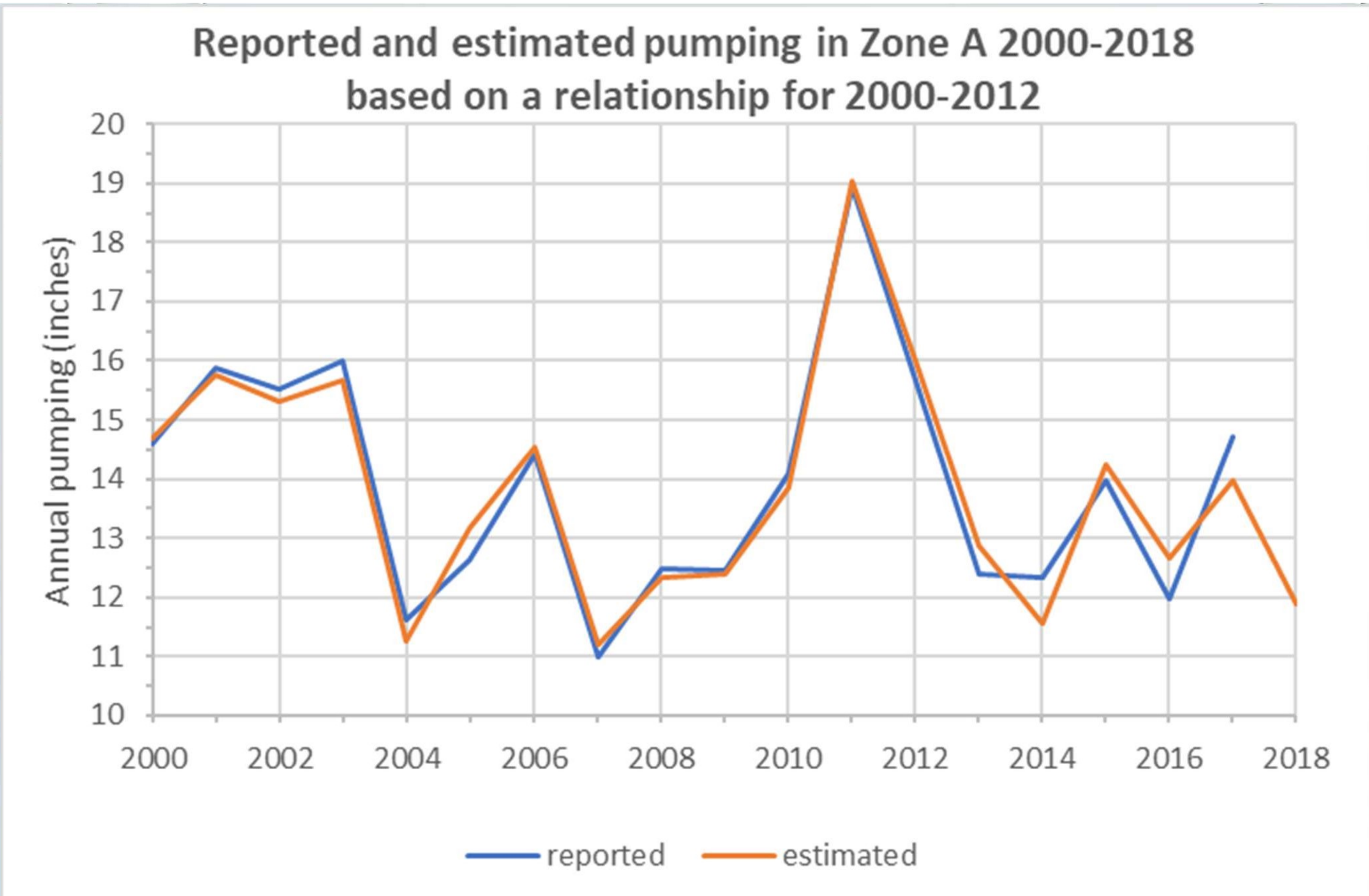
Model	no. variables	Water use predictors (2000-2016)
f1(P)	1	P annual
f2(P)	1	P [May-Sep]
f3(ET,P)	2	ET, P [May-Sep]
f4(ET)	1	ET [May-Sep]
f5(ETi,Pi)	5	ET, P [Mar-May, Jun-Jul, Aug-Sep]
f6(ETi,Pi)	10	ET, P [individual months May-Sep]
Avg [f5, f6]		[average of estimates given by f5 and f6]
f7(ETi,Pi)	6	ET [May, Jun-Jul, Aug-Sep], P[Apr-May, Jun-Jul, Aug]

Performance of estimators for GMD5 Zone A

model	R^2	s.e. KAF	s.e. in	s.e./mean
f1(P)*	0.75	14.1	1.05	0.0756
f2(P)	0.8	13.1	0.93	0.0670
f3(ET,P)	0.86	10.7	0.75	0.0540
f4(ET)	0.76	14.3	1.00	0.0720
f5(ETi,Pi)	0.95	6.5	0.46	0.0331
f6(ETi,Pi)	0.95	6.5	0.46	0.0331
Avg [f5, f6]	0.96	5.6	0.38	0.0274
f7(ETi,Pi)	0.98	3.9	0.28	0.0202

(*) Compare Fig. 4b (Whittemore et al., 2016): R^2=0.74 for GMD2 and GMD5 (1996-2012)


GMD5 Zone A groundwater rights: est. vs. reported use 2000-2012 (inches)
predictor variables:
ET (May, Jun-Jul, Aug-Sep)
P (Apr-May, Jun-Jul, Aug)
y = 0.9536x + 0.5946
R² = 0.9792
Estimated use (inches)
Reported use (12Q/A, inches)
10
12
14
16
18
10
11
12
13
14
15
16
17
est.f7(et,p)
Linear (est.f7(et,p))


Reported and estimated pumping in Zone A 2000-2018
based on a relationship for 2000-2012
Annual pumping (inches)
20
19
18
17
16
15
14
13
12
11
10
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
reported
estimated

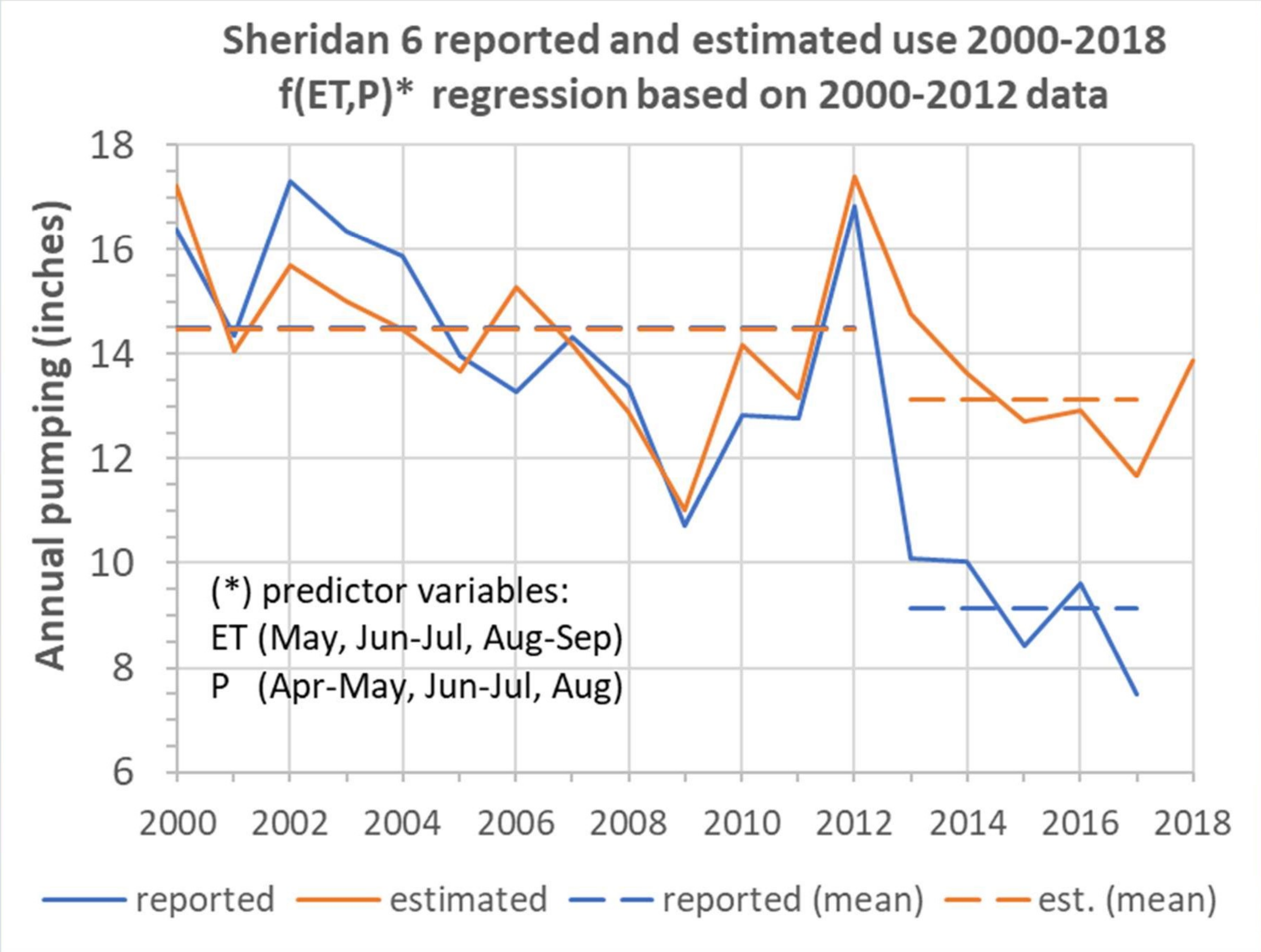
Does this relationship hold for other parts of the state?

Is this relationship scalable?

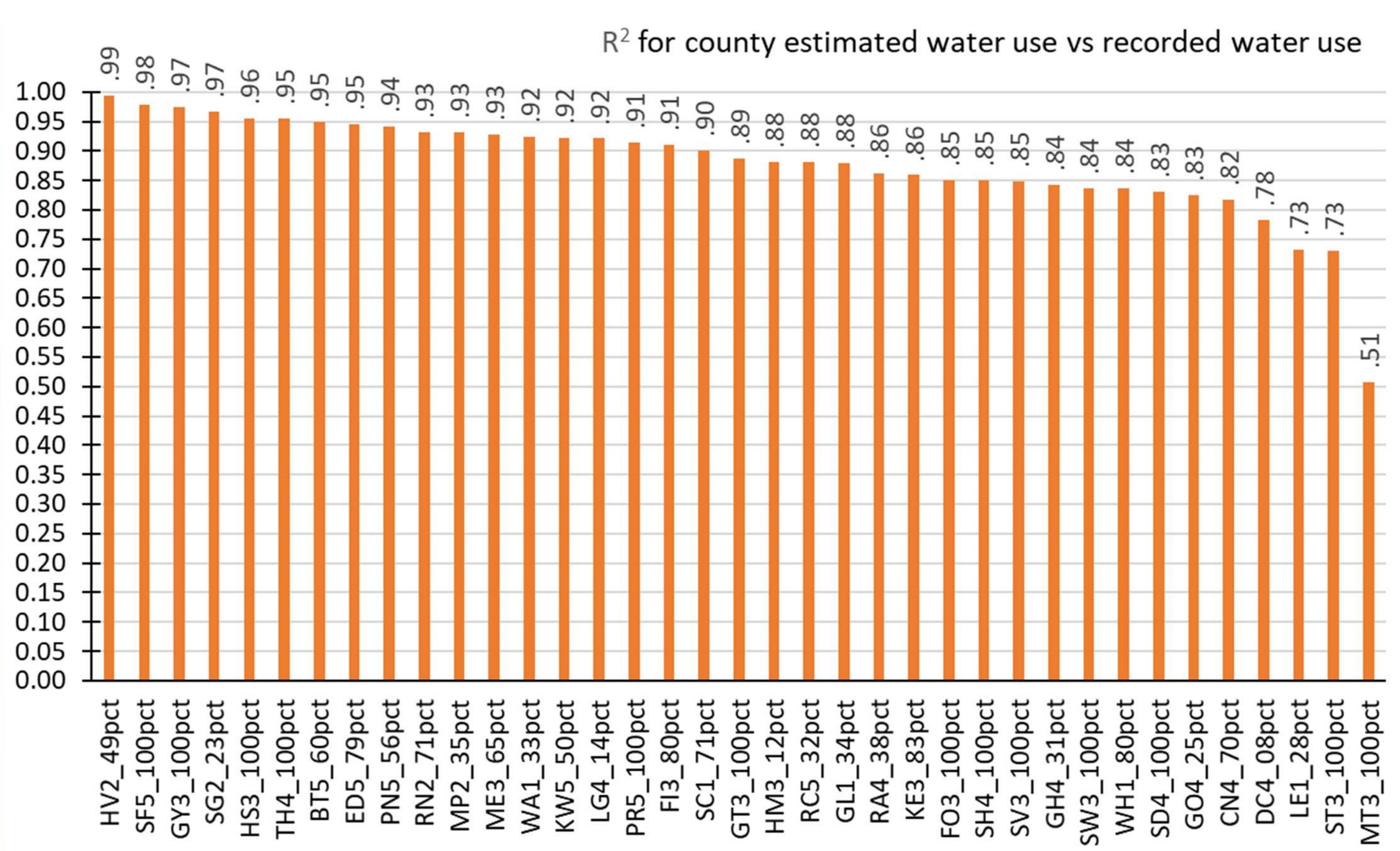
What else can we do with it?

Local Enhanced Management Areas (LEMAs)

- Purpose: **conservation**


Sheridan 6 reported and estimated use 2000-2018
f(ET,P)* regression based on 2000-2012 data
Annual pumping (inches)
18
16
14
12
10
8
6
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
(*) predictor variables:
ET (May, Jun-Jul, Aug-Sep)
P (Apr-May, Jun-Jul, Aug)
reported
estimated
reported (mean)
est. (mean)

Counties

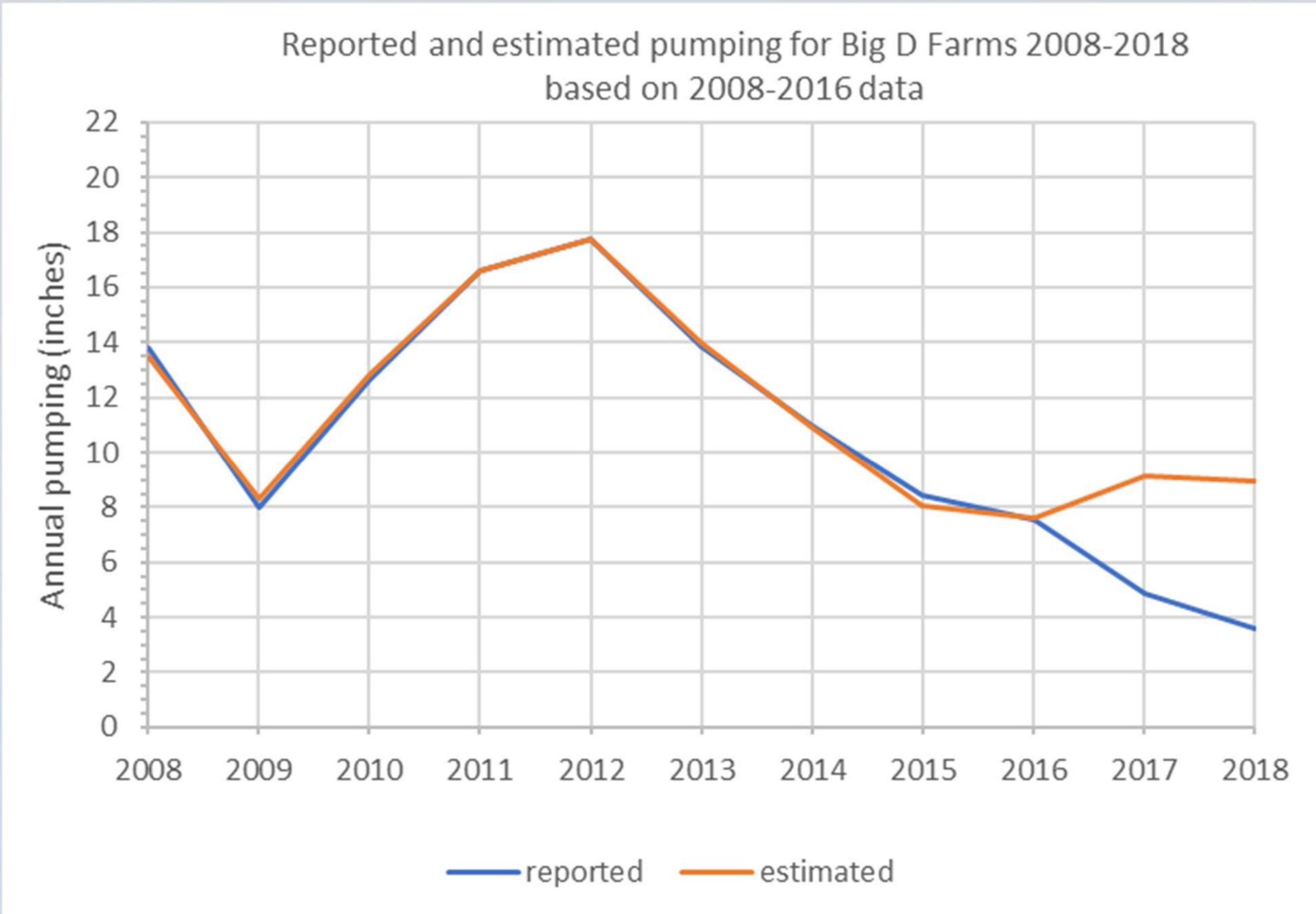


R^2 for county estimated water use vs recorded water use
HV2_49pct .99
SF5_100pct .98
GY3_100pct .97
SG2_23pct .97
HS3_100pct .96
TH4_100pct .95
BT5_60pct .95
ED5_79pct .95
PN5_56pct .94
RN2_71pct .93
MP2_35pct .93
ME3_65pct .93
WA1_33pct .92
KW5_50pct .92
LG4_14pct .92
PR5_100pct .91
FI3_80pct .91
SC1_71pct .90
GT3_100pct .89
HM3_12pct .88
RC5_32pct .88
GL1_34pct .88
RA4_38pct .86
KE3_83pct .86
FO3_100pct .85
SH4_100pct .85
SV3_100pct .85
GH4_31pct .84
SW3_100pct .84
WH1_80pct .84
SD4_100pct .83
GO4_25pct .83
CN4_70pct .82
DC4_08pct .78
LE1_28pct .73
ST3_100pct .73
MT3_100pct .51

Water Conservation Areas (WCAs)

- Purpose: **conservation**

How do we know if someone has been conserving?

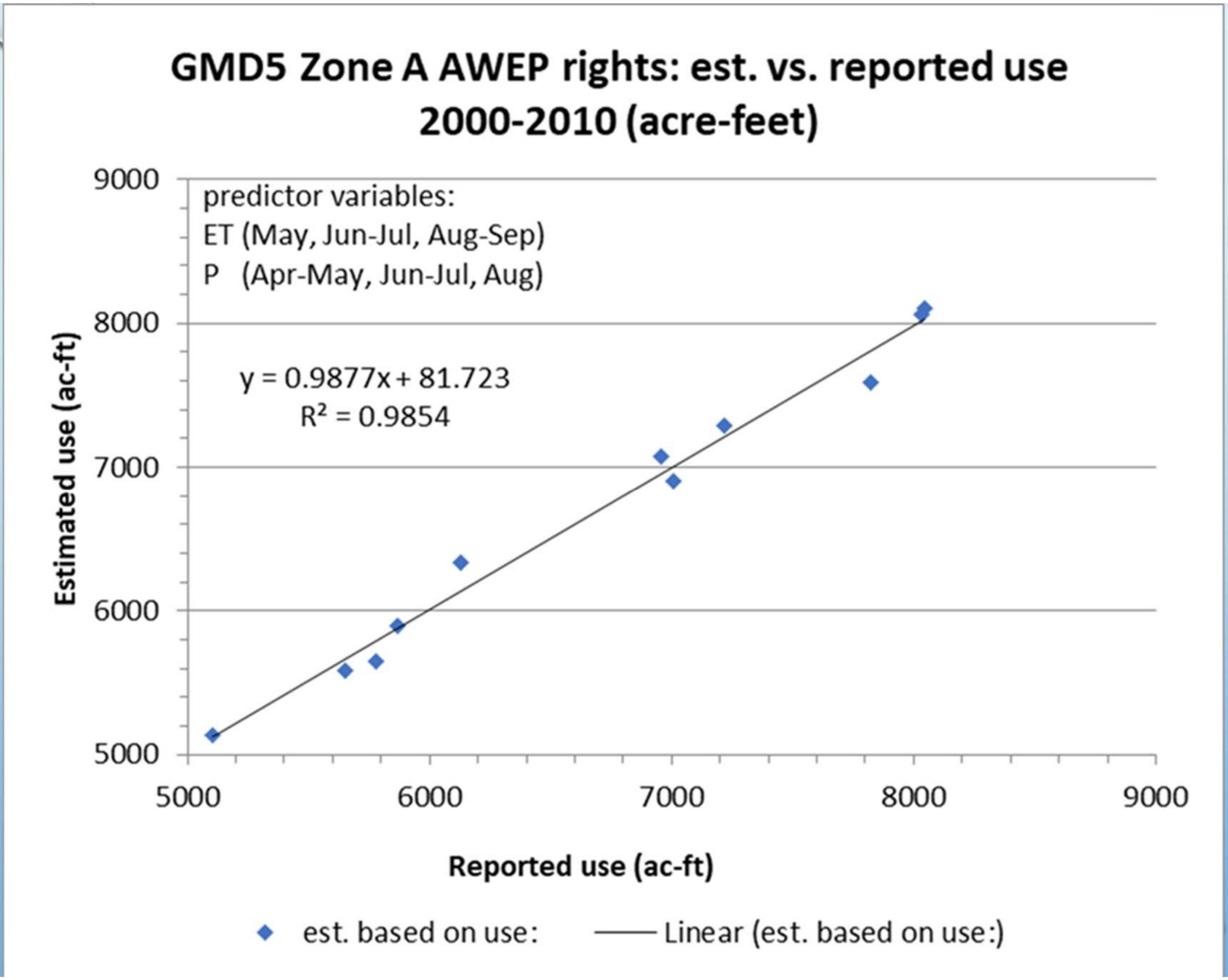

Reported and estimated pumping for Big D Farms 2008-2018
based on 2008-2016 data
Annual pumping (inches)
0
2
4
6
8
10
12
14
16
18
20
22
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
reported
estimated

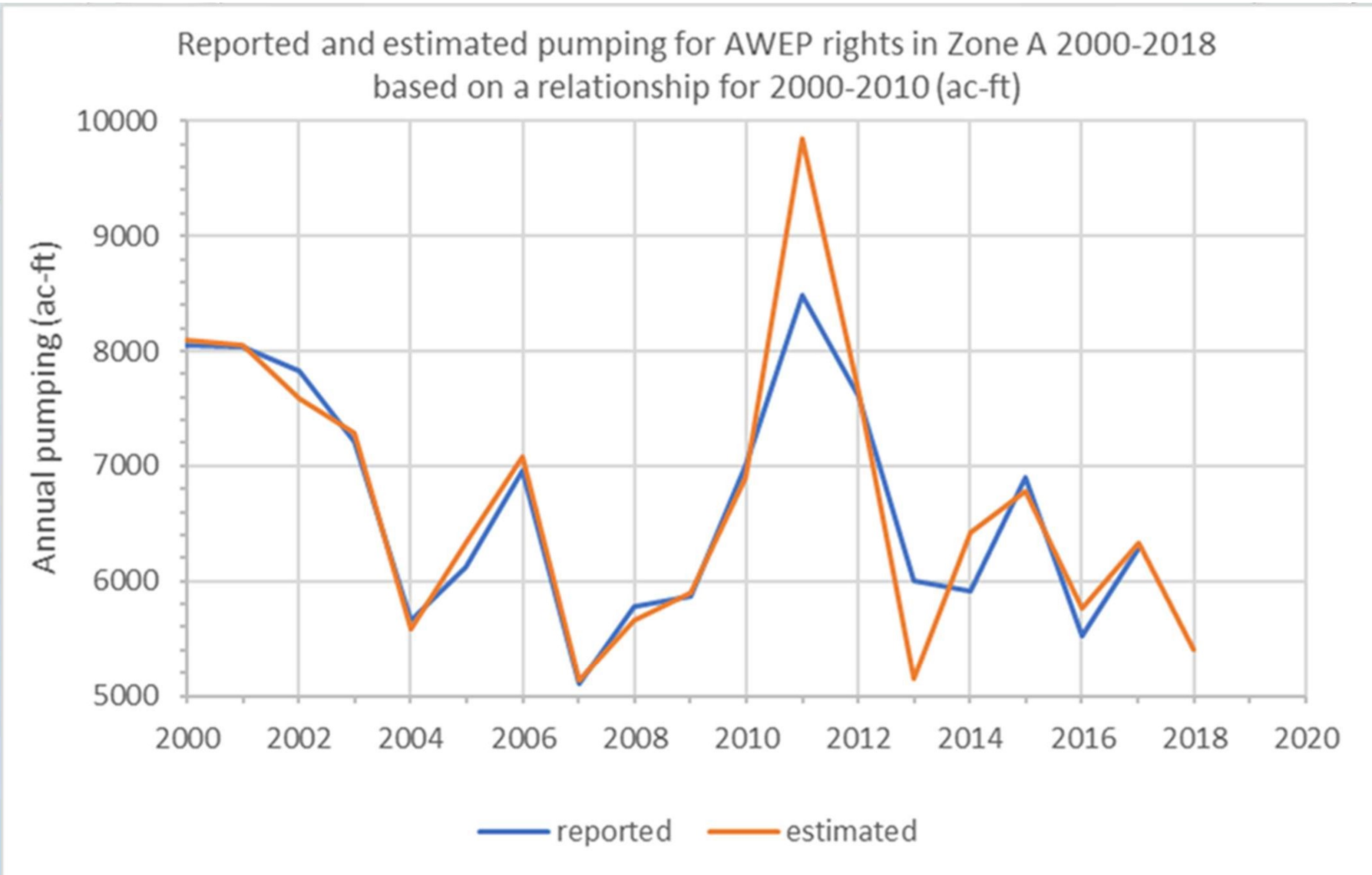
Conservation Programs

Conservation Programs

Agricultural Water Enhancement Program

(AWEP)


GMD5 Zone A AWEP rights: est. vs. reported use
2000-2010 (acre-feet)
predictor variables:
ET (May, Jun-Jul, Aug-Sep)
P (Apr-May, Jun-Jul, Aug)
y = 0.9877x + 81.723
R² = 0.9854
Estimated use (ac-ft)
Reported use (ac-ft)
9000
8000
7000
6000
5000
5000
6000
7000
8000
9000
est. based on use:
Linear (est. based on use:)


Reported and estimated pumping for AWEP rights in Zone A 2000-2018
based on a relationship for 2000-2010 (ac-ft)
Annual pumping (ac-ft)
10000
9000
8000
7000
6000
5000
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
reported
estimated

Statutes give due consideration for past conservation

- Generally - K.S.A. 82a-744 "…due consideration to water management or conservation measures previously implemented by a water right holder when implementing any further limitations"
- Water Conservation Areas – K.S.A. 82a-745
- LEMAs - K.S.A. 82a-1041

To Do:

- Continue to evaluate performance
- Use to evaluate past conservation
- Apply to GMD 4 district-wide LEMA (just put in place 2018)
- Apply to other WCAs, Water Technology Farms
- Look at refinement of predictor variables

In summary:

Past behavior can be modeled to evaluate changes in behavior, e.g. conservation

Just need good data