Climate change impacts on a Sierra Nevada foothill watershed

Two decades of citizen-science data demonstrate climate-driven shifts in perennial stream water quality

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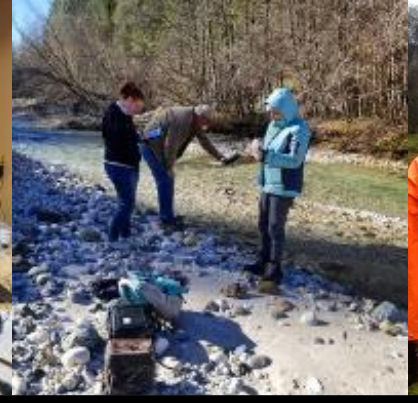
[1]Sierra Streams Institute [2]University of California, Merced





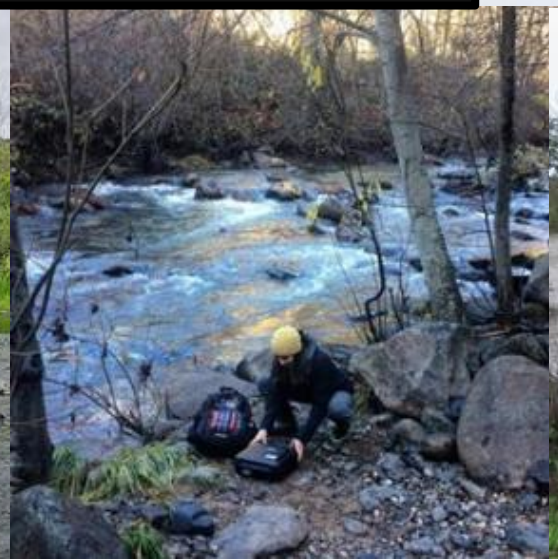


Deer Creek Monitoring Program

10 sites established in 2000
6 sites added between 2001-04
Last two sites (added between 2008-2010
17 sites monitored monthly
All monitored by volunteer Citizen Scientists

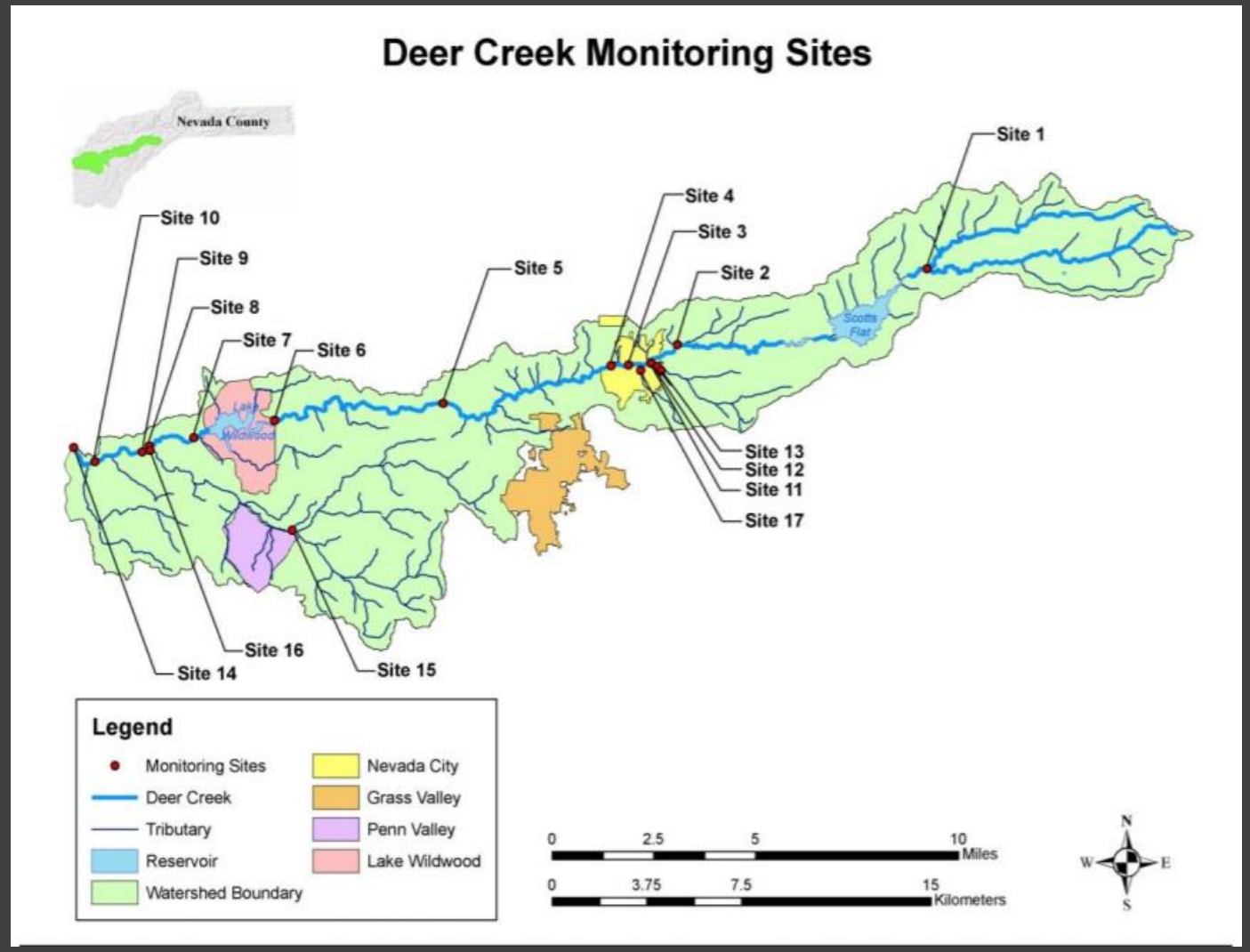




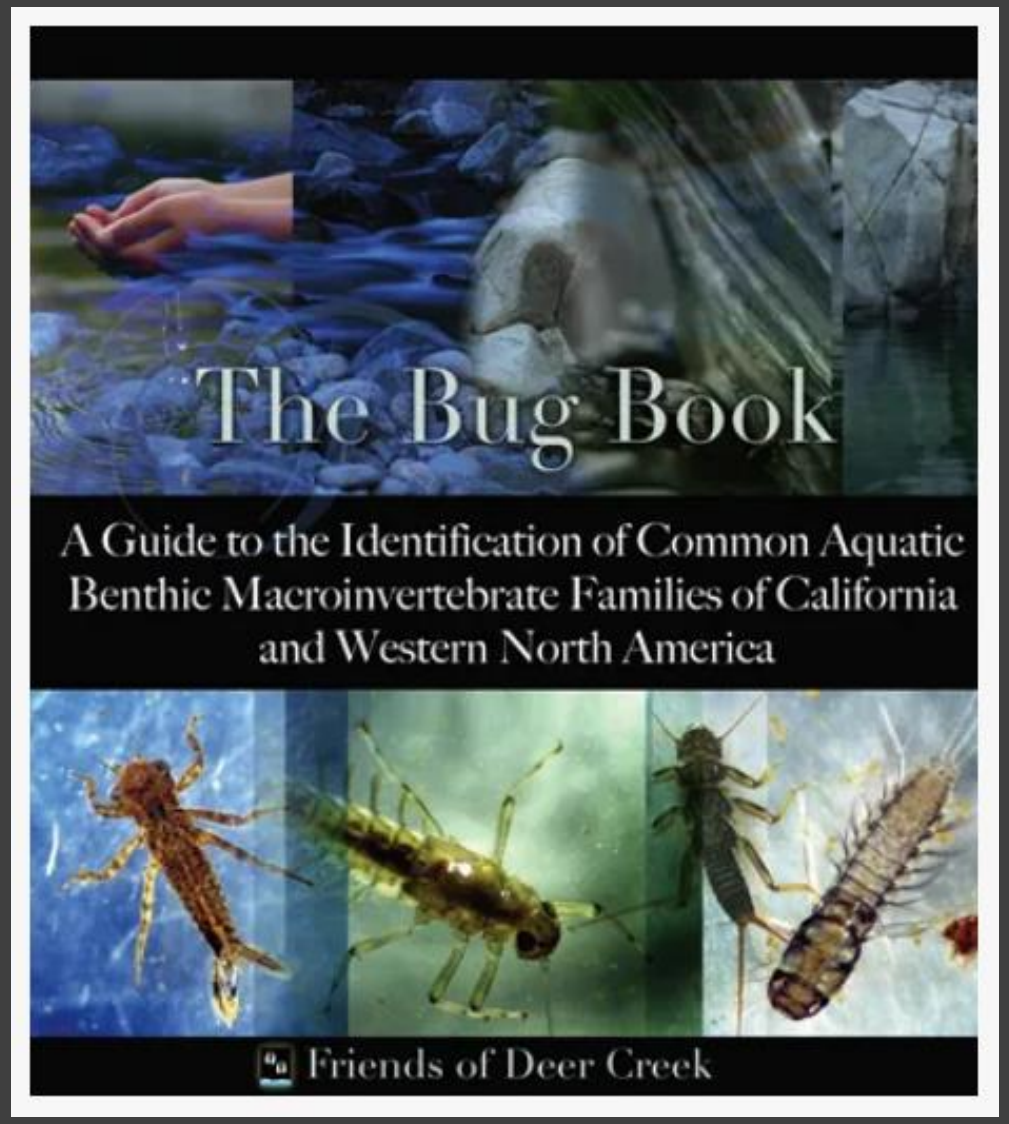



Water Quality Parameters

- Nitrate
- Phosphate
- Conductivity
- pH
- *E. Coli*
- Total Coliform
- Air (˚C)
- Water (˚C)
- Dissolved Oxygen
- Turbidity

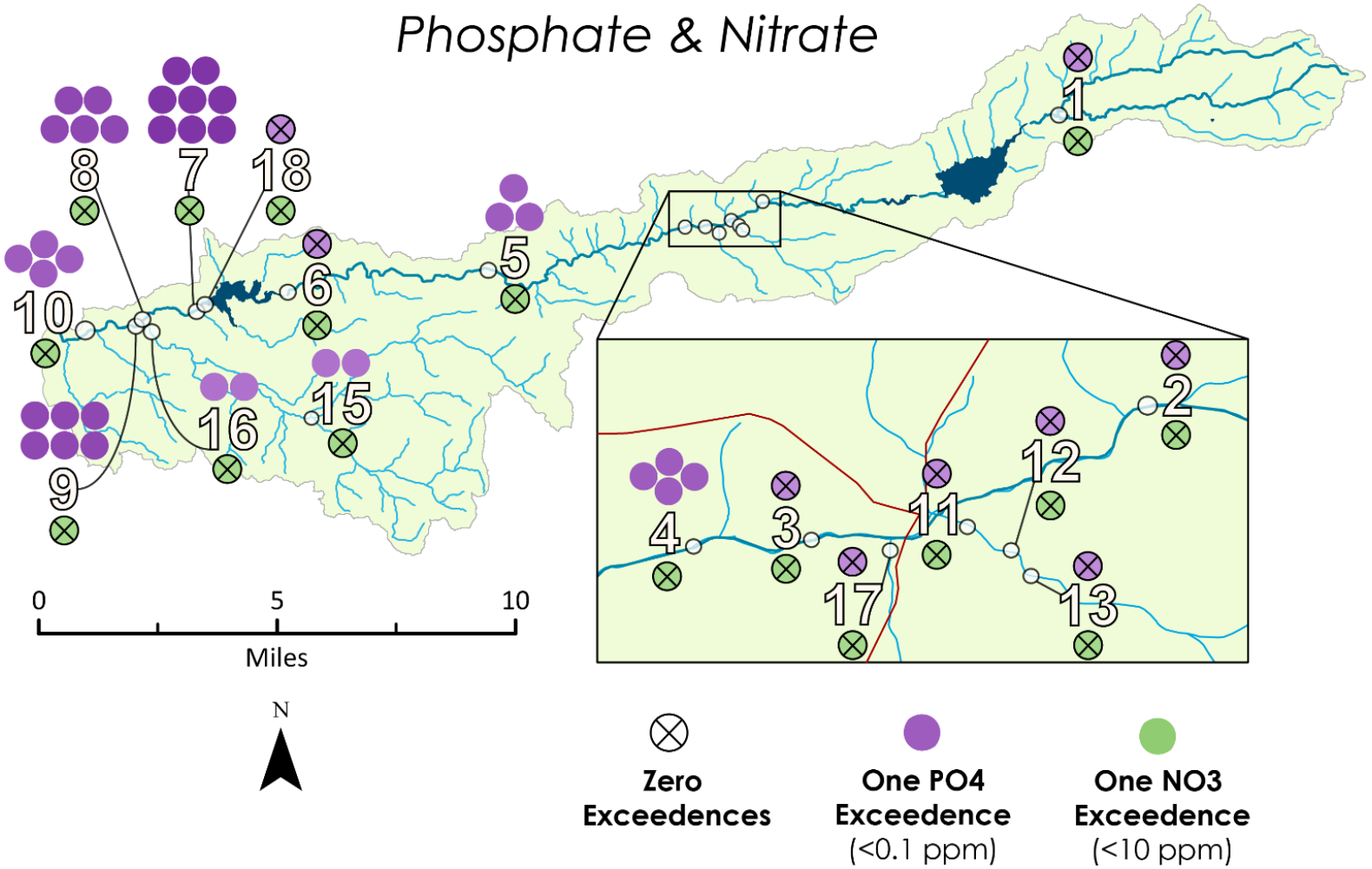


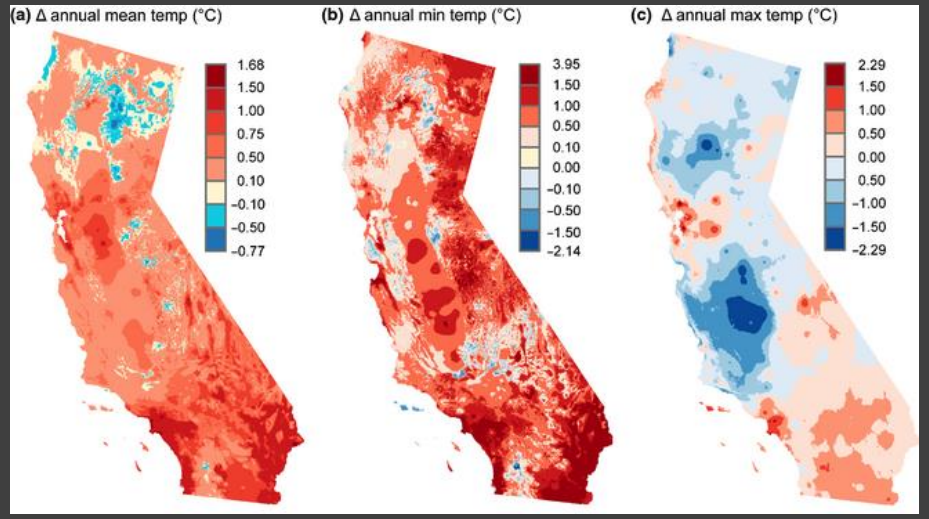
Benthic Macroinvertebrates (BMI)



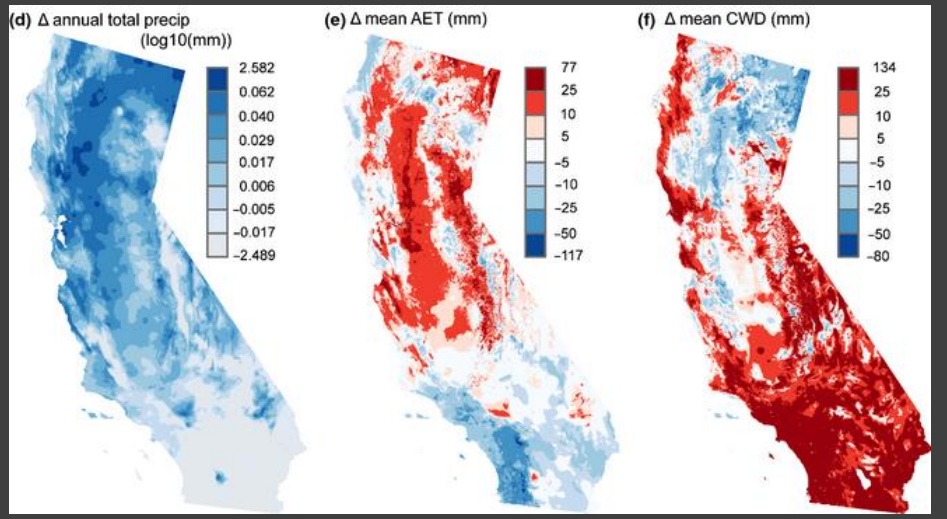
Deer Creek Watershed

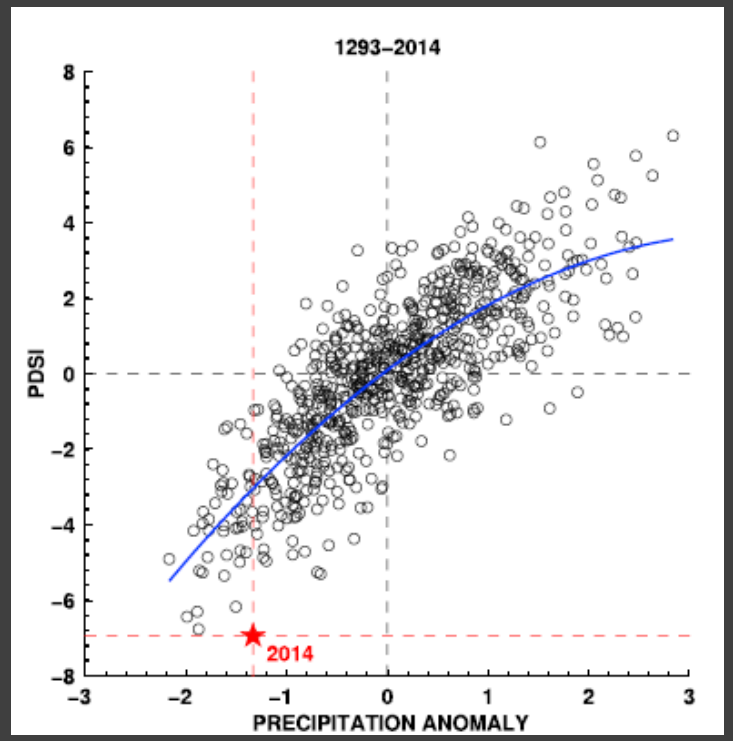
Phosphate & Nitrate





Rapacciuolo et al. 2014





Griffin and Anchukaitis 2014

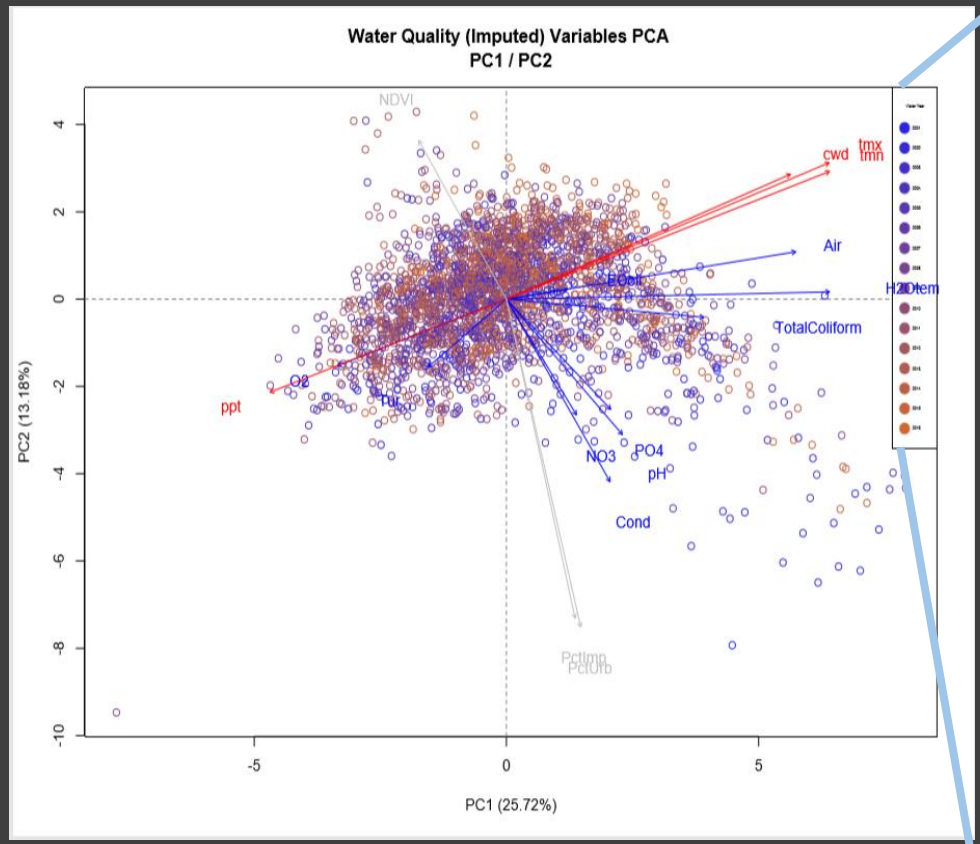
Questions:

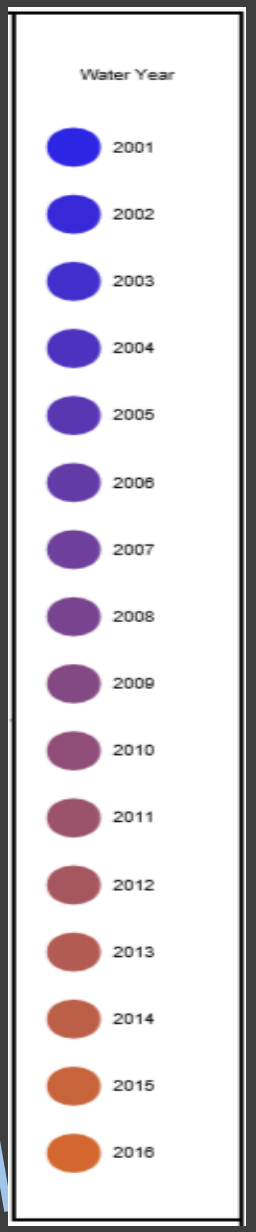
1) Do climatic drivers outweigh land use in determining water quality and biological response?

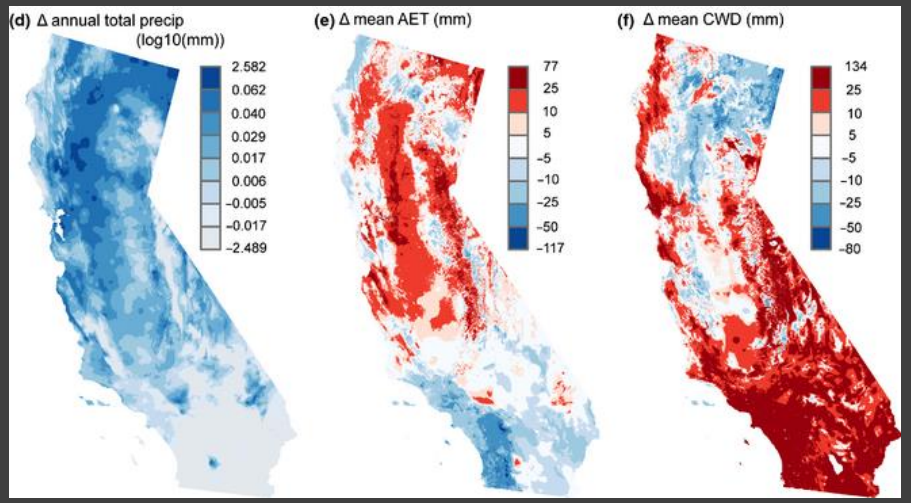
2) What can responses to the extreme climatic events of the past two decades tell us about future climate susceptibility or resilience?

Approach

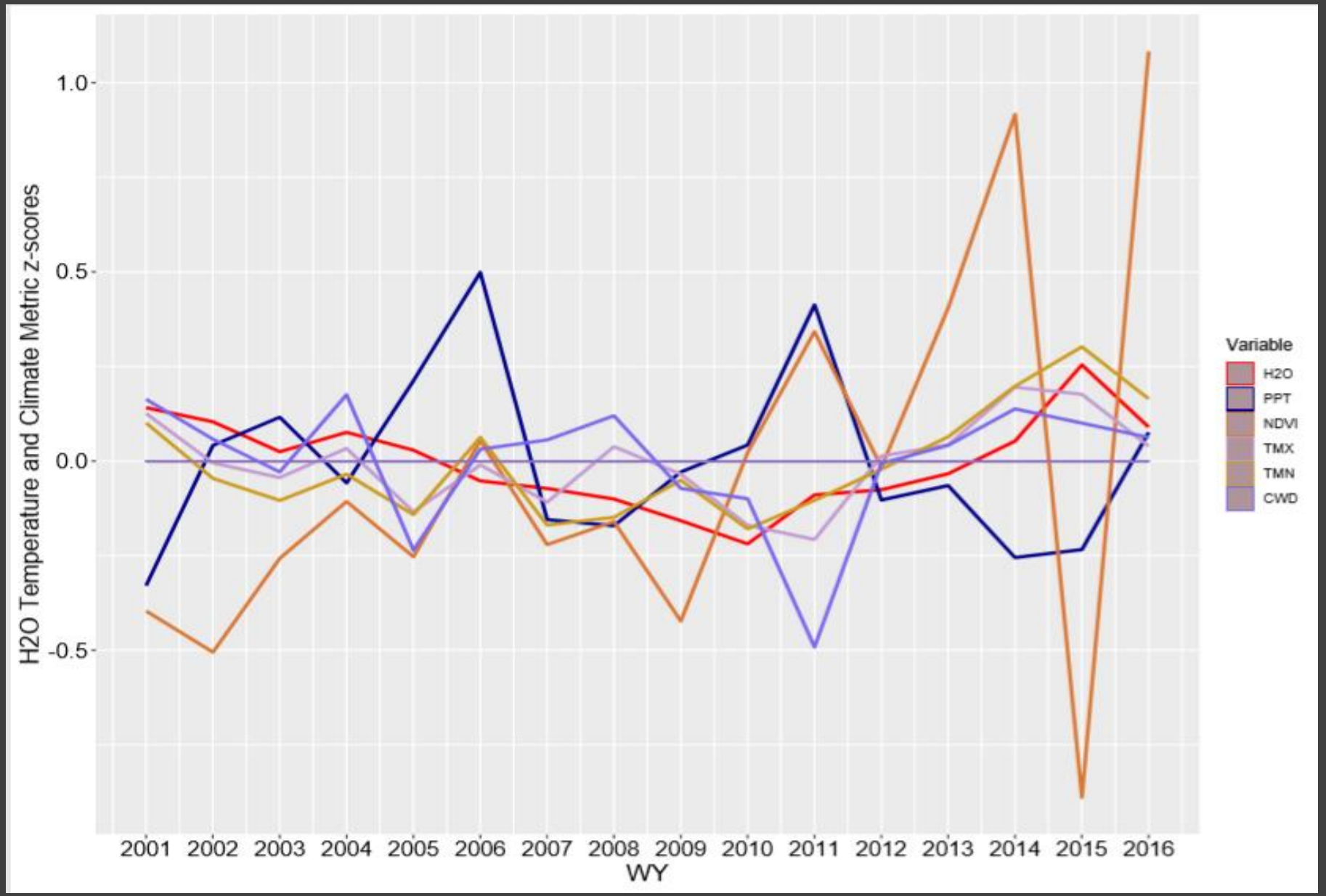
- Trend analysis
- Ordinations for variable reduction and trend analysis
- Structural Equation Models
  - Climate data: CalBCM (Flint et al. 2013)
    - TMX
    - TMN
    - CWD
      - (PET-AET, aridity)
    - PPT
  - Land use data: Google Earth Engine and GIS:
    - % Urban
    - % Impervious
    - Canopy cover (NDVI)





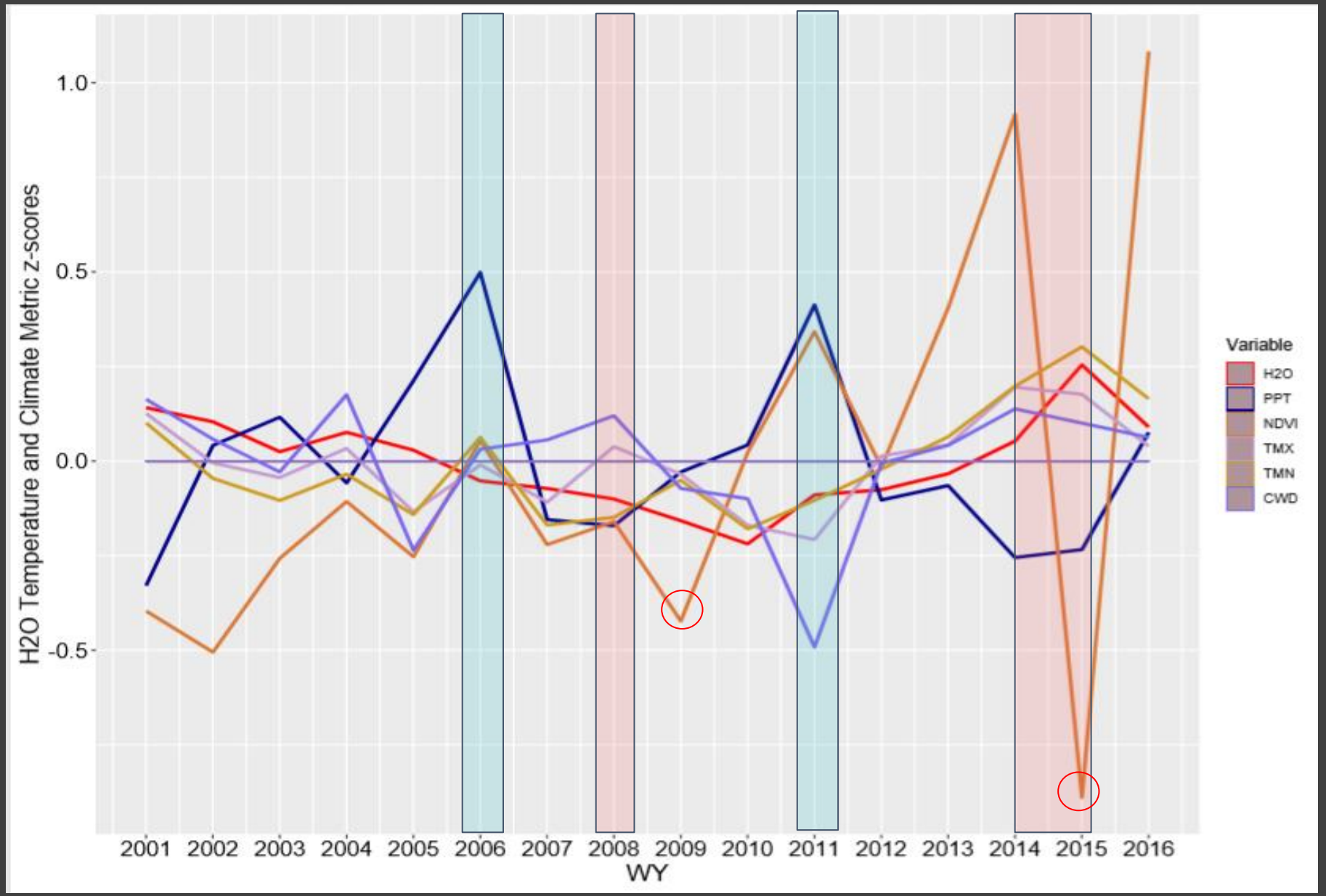


2000	AN
2001	D
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



California Data Exchance Center (CDEC), Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices

2000	AN
2001	D
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



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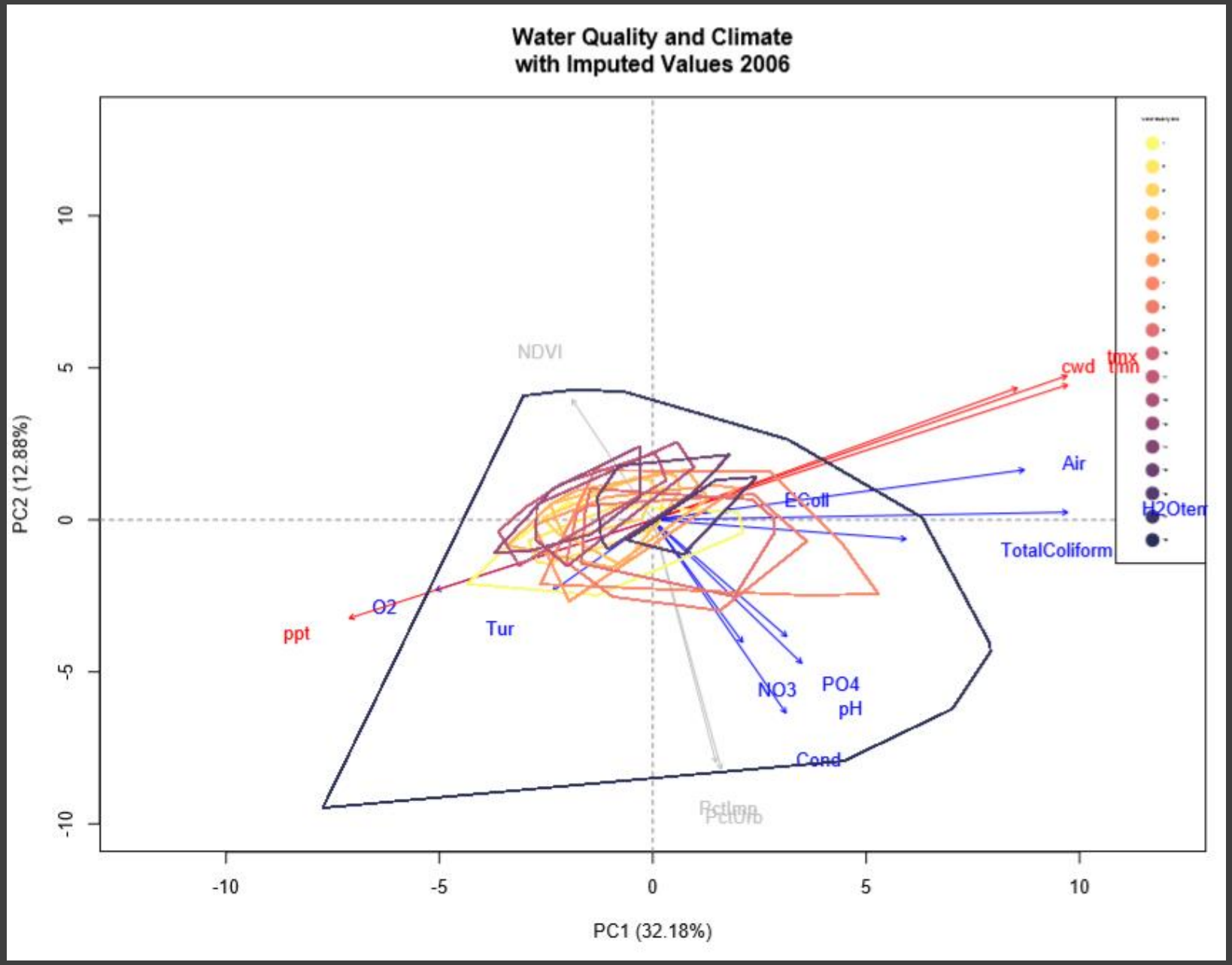
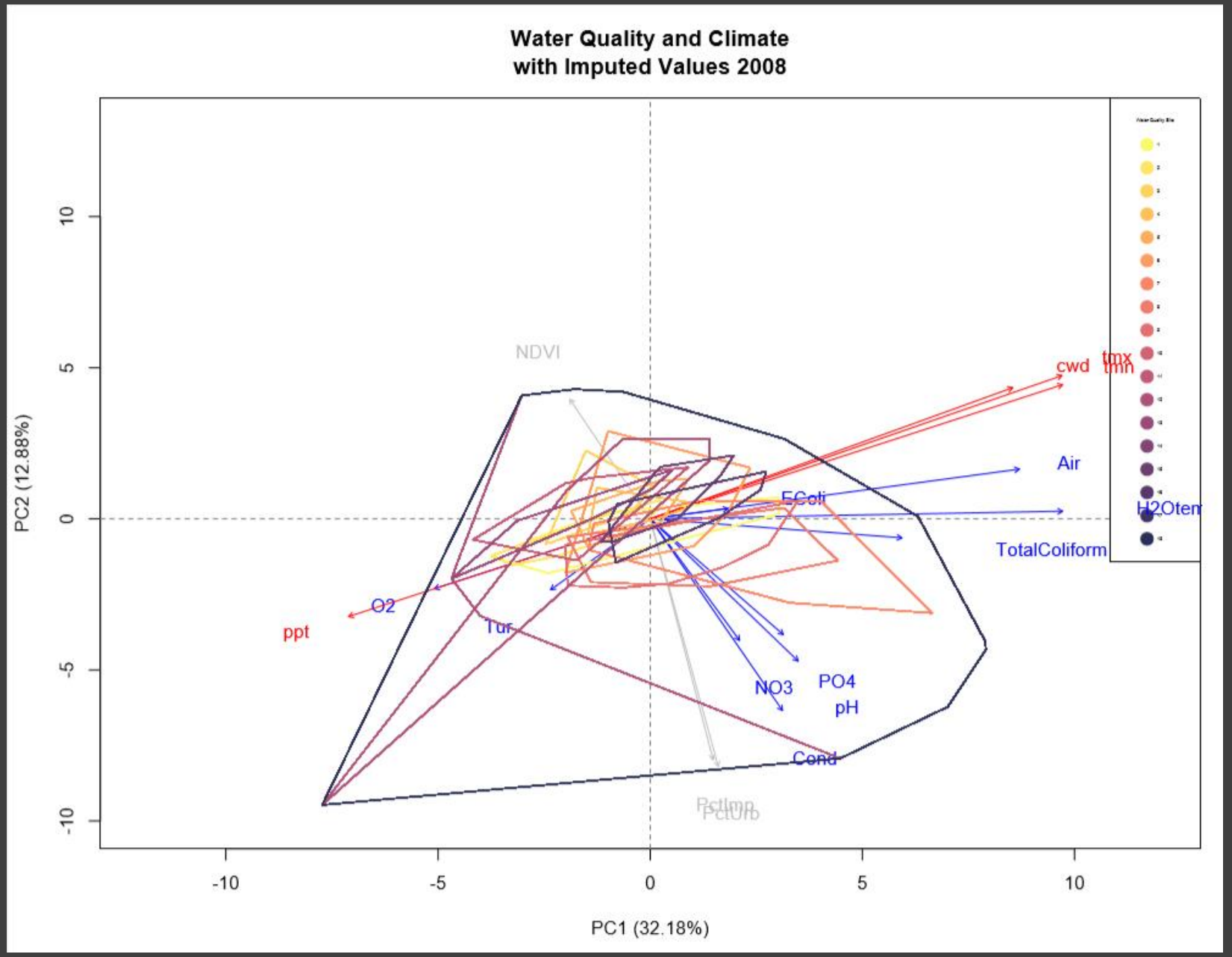
2001	D
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



2000	AN
2001	D
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



2000	AN
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2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
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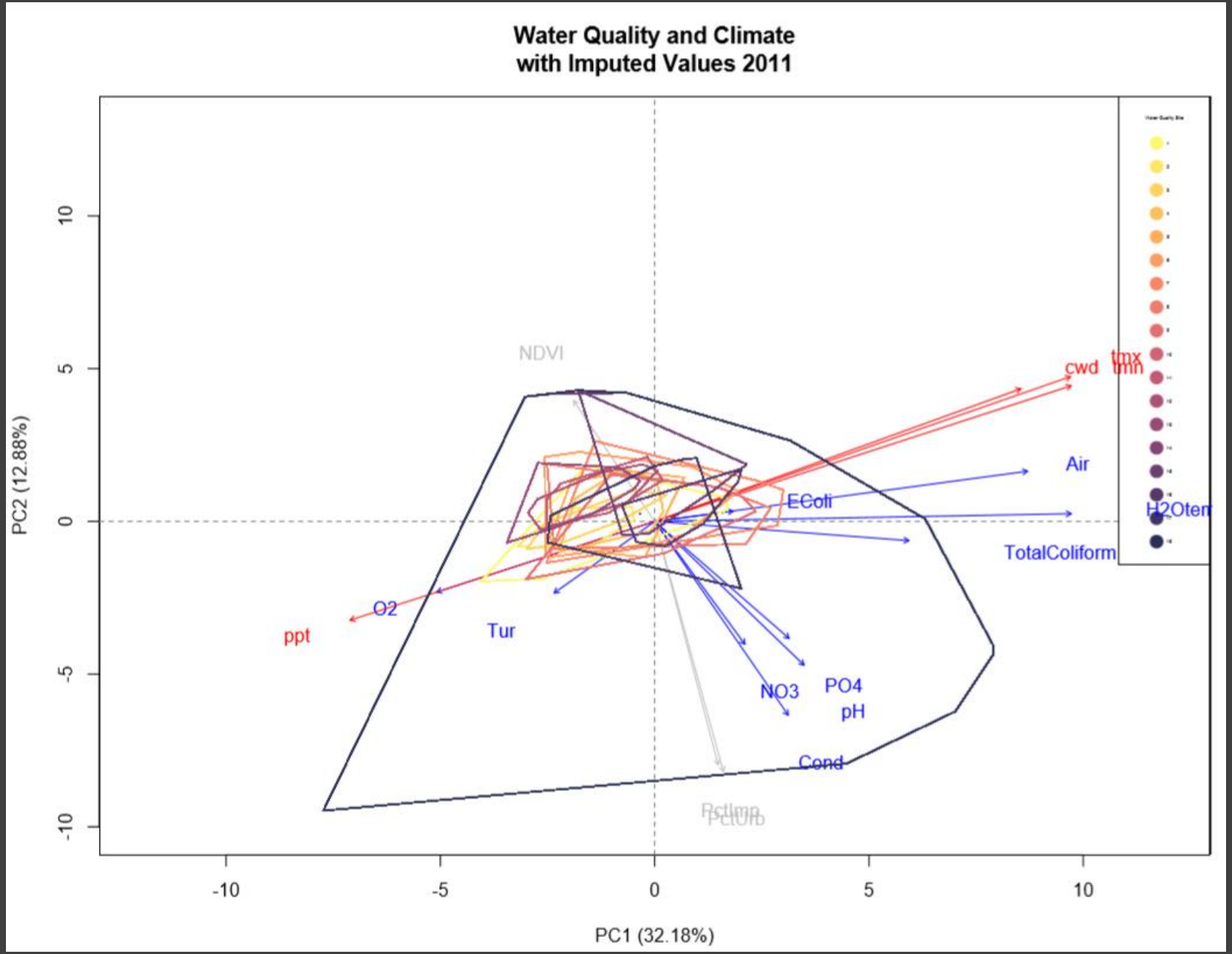
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



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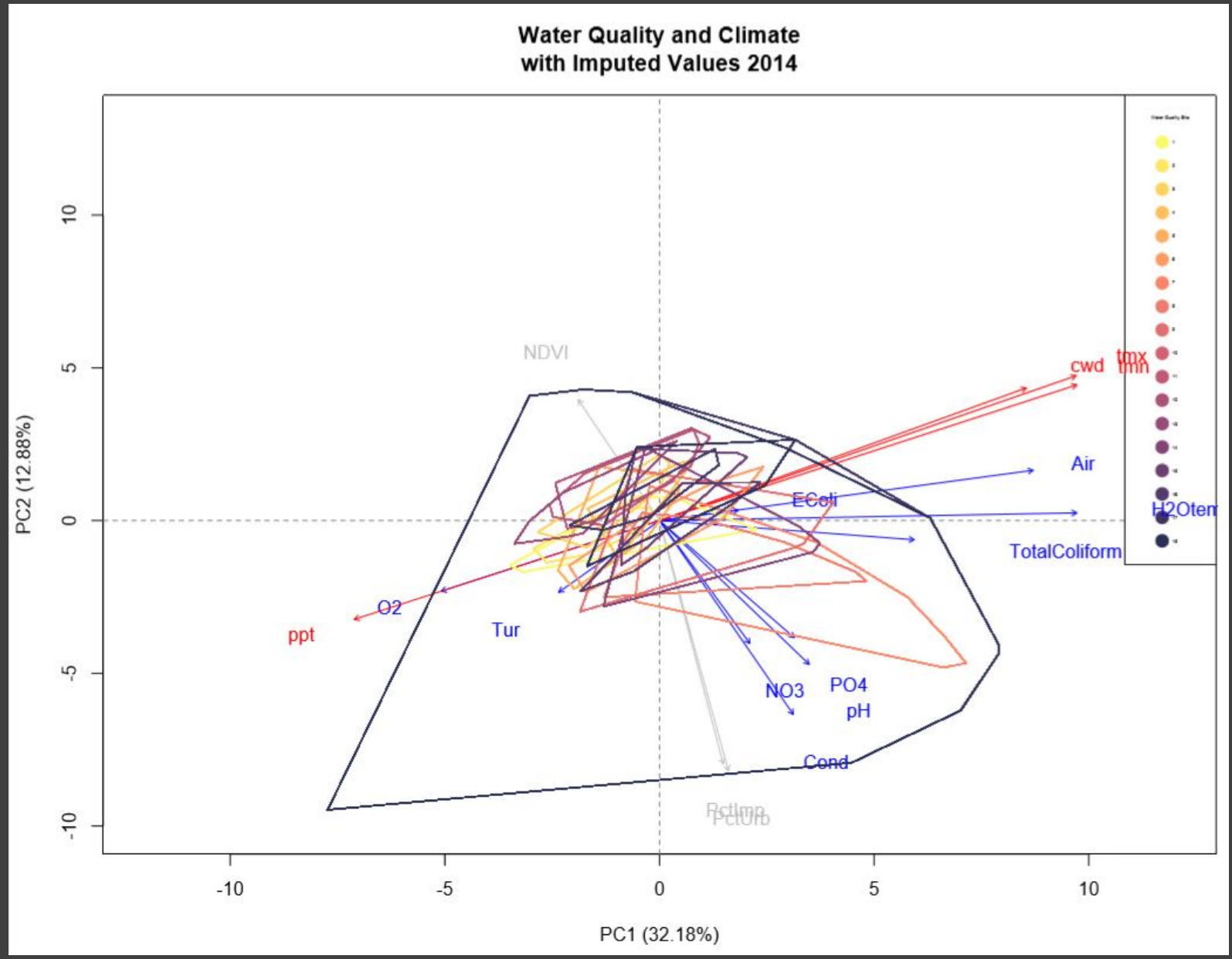
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



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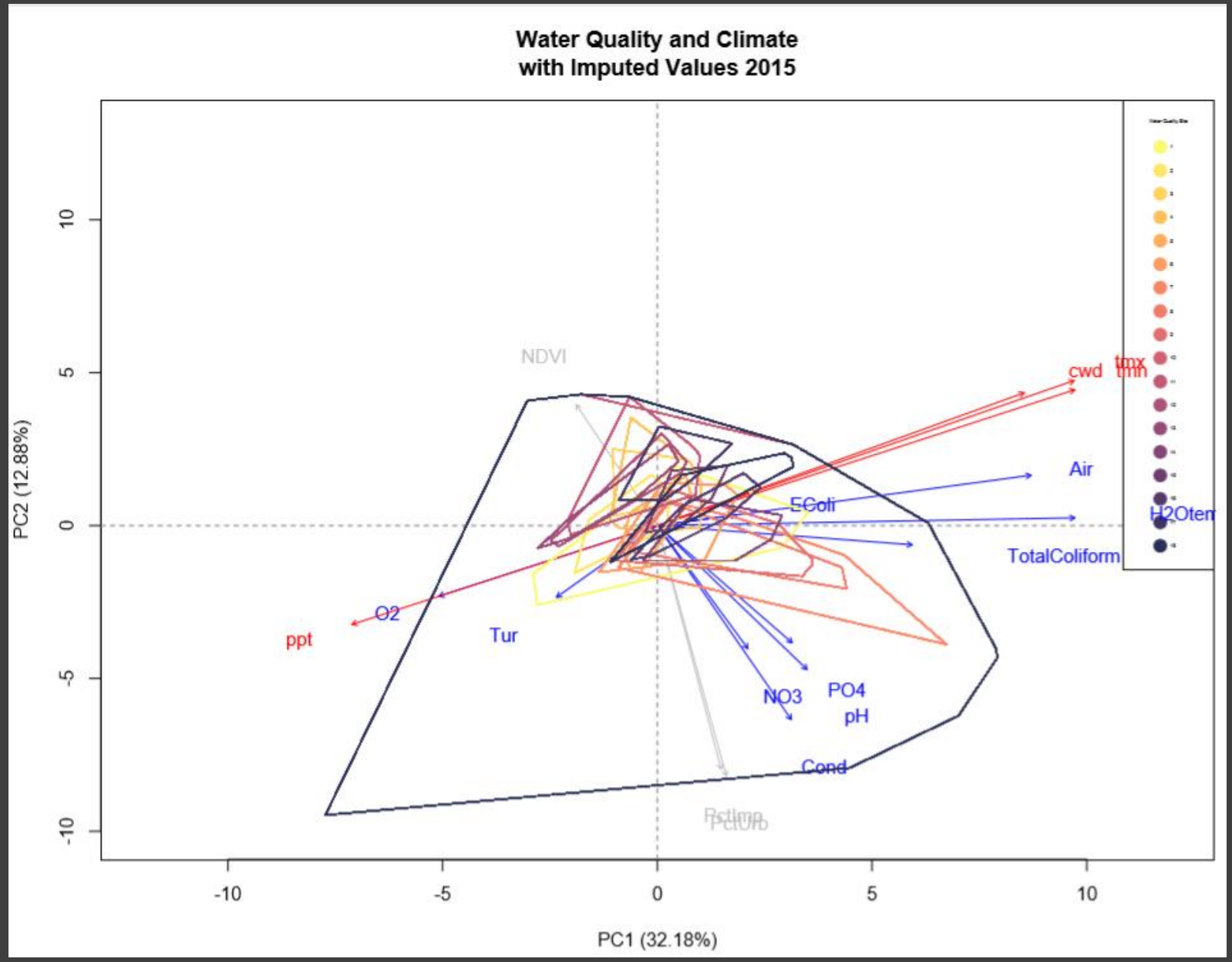
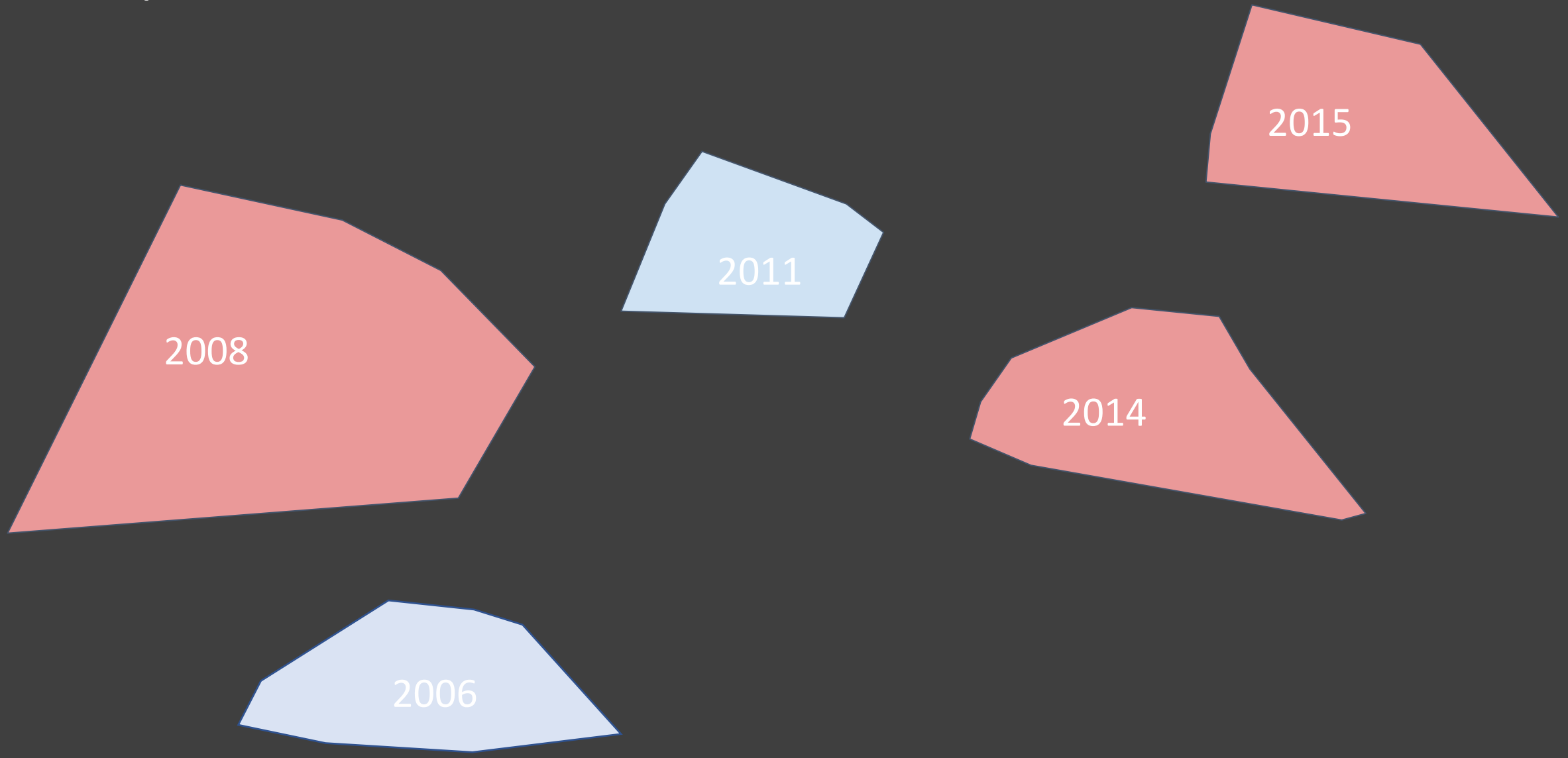
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W

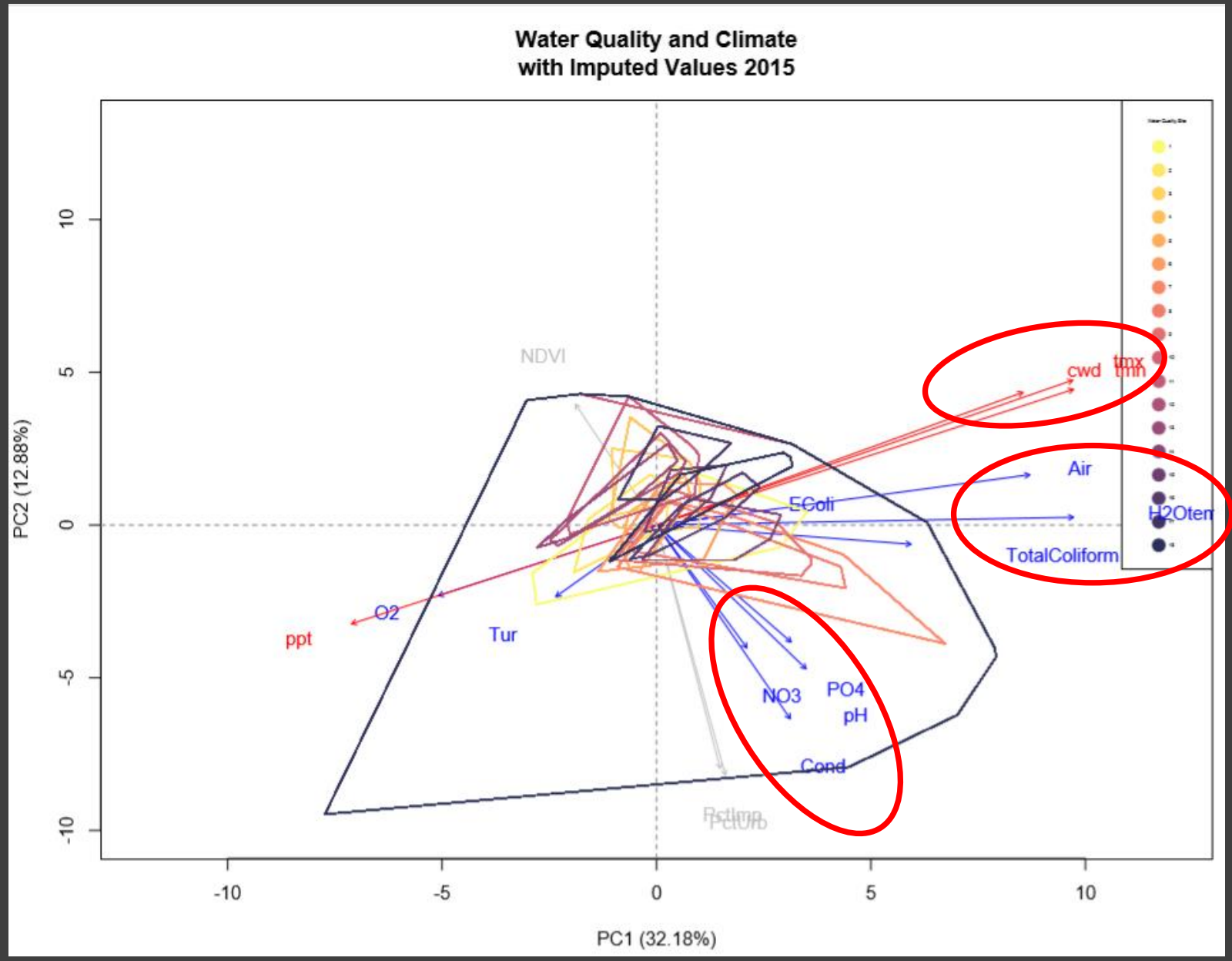


California Data Exchance Center (CDEC), Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices

Comparison Overall Hulls



2000	AN
2001	D
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



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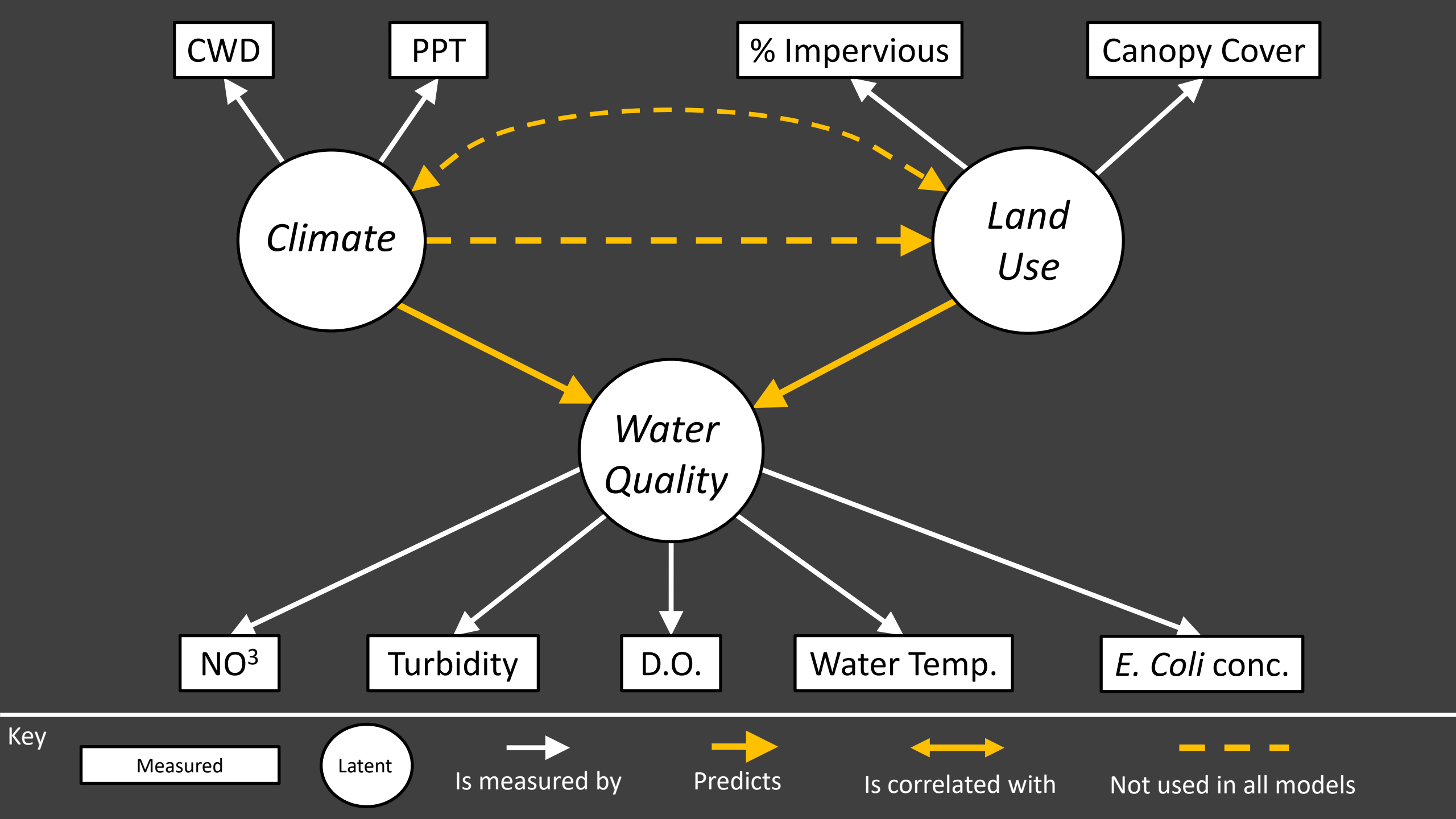
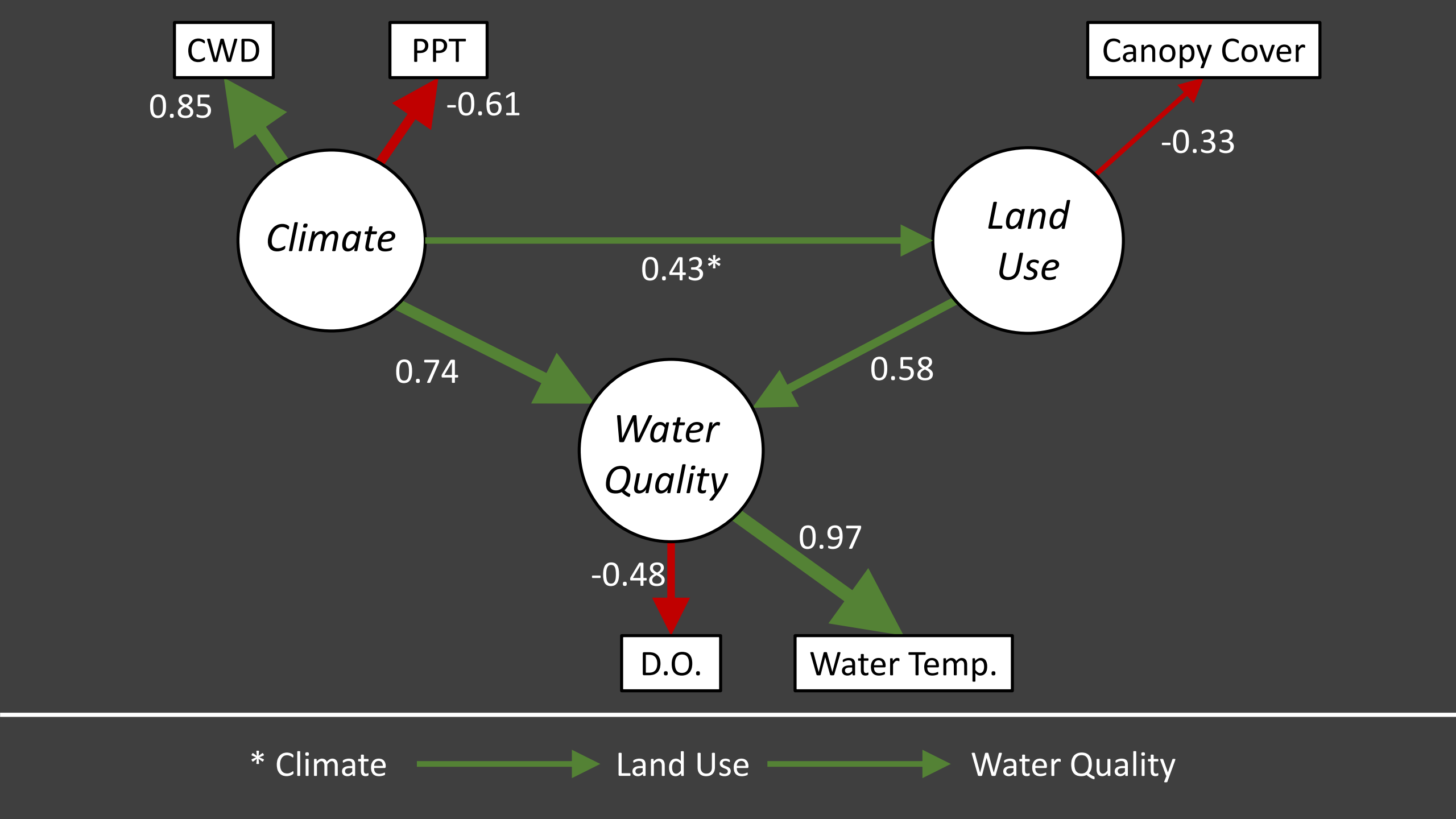
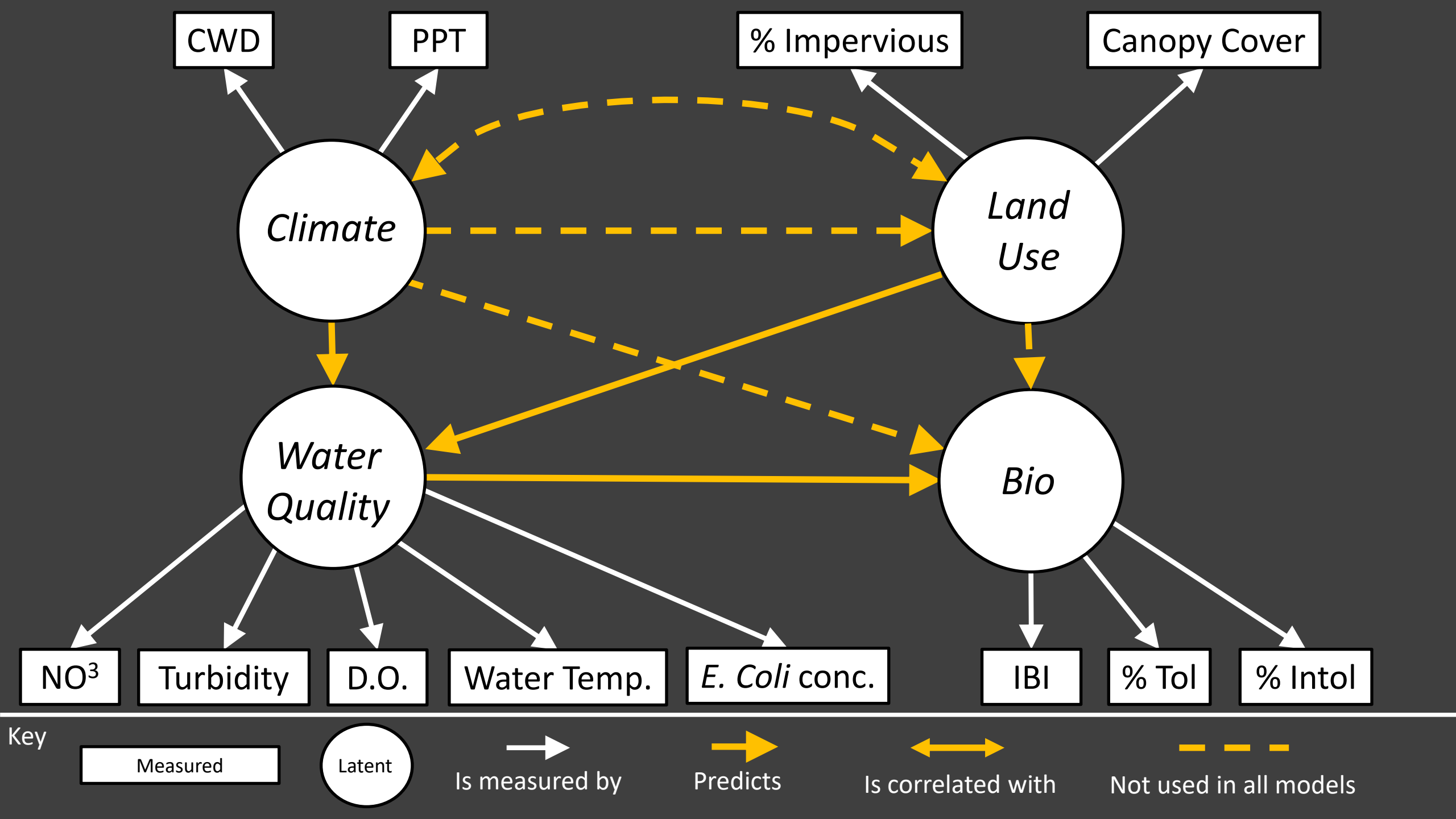
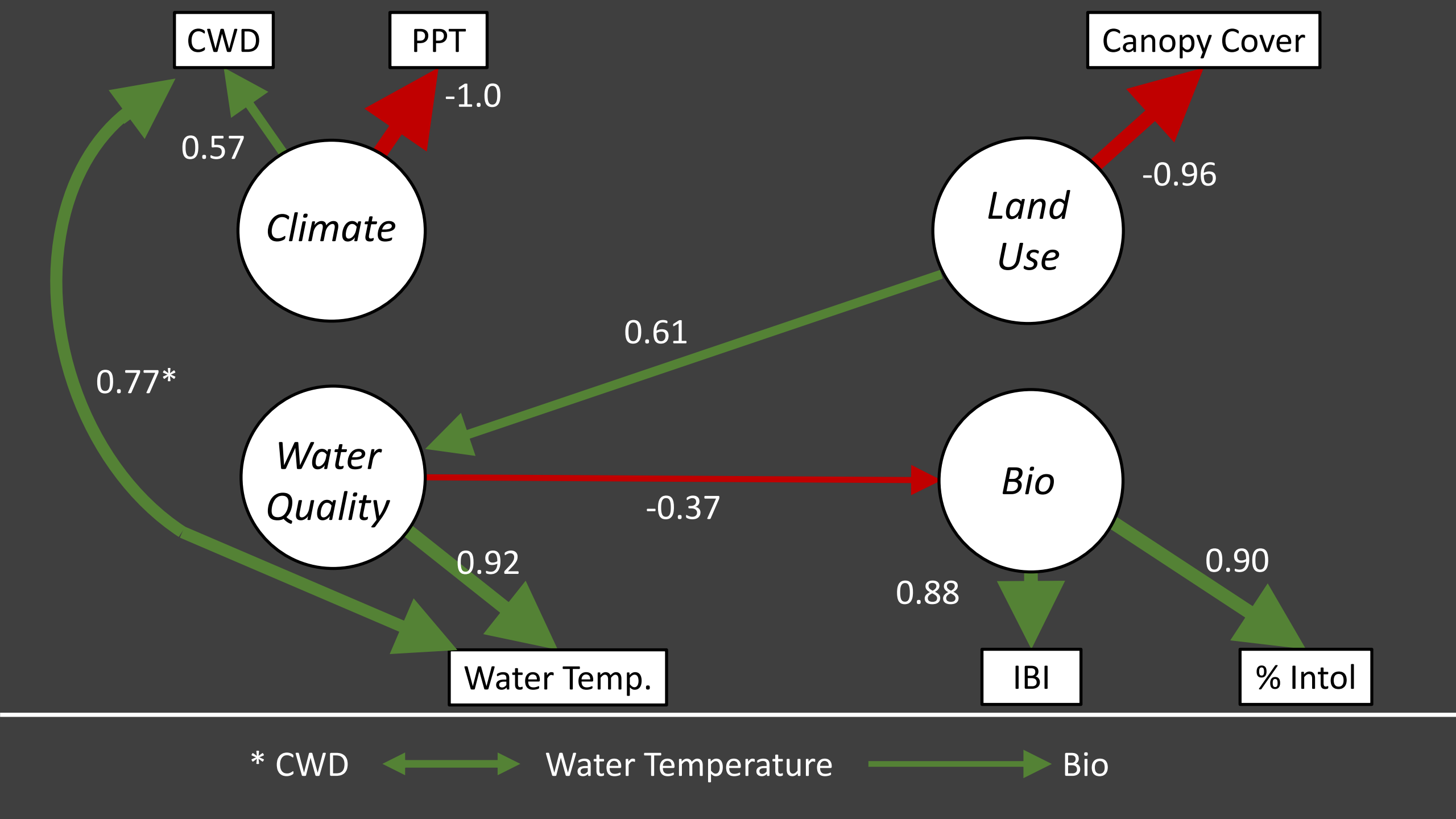
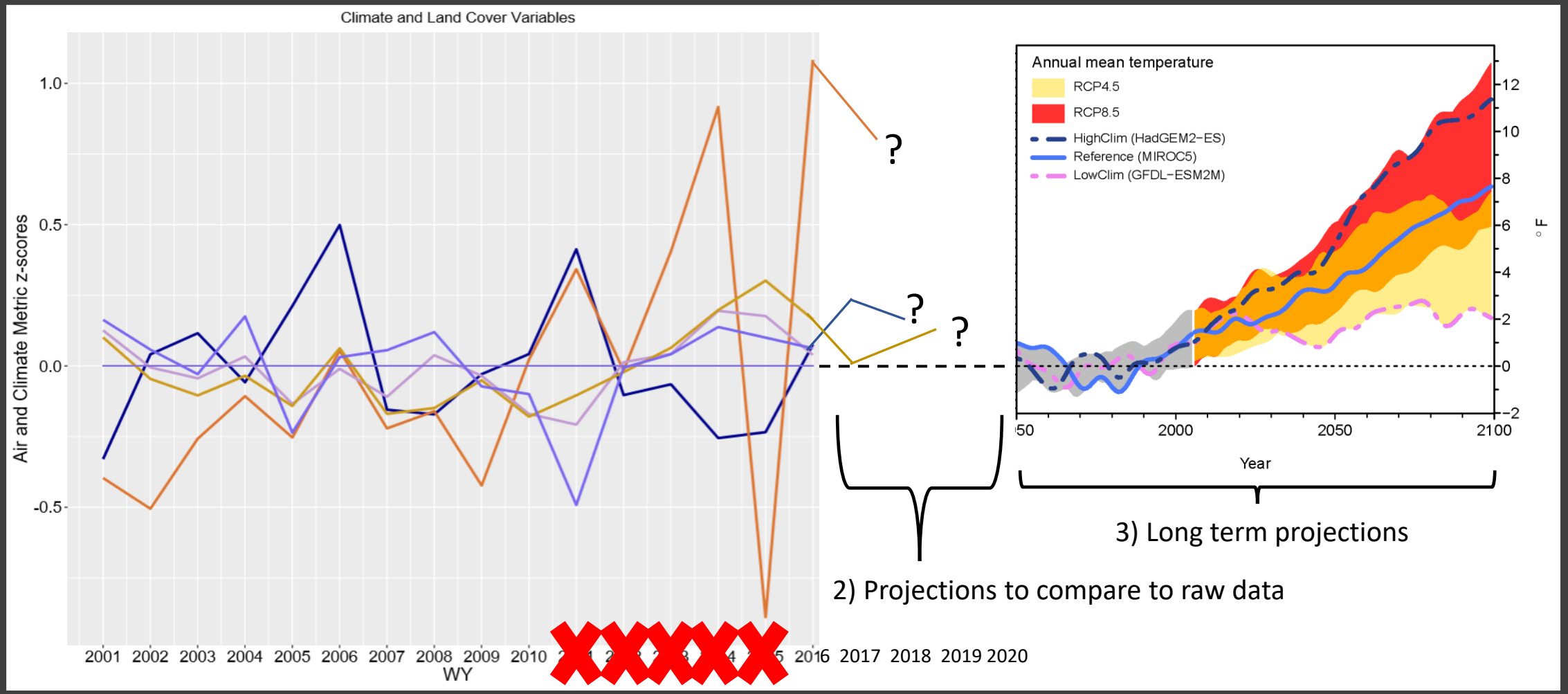

CWD
PPT
% Impervious
Canopy Cover
Climate
Land Use
Water Quality
NO3
Turbidity
D.O.
Water Temp.
E. Coli conc.
Key
Measured
Latent
Is measured by
Predicts
Is correlated with
Not used in all models


CWD
PPT
Canopy Cover
0.85
-0.61
-0.33
Climate
Land Use
0.43*
0.74
0.58
Water Quality
0.97
-0.48
D.O.
Water Temp.
* Climate
Land Use
Water Quality


CWD
PPT
% Impervious
Canopy Cover
Climate
Land Use
Water Quality
Bio
NO3
Turbidity
D.O.
Water Temp.
E. Coli conc.
IBI
% Tol
% Intol
Key
Measured
Latent
Is measured by
Predicts
Is correlated with
Not used in all models

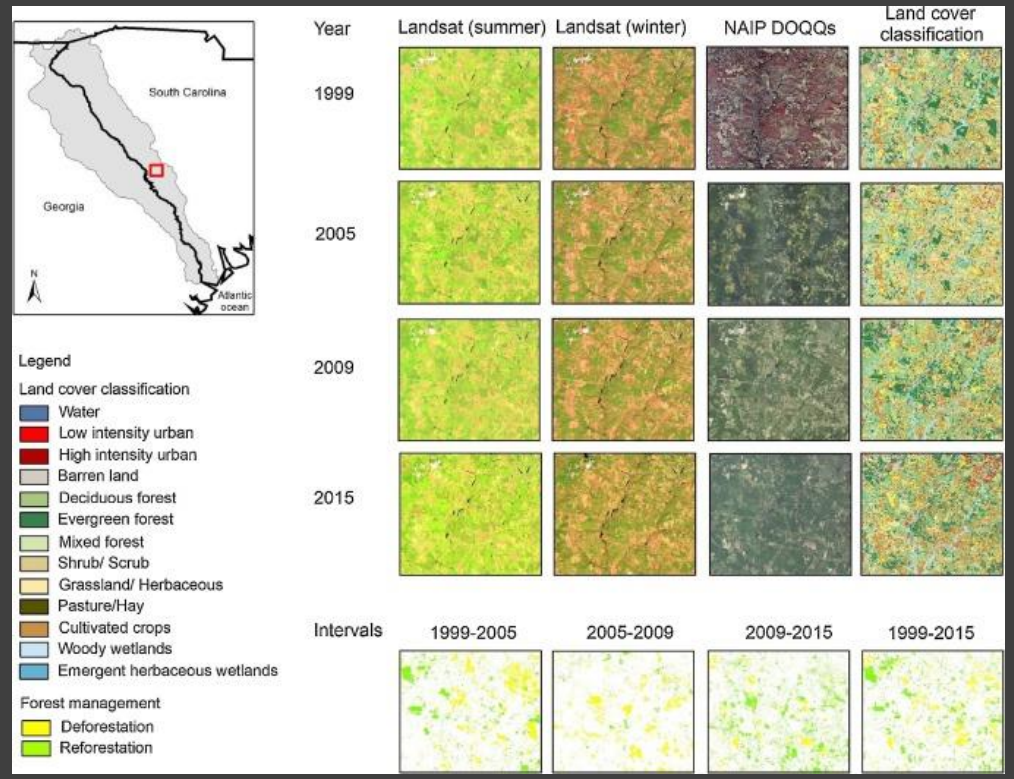

CWD
PPT
Canopy Cover
-1.0
0.57
Climate
Land Use
-0.96
0.61
0.77*
Water Quality
Bio
-0.37
0.92
0.90
0.88
Water Temp.
IBI
% Intol
* CWD
Water Temperature
Bio

Next Steps



1) Removal of extreme years

Next Steps



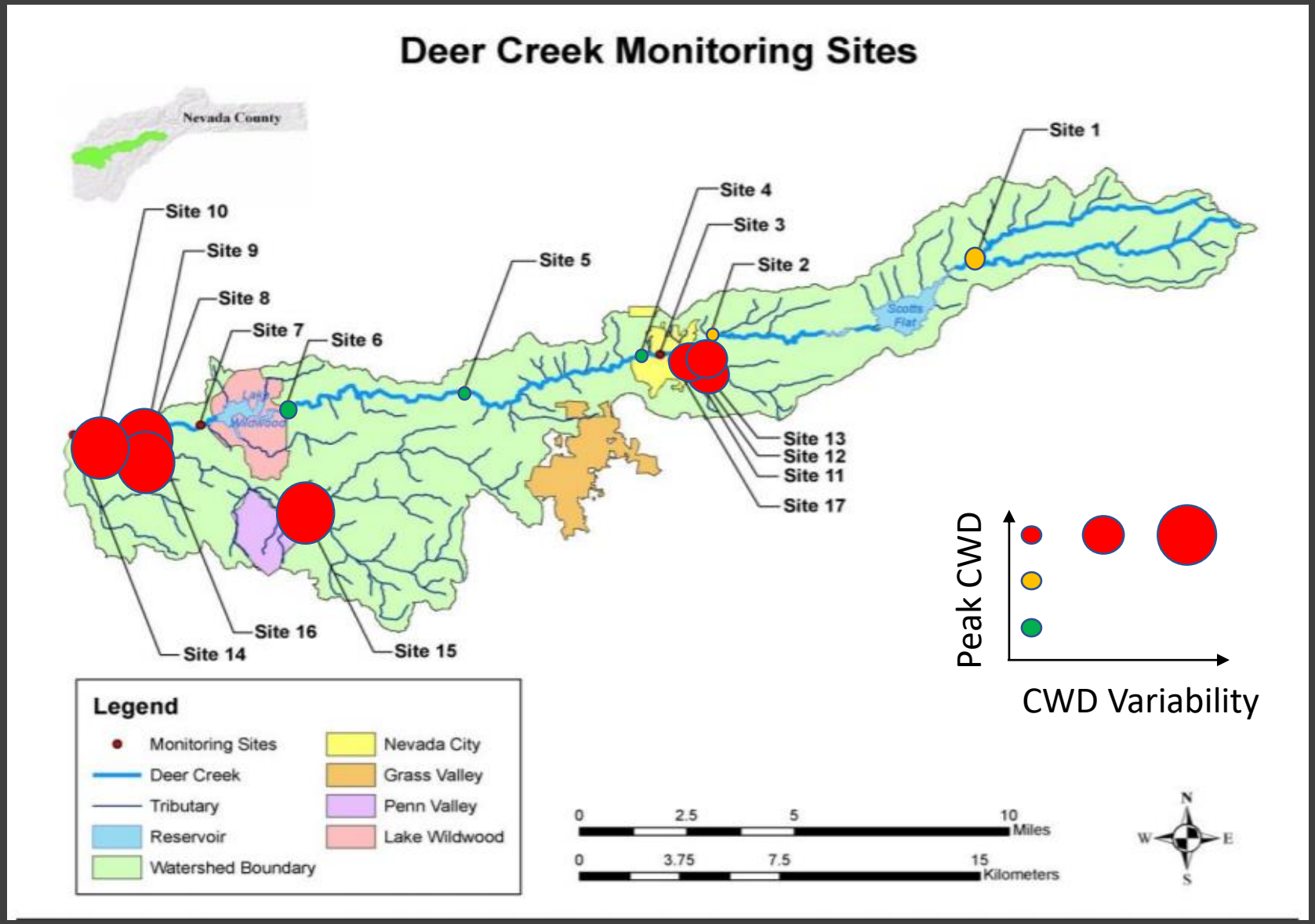
Zurqani et al. 2018

Land Use

Physical Habitat (PHab)

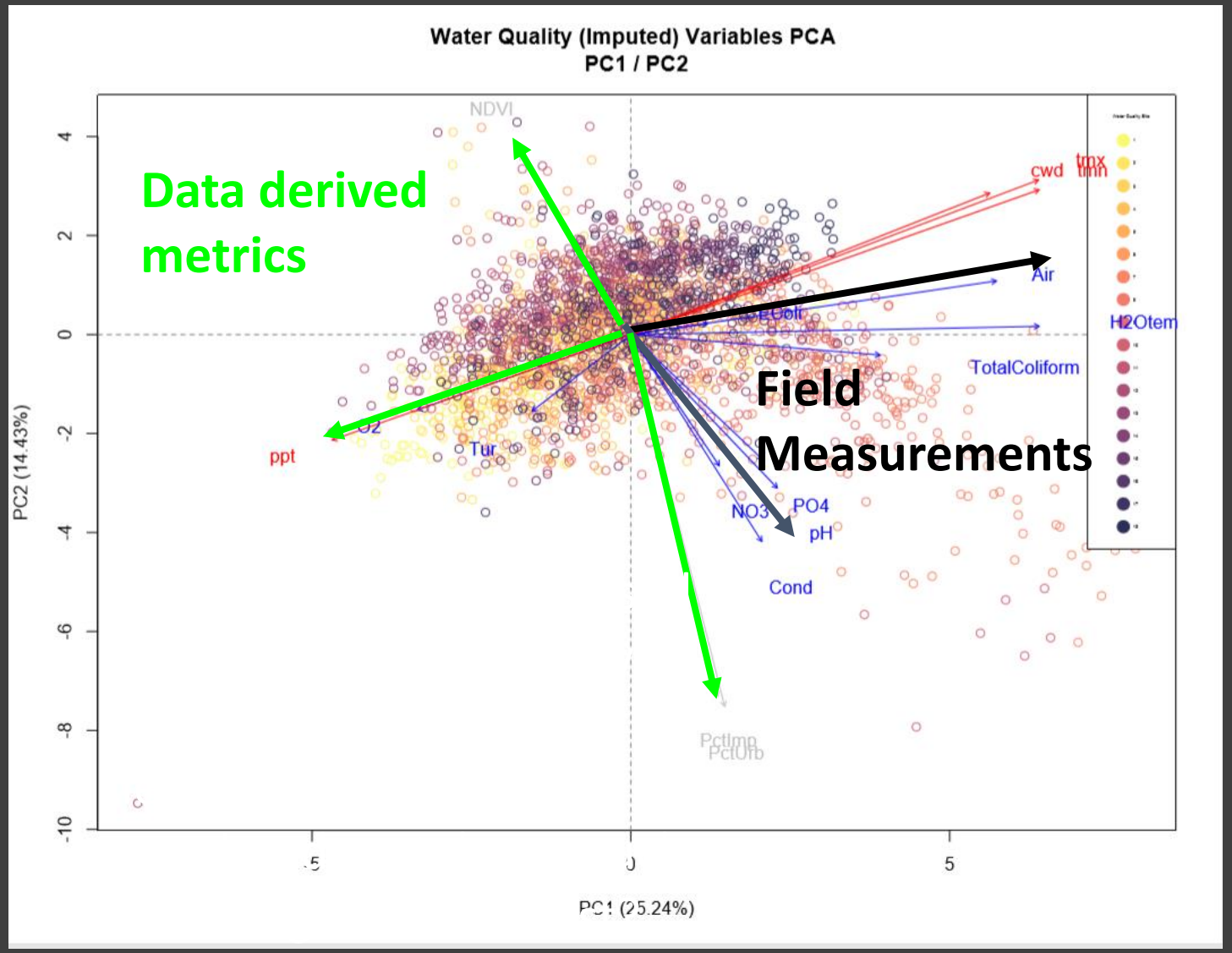
Identifying climate susceptibility and resilience

RiverDB visualization?

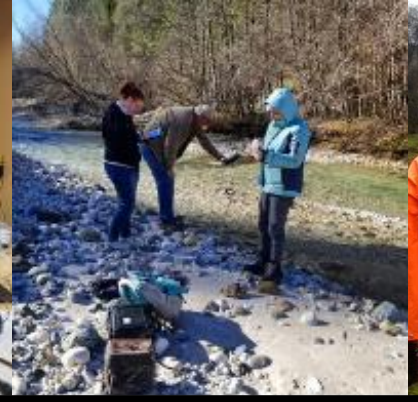


Dimension reduction benefits

1. **Build out optimized monitoring programs**
2. **For example: Water temp is easily measured, and highly predictive**
3. **Can potentially reduce field costs/efforts**







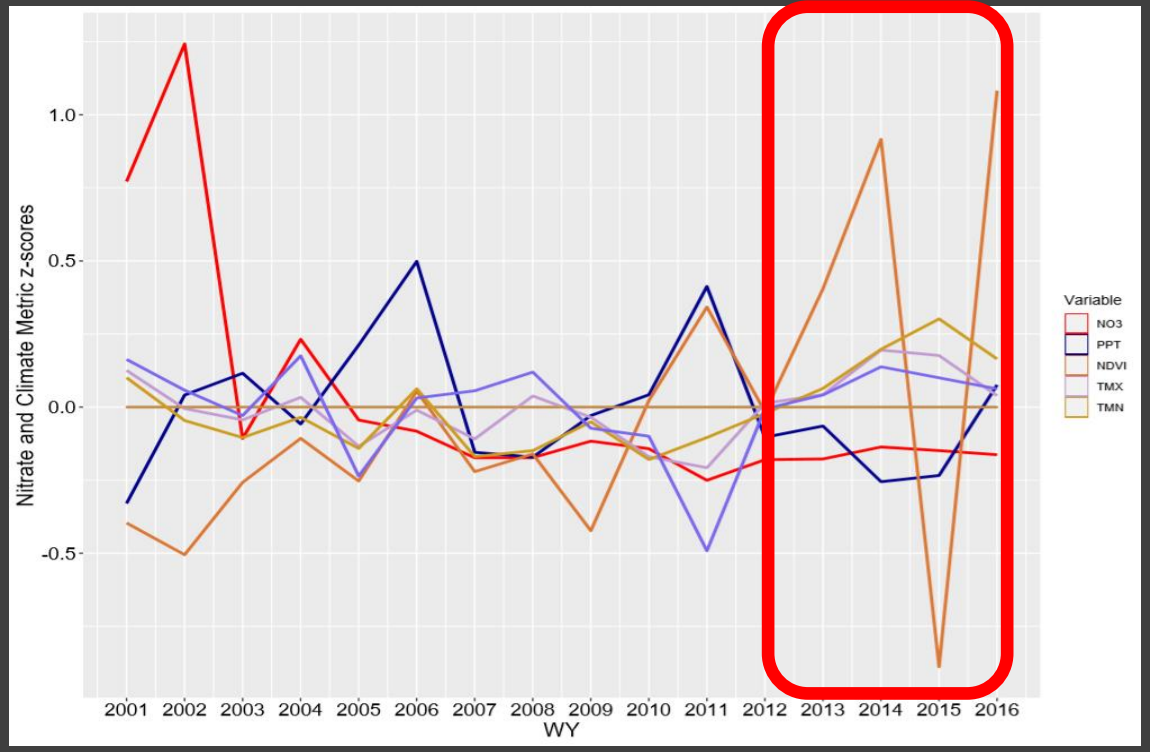

Thank you!

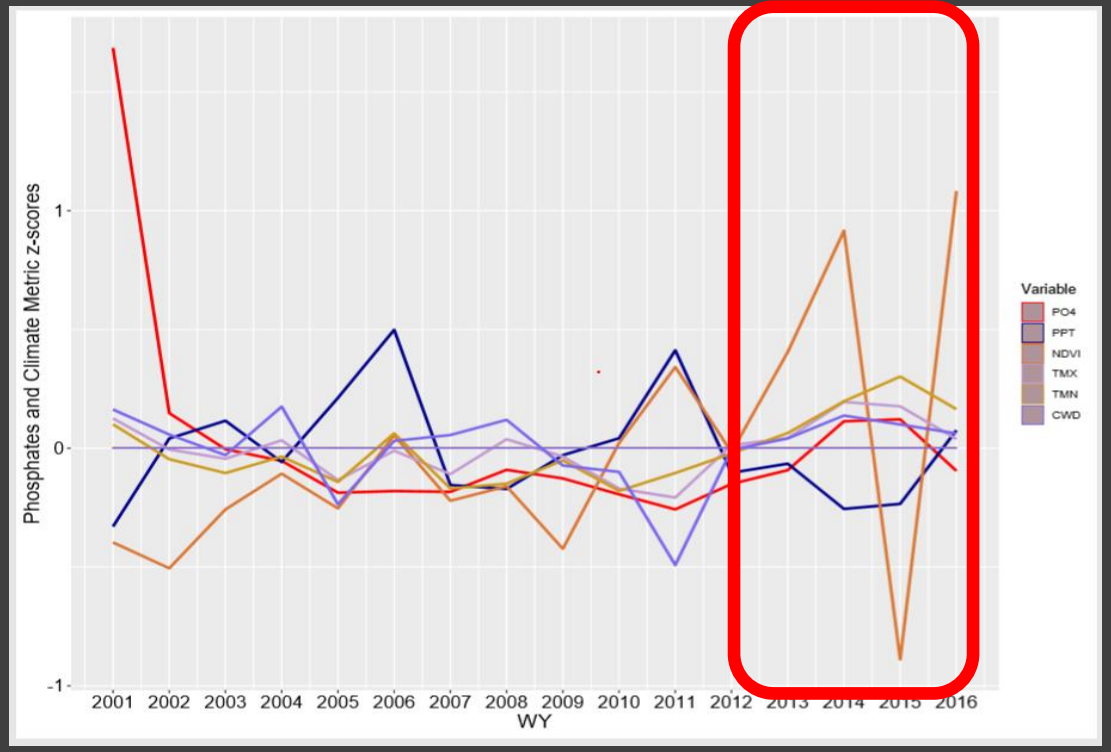
20 years of wonderful volunteers
Water Quality Crew
Bug Crew
Sierra Nevada AmeriCorps Partnership members
Prior lab staff: Grayson Carlile, Mo Loden, Kaitlyn Hacker, John Van der Veen, Karin Emmanuelson

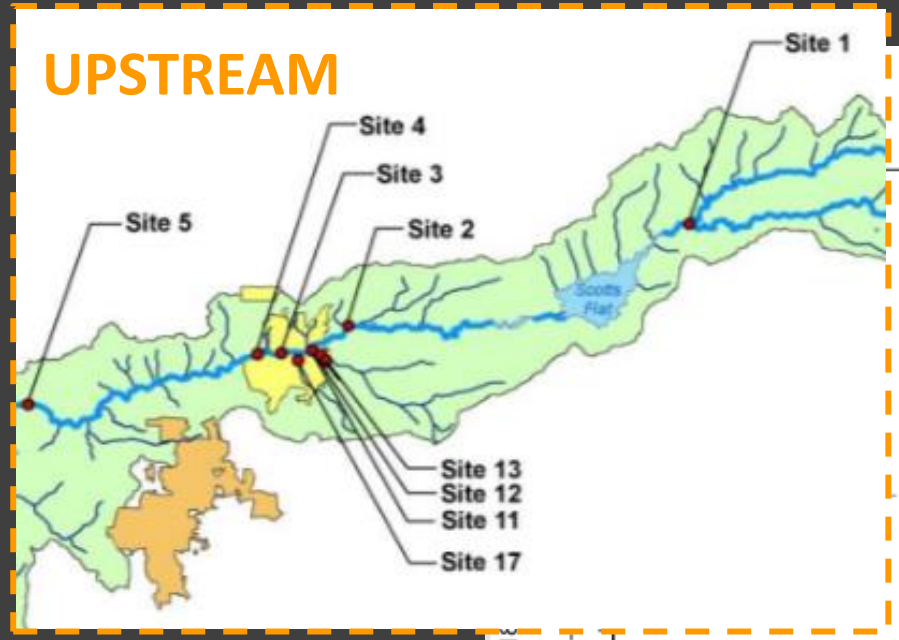


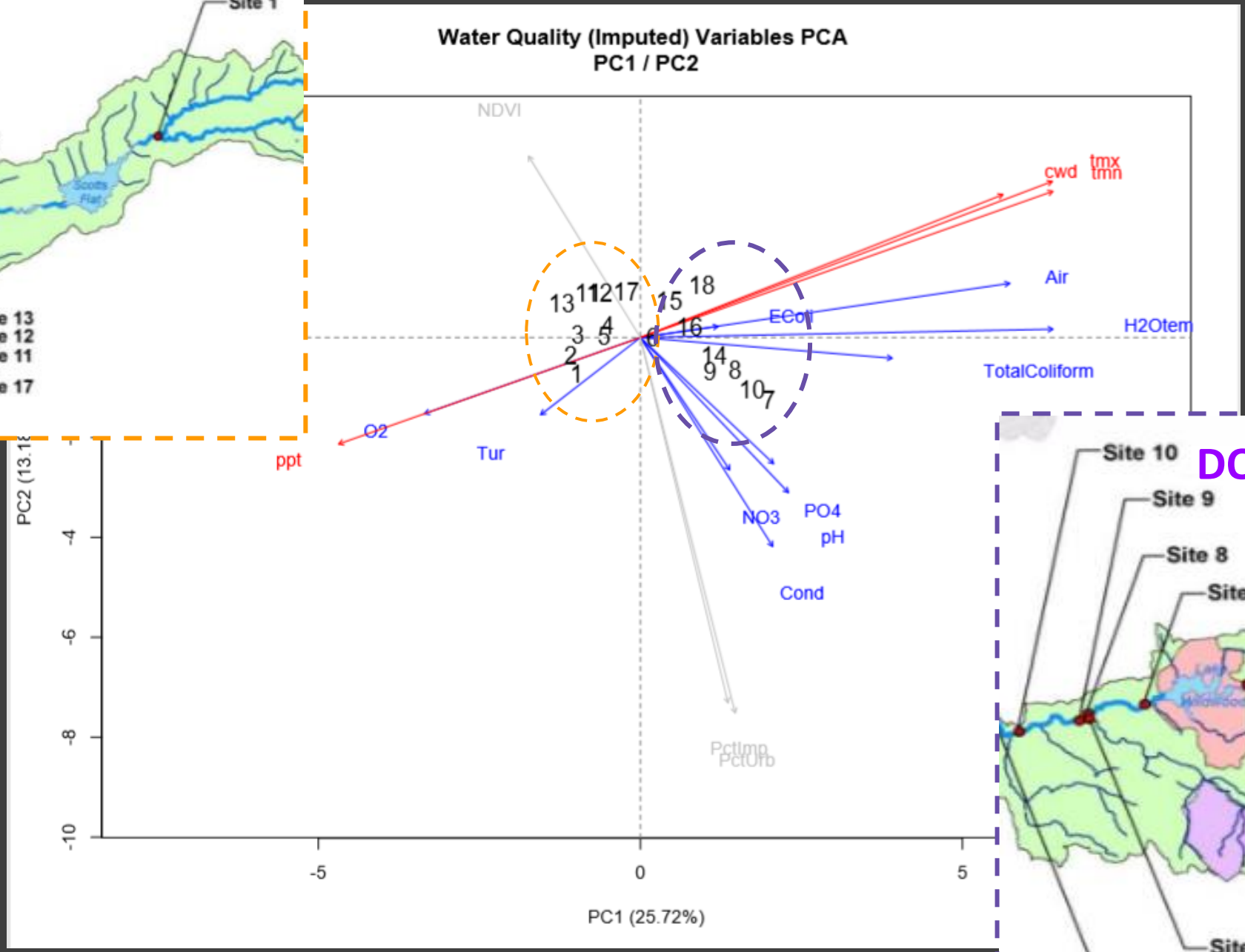
Sierra Nevada Americorps
Serving the Sierra
Partnership

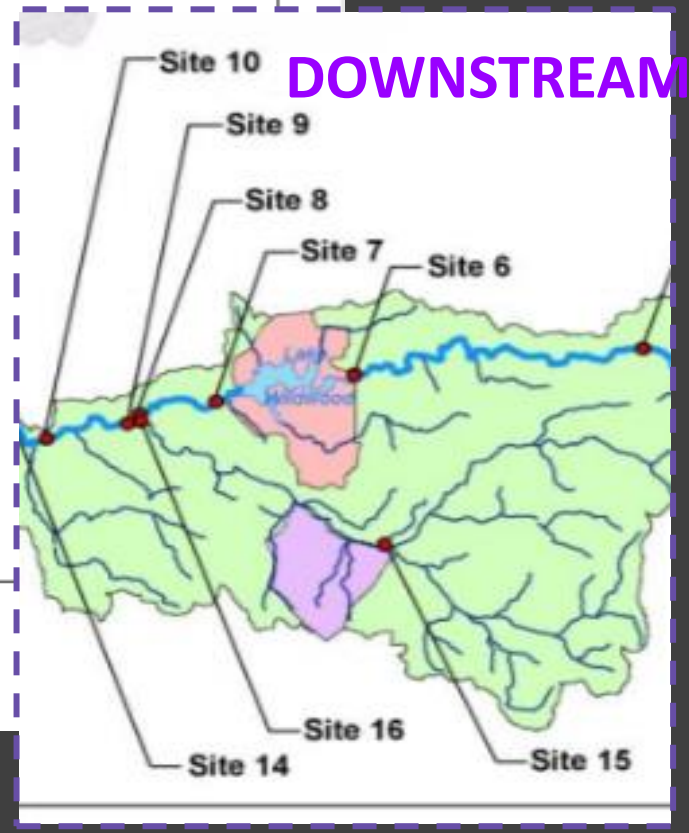
Decoupling of NO^3 and PO^4



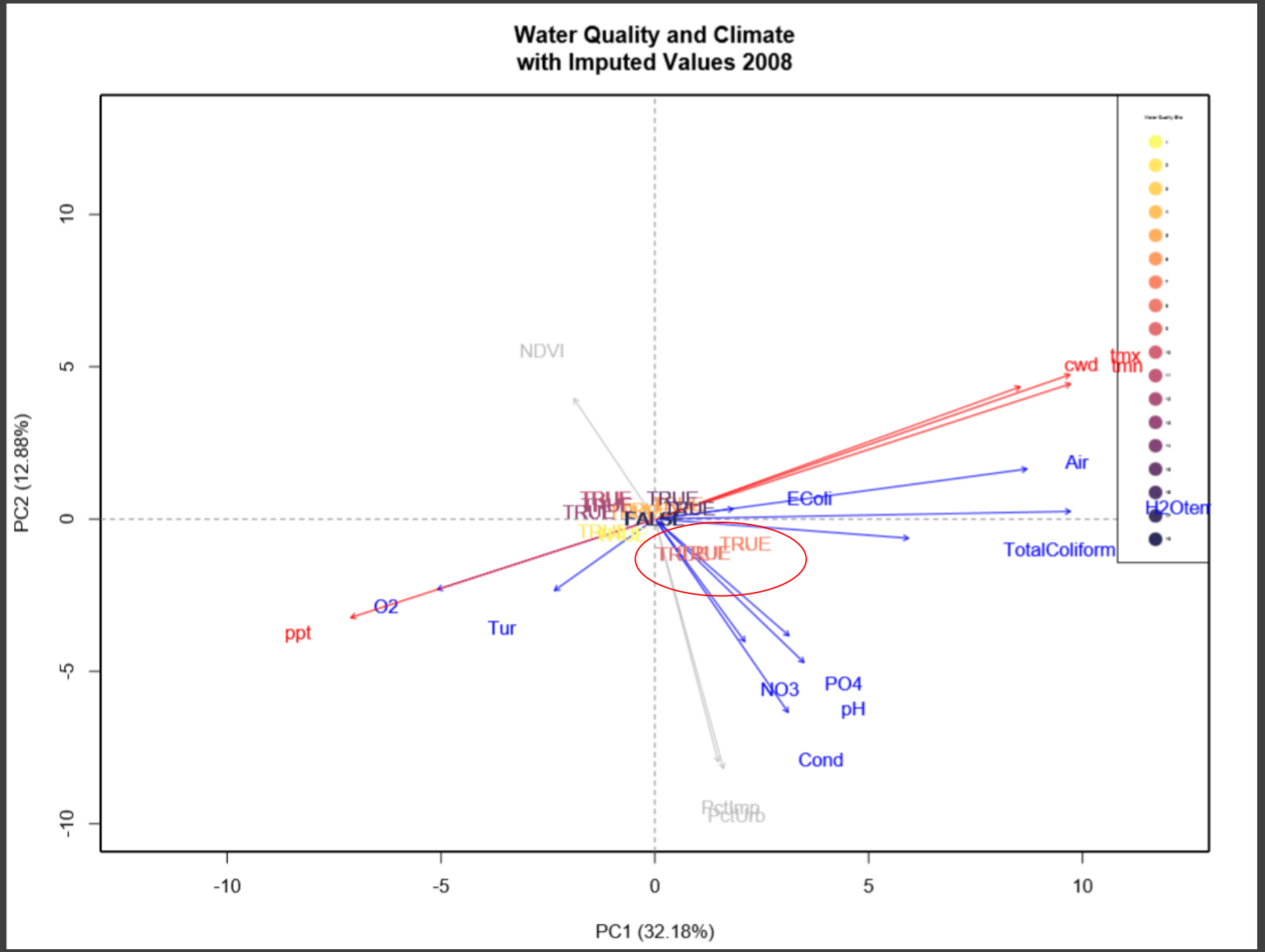



UPSTREAM
Site 1
Site 4
Site 3
Site 5
Site 2
Site 13
Site 12
Site 11
Site 17

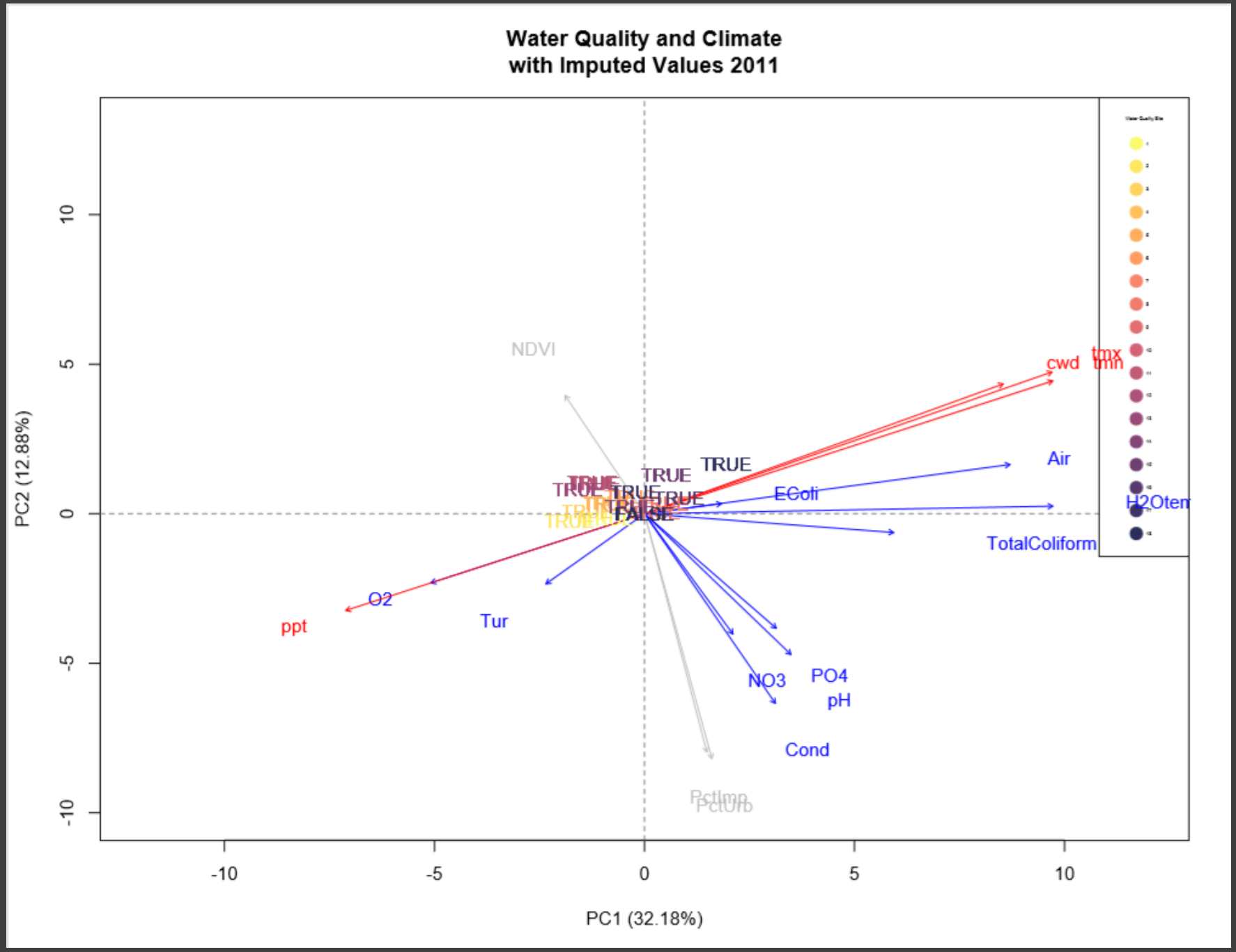

Water Quality (Imputed) Variables PCA
PC1 / PC2
NDVI
cwd
tmx
tmn
Air
H2Otem
TotalColiform
EColi
O2
ppt
Tur
NO3
PO4
pH
Cond
PctImp
PctUrb
13
11
12
17
15
18
16
4
3
5
6
2
1
14
9
8
10
7
PC2 (13.1
-4
-6
-8
-10
-5
0
5
PC1 (25.72%)


DOWNSTREAM
Site 10
Site 9
Site 8
Site 7
Site 6
Site 16
Site 14
Site 15

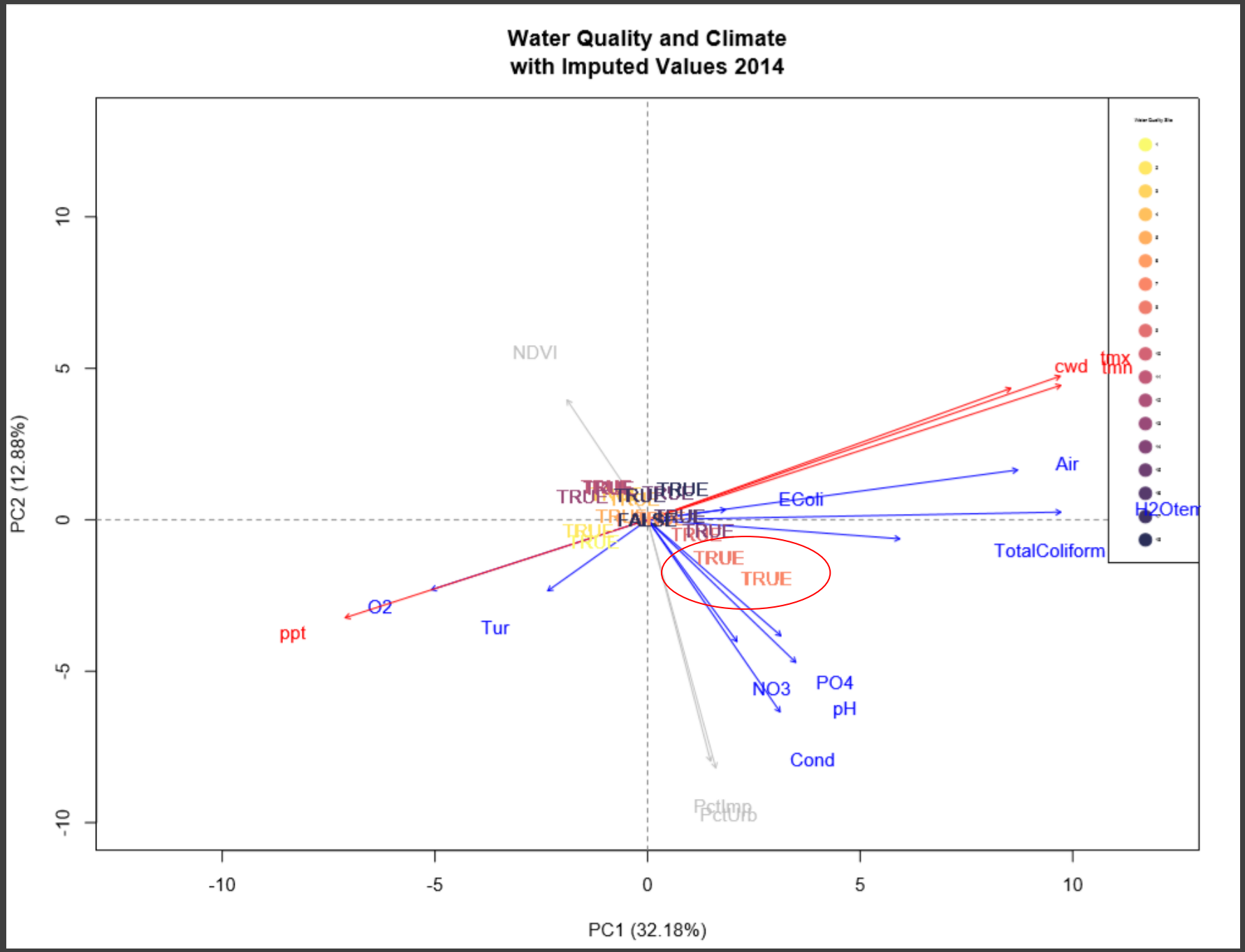
2000	AN
2001	D
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



2000	AN
2001	D
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



2000	AN
2001	D
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W



2000	AN
2001	D
2002	D
2003	AN
2004	BN
2005	AN
2006	W
2007	D
2008	C
2009	D
2010	BN
2011	W
2012	BN
2013	D
2014	C
2015	C
2016	BN
2017	W
2018	BN
2019	W