

INDICATORS OF CHANGING LAND AND WATER USE IN THE SACRAMENTO VALLEY

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Colusa County Groundwater Commission

About Davids Engineering

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- Work primarily for agricultural water suppliers
 - ▣ Mainly California
 - ▣ Also Arizona, New Mexico, Washington
- Davis and Chico offices
- Services
 - ▣ Ag water management
 - ▣ Facilities
 - ▣ Field services (Chico office)
 - ▣ Remote sensing

Study Qualifications

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- Davids Engineering “in-house” investigation
- No official peer review at this point, but results validated by other data
- Refinement and further validation needed

Motivating Factors and Objectives

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□ Motivating Factors:

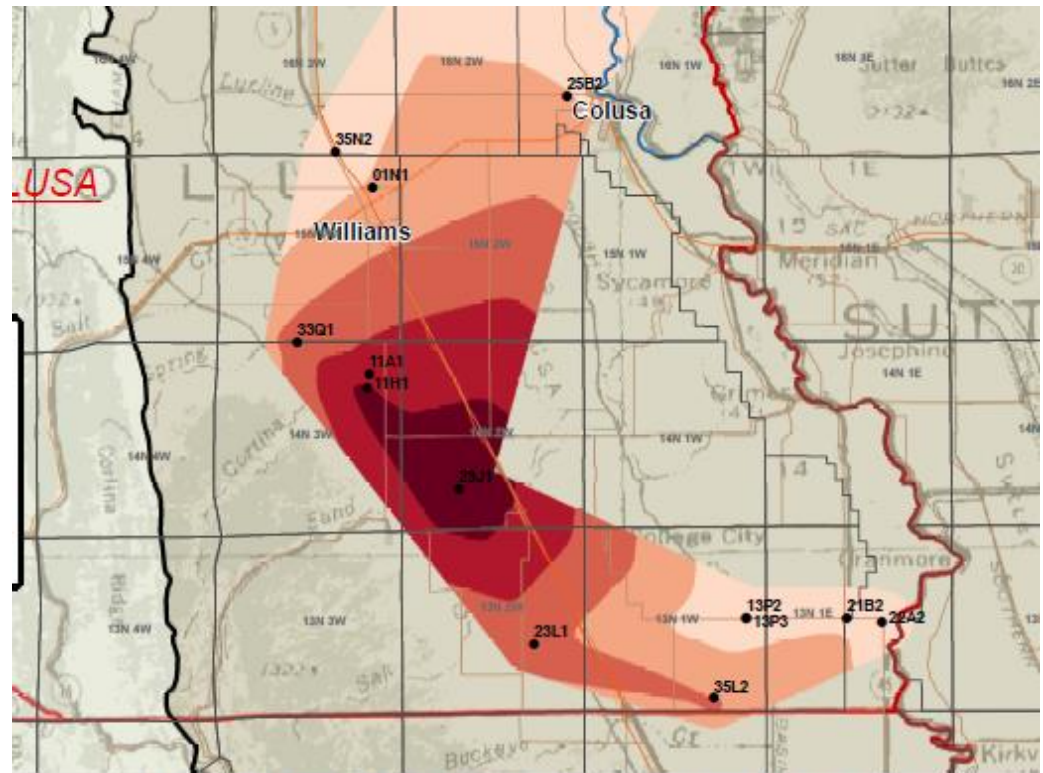
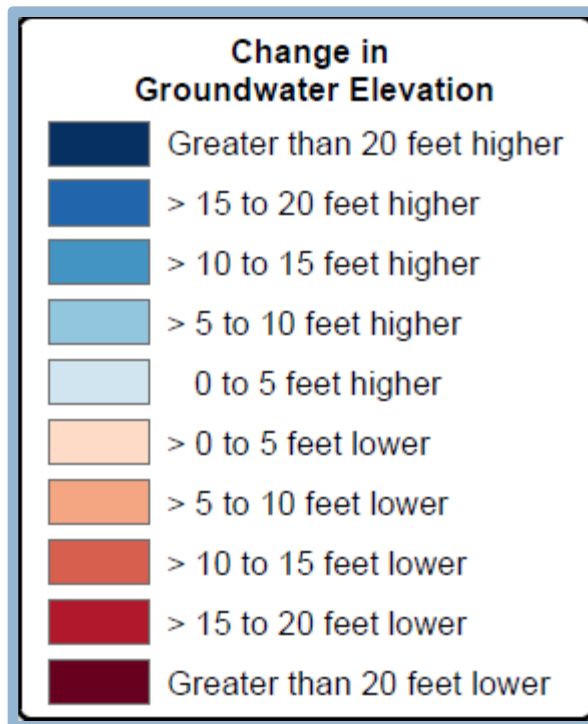
- ▣ Ongoing, rapid expanding and intensifying irrigated agriculture in the Sacramento Valley
- ▣ Declining groundwater levels in certain areas
- ▣ Emerging concerns over the effects of declining groundwater levels, especially on streamflow

□ Study Objectives:

- ▣ Quantify irrigation expansion and intensification
- ▣ Express in terms of increased water consumption

Change in Groundwater Elevations Spring 2004 to Spring 2013 (DWR, 2014)

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**NORTHERN SACRAMENTO VALLEY
CHANGE IN GROUNDWATER ELEVATION MAP
SPRING 2004 TO SPRING 2013
INTERMEDIATE AQUIFER ZONE**

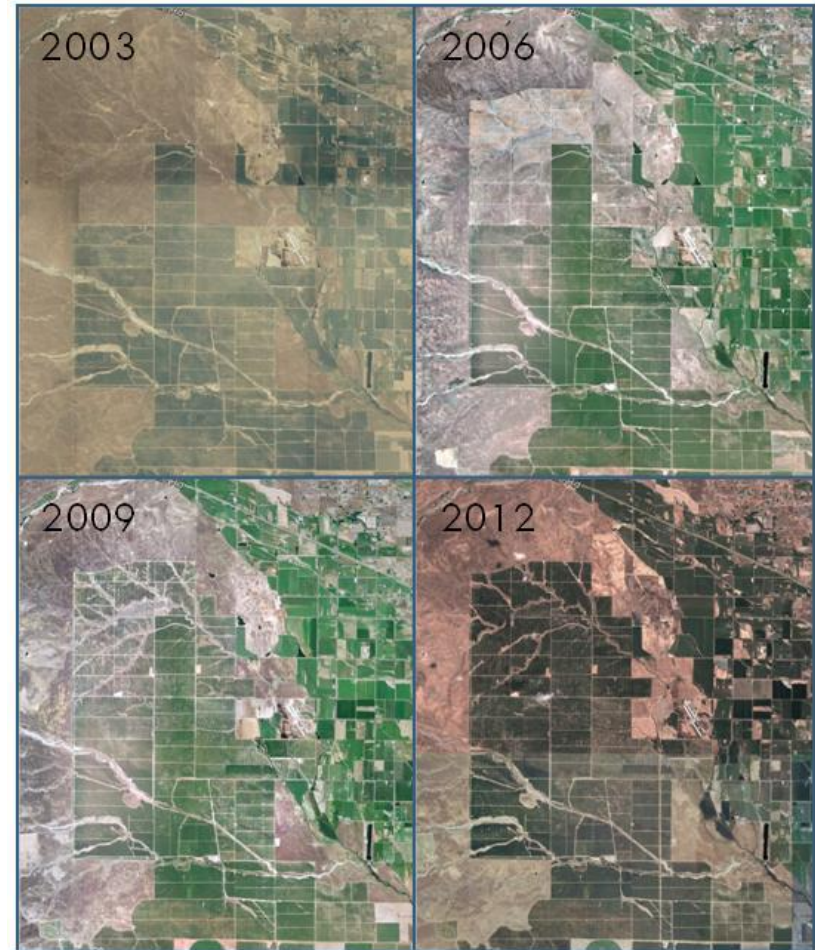
(Wells generally greater than 200 ft deep and less than 600 ft deep bas)

Presentation Outline

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- Technical Approach
- Valley Wide Trends
 - ▣ Validations
- Colusa County Trends
 - ▣ Including neighboring counties
 - ▣ Surface Water vs. Groundwater Areas
- Discussion

Almond Orchard West of Orland



Technical Approach

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- Stitching together Valley-wide land use from DWR land use surveys, ag commissioner crop reports, and DPR pesticide use reports is time consuming and challenging
- Instead, using satellite data, estimate Valley-wide changes in:
 - ▣ The **extent** of the “green” or water using (irrigated) area
 - ▣ The **intensity** of consumptive water use within the continuously green (irrigated) area

Summary of Available DWR Land Use Surveys

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<u>County</u>	<u>DWR Survey Year</u>	<u>Area Included in Analysis (ac)*</u>	<u>Percent of Analysis Area*</u>
Butte	2011	354,000	12%
Colusa	2009	353,000	12%
Glenn	2009	326,000	11%
Placer	1994	99,000	3%
Sacramento	2000	387,000	13%
Shasta	2005	9,000	0.3%
Solano	2003	248,000	8%
Sutter	1998	335,000	11%
Tehama	2012	298,000	10%
Yolo	2008	446,000	15%
Yuba	2005	135,000	5%

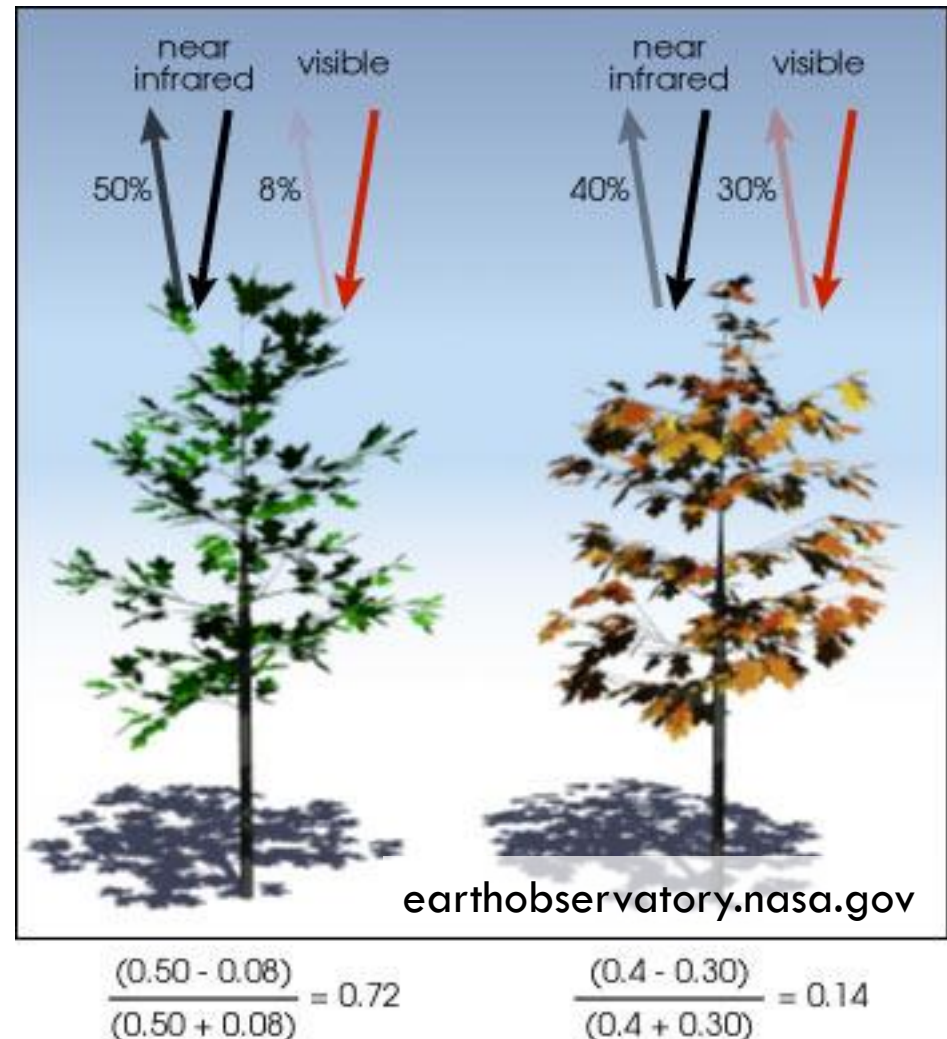
* Does not include developed areas or riparian, wetland, or riverine areas.

Key Measure of Consumptive Water Use: Normalized Difference Vegetation Index

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- NDVI indicates the presence and intensity of green vegetation on the Earth's surface
- “Greenness” equates to photosynthetic activity, water using

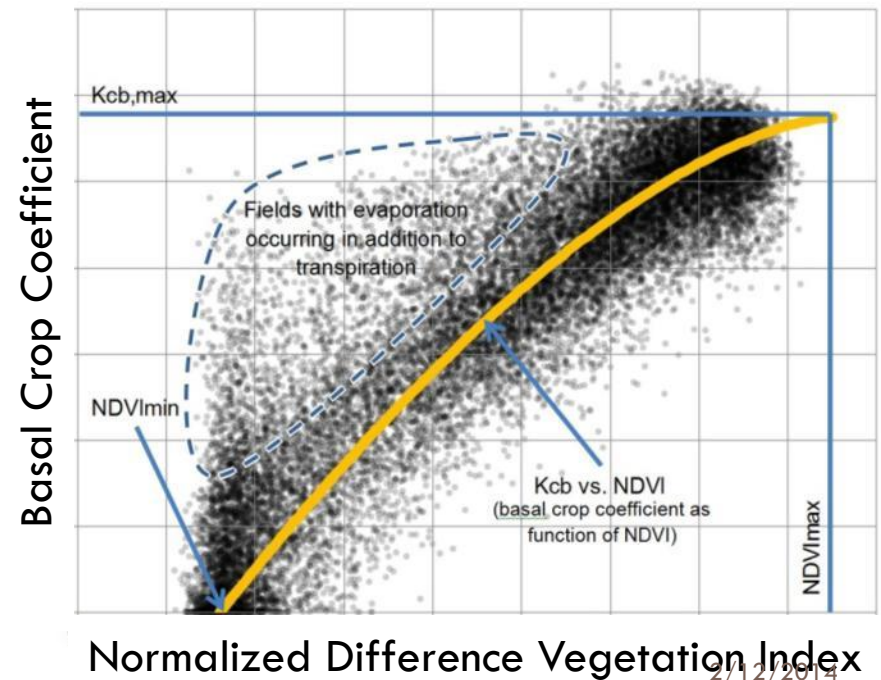
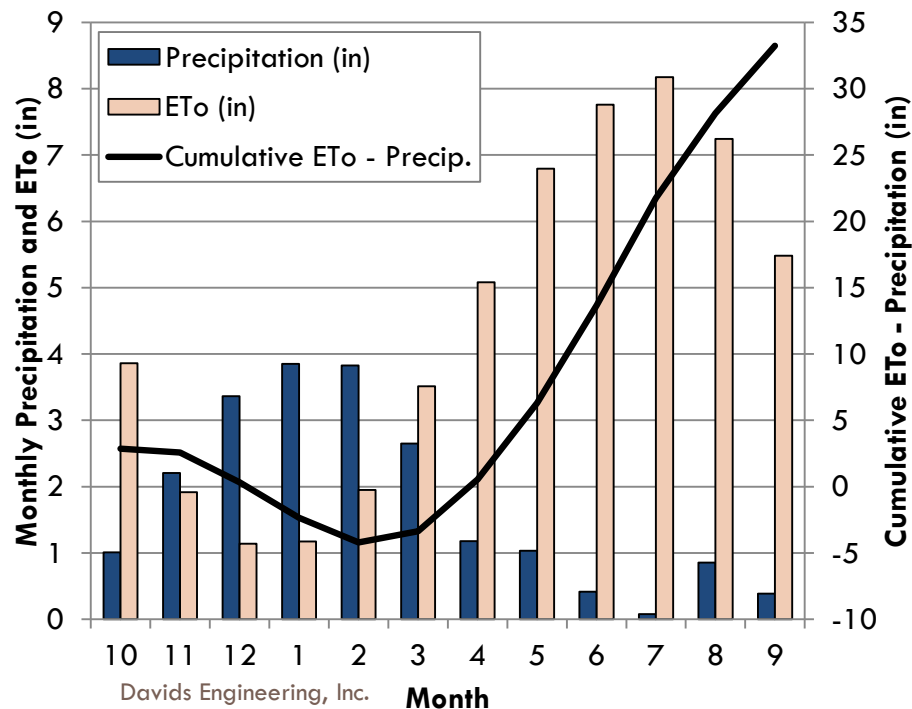
$$NDVI = \frac{\rho_{NIR} - \rho_{red}}{\rho_{NIR} + \rho_{red}}$$



Analytical Rationale

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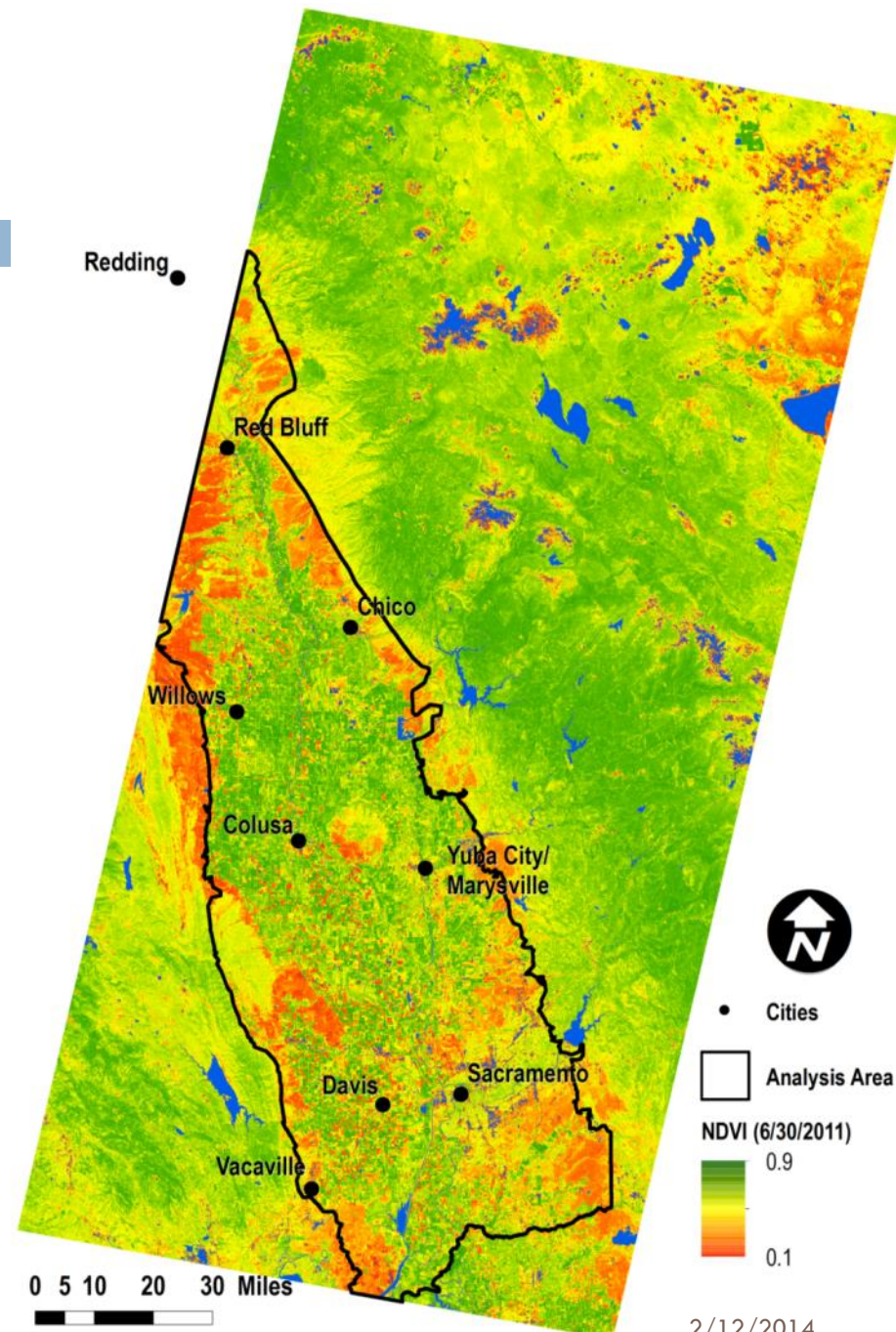
- Most areas with green vegetation during mid-Summer are irrigated (or sub-irrigated)
- As vegetation “greenness” increases, water use (or evapotranspiration, ET) increases



Satellite Data

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- Nineteen Landsat images from 1985 to 2011 (27 years)
- Selected between July 21 and August 17 based on cumulative Growing-Degree Days (GDD)



Threshold NDVI Values

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- Water Using (“Irrigated”) Area in a Given Year:
 - ▣ $\text{NDVI} \geq 0.25$ (green vegetation present)
- Continuous (i.e., consistent) Water Using Area for Analysis Period:
 - ▣ $\text{NDVI} \geq 0.25$ in at least 15 of 19 images for individual “pixels”

NDVI = 0.19



Grain Stubble

NDVI = 0.20



Bare Soil

NDVI = 0.28



Young Pistachio

NDVI = 0.31



Cut Alfalfa

NDVI = 0.40



Young Almond

NDVI = 0.54



Tomato

NDVI = 0.63



Corn or Sorghum

NDVI = 0.76

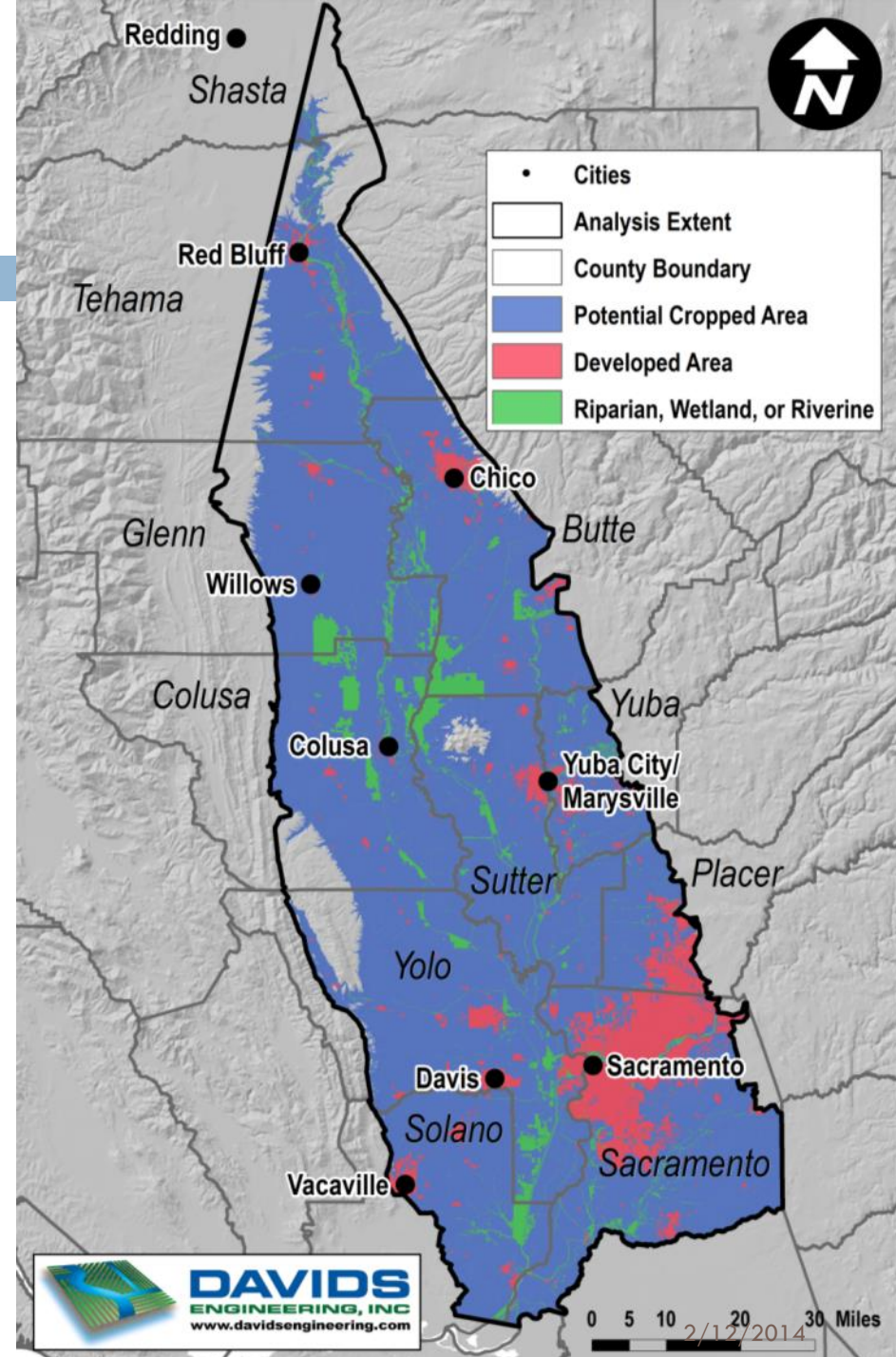


Mature Alfalfa Stand

Analysis Area

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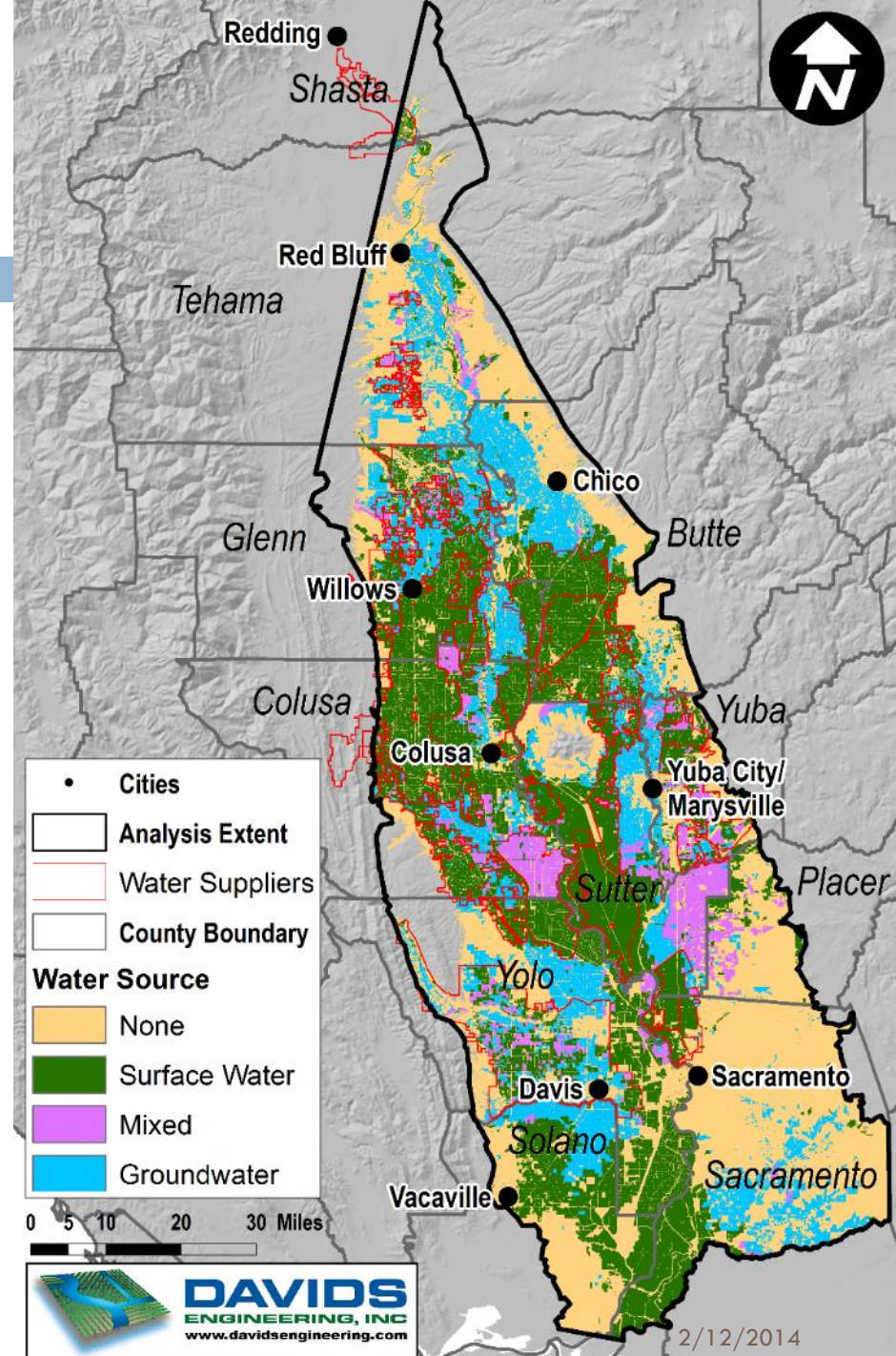
- Portions of 11 Sacramento Valley Counties
- 3.0 million acres
- Limited Somewhat by Landsat Image Extent
- Excluded Areas
 - ▣ Elevation greater than 450 feet
 - ▣ Developed (urban) areas
 - ▣ Riparian, wetland, and riverine areas



Analysis Area (continued)

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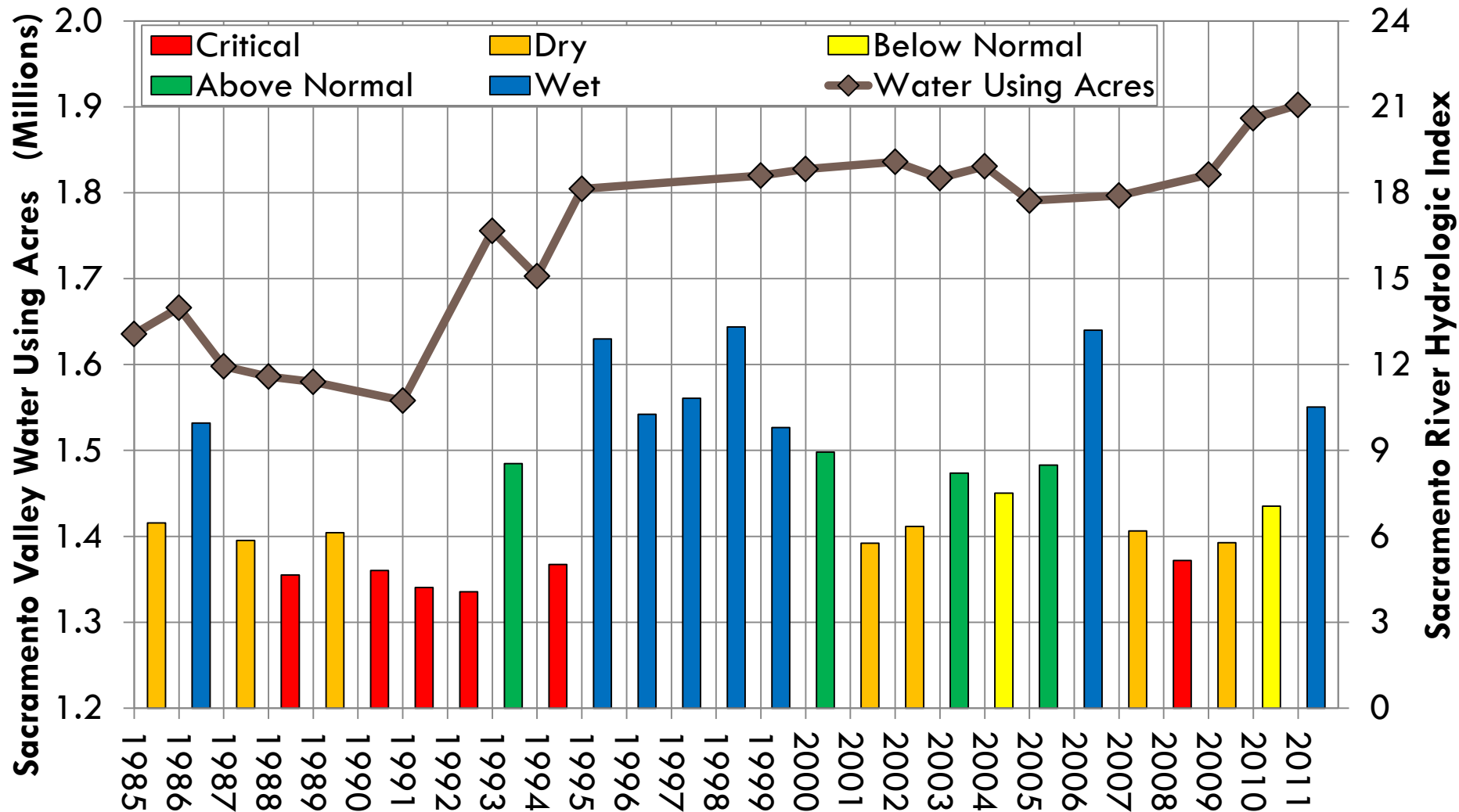
- Possible Analysis “Zones”
 - ▣ County
 - ▣ Water Supplier
 - ▣ Groundwater Subbasin
 - ▣ DWR Water Source
 - ▣ Developed vs. Undeveloped
 - ▣ Riparian/Wetland/Riverine vs. Other
 - ▣ Public Lands (refuges, state parks, etc.) vs. Private



Valley-Wide Water-Using Area and Hydrologic Year Type

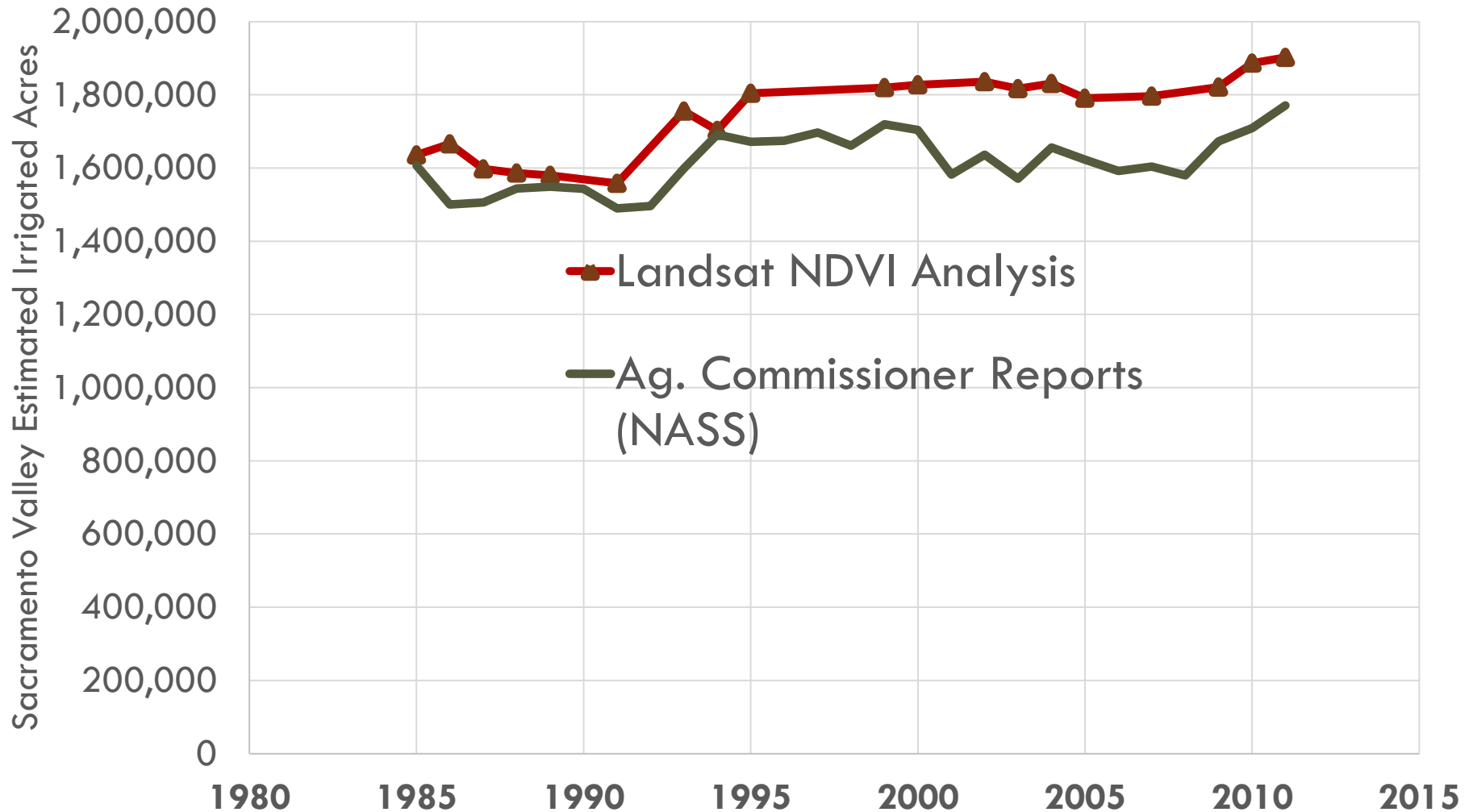
17

(Excludes riparian, wetland, riverine, and developed)



Comparison of NDVI Results to Consolidated Ag Commissioner Data

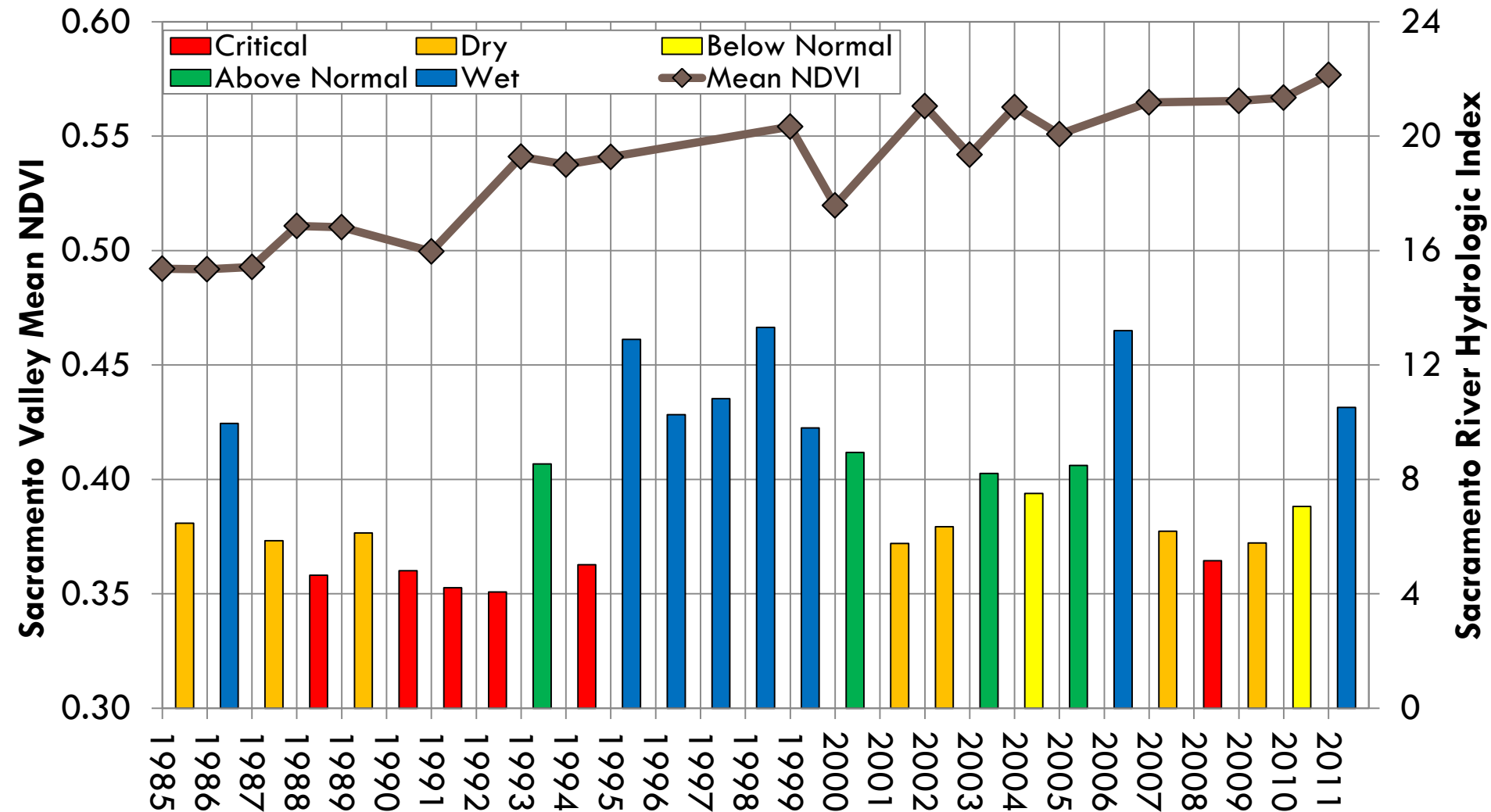
18



Valley-Wide Mean NDVI (Intensity) and Hydrologic Year Type

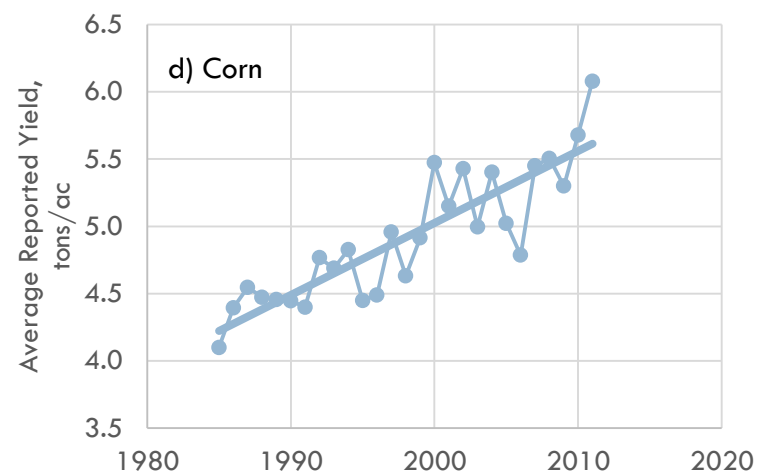
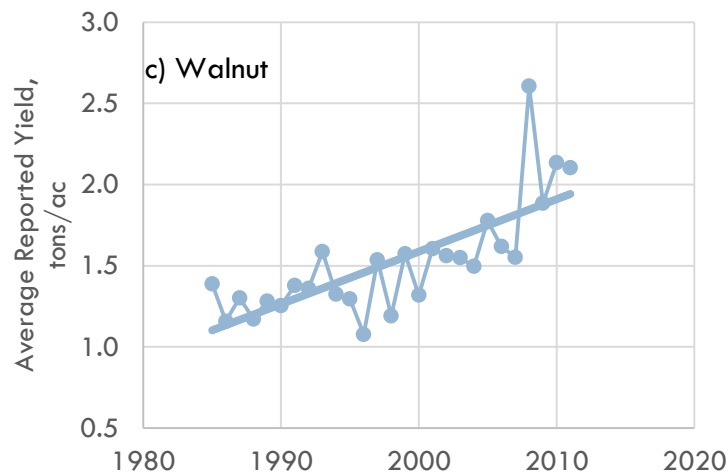
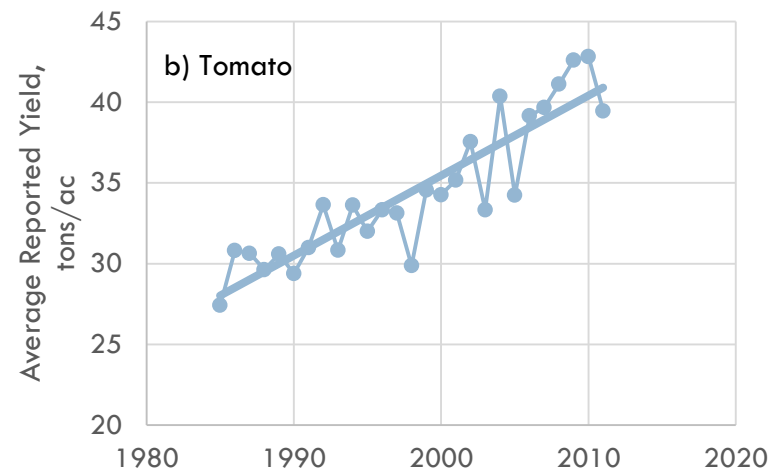
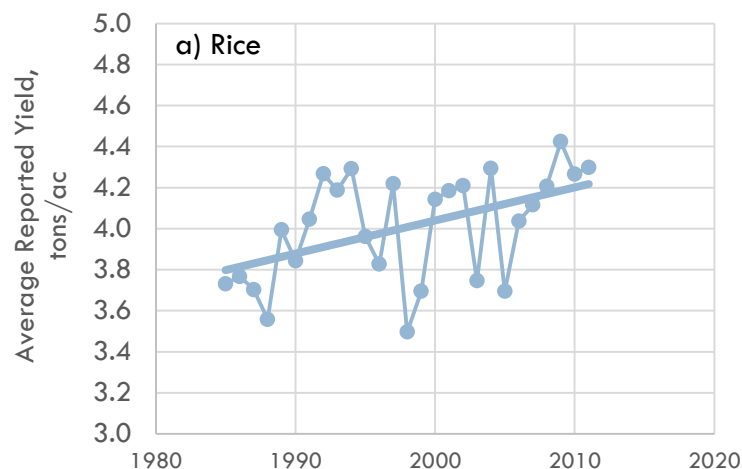
19

(Excludes riparian, wetland, riverine, and developed)



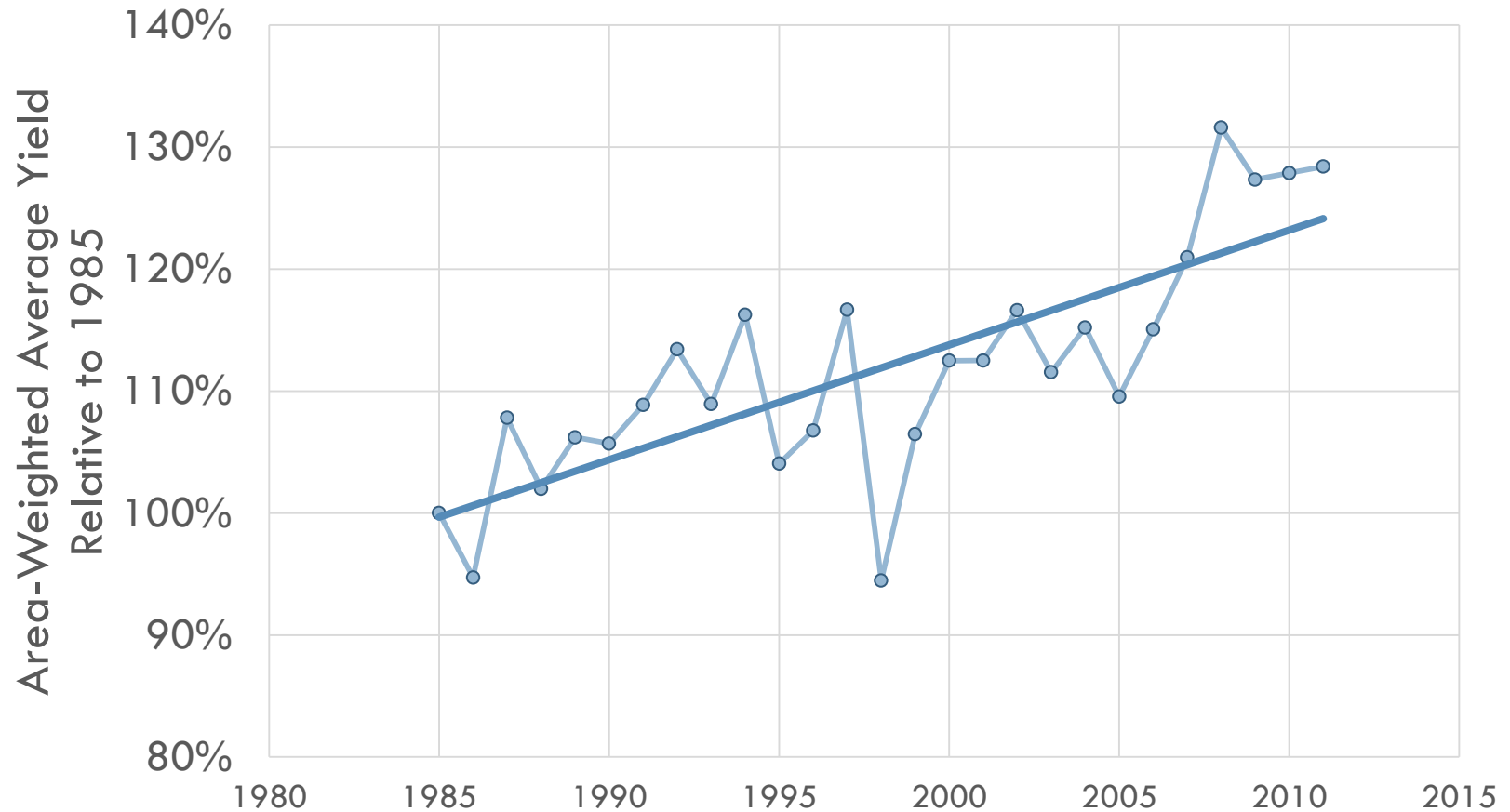
Sacramento Valley Crop Yields 1985 to 2011

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Area-Weighted Average Crop Yield Relative to 1985

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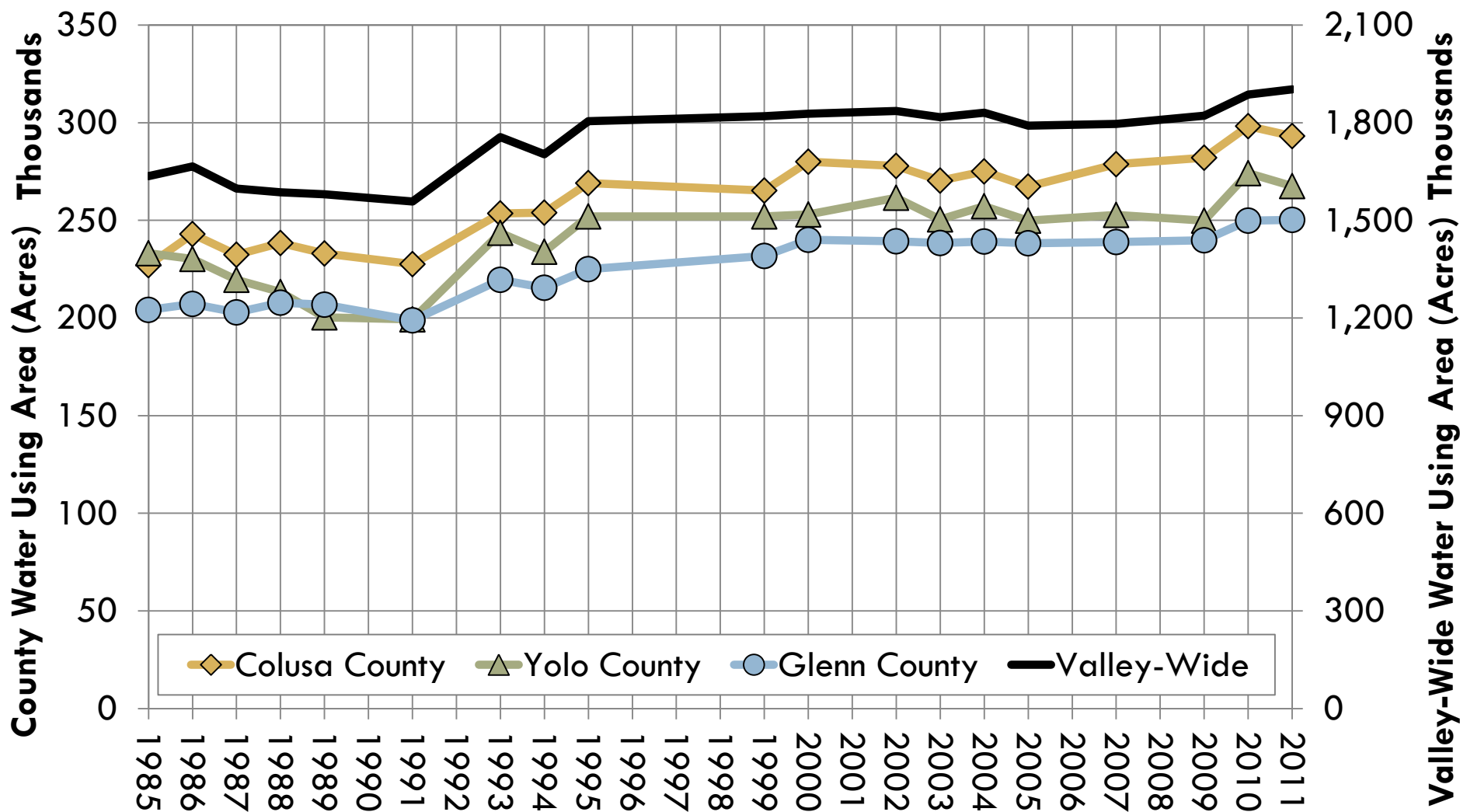
Summary: Valley-Wide Changes

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- Relative to 1985, Sacramento Valley consumptive water use has increased due to both increased acreage and intensity:
 - ▣ Water using area has increased by about 260,000 acres (15%)
 - ▣ Per-acre water use intensity has increased by almost 20% (NDVI 0.49 to 0.58)
- Increases in the extent of the water using area were greatest between around 1991 and 1995, with more gradual increases thereafter

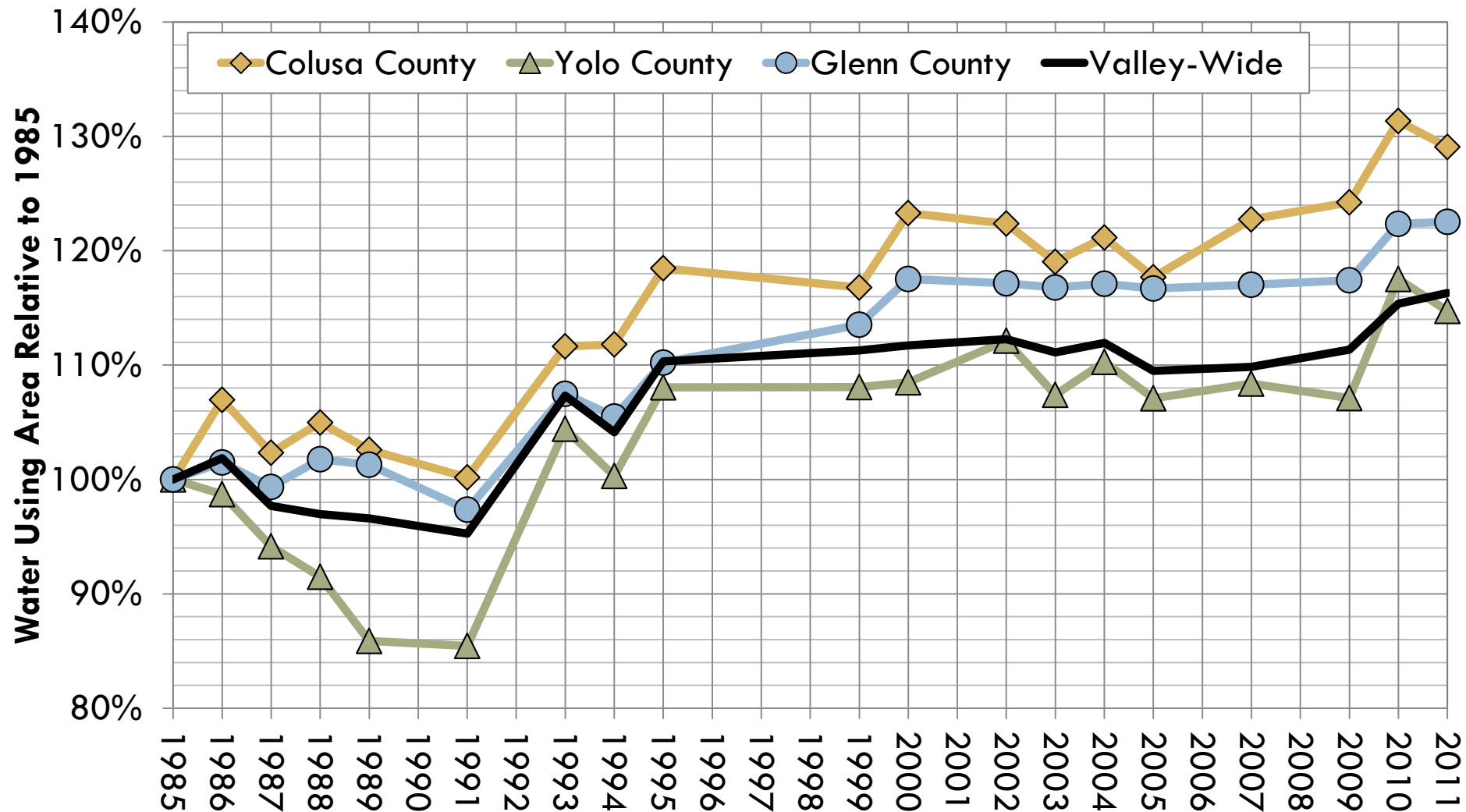
Water-Using Area by County

23



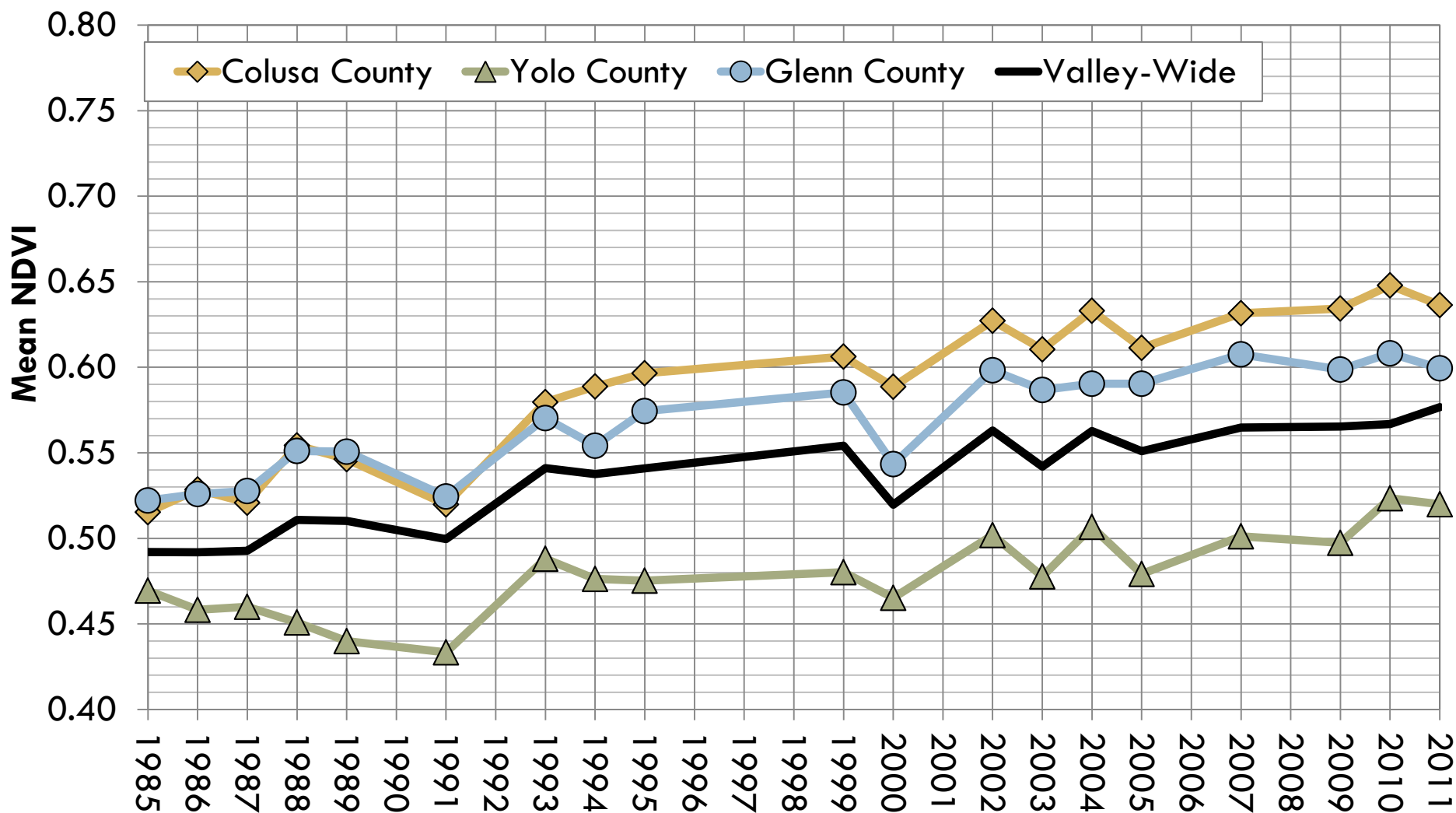
Water-Using Area by County Relative to 1985

24



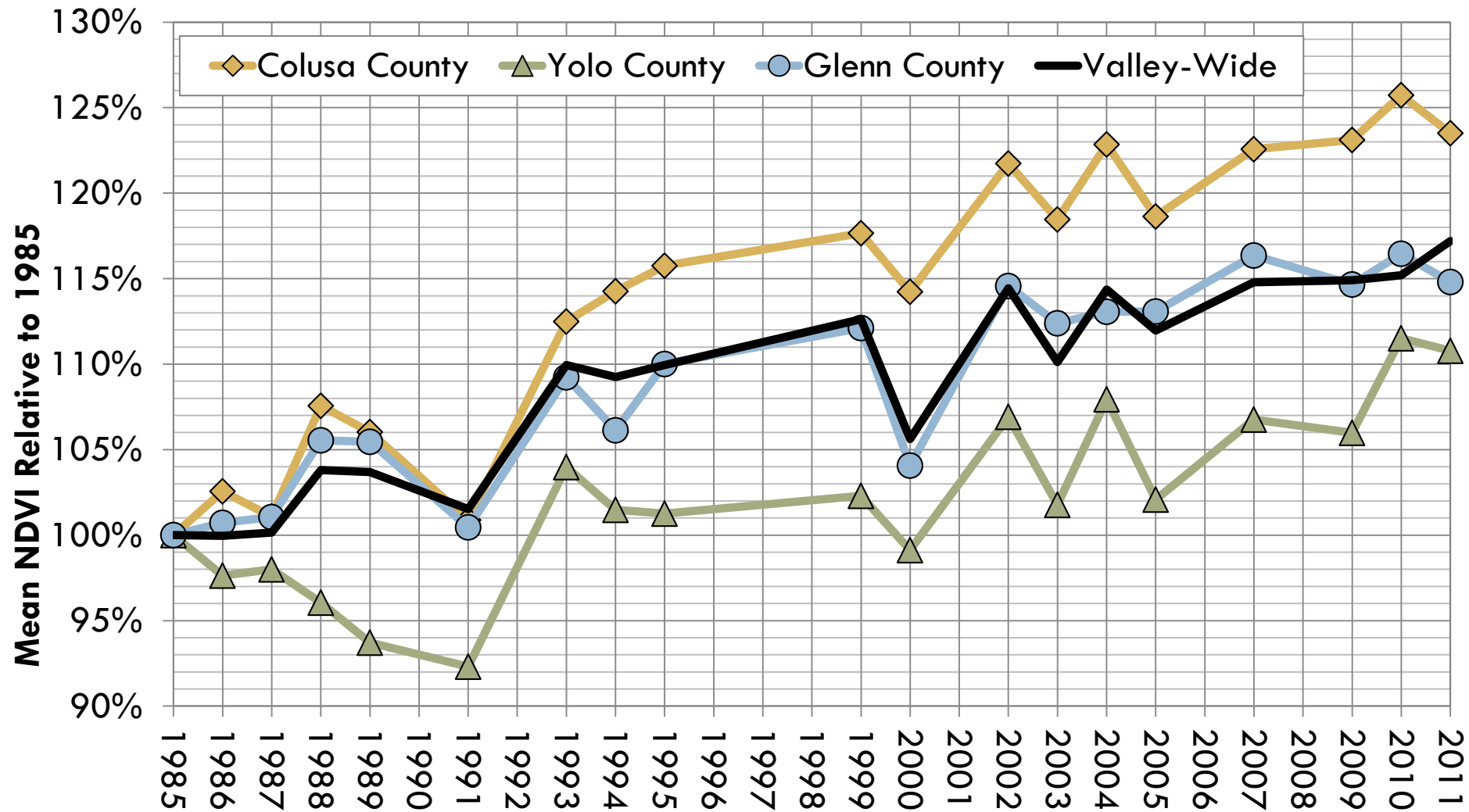
Water-Use Intensity by County

25

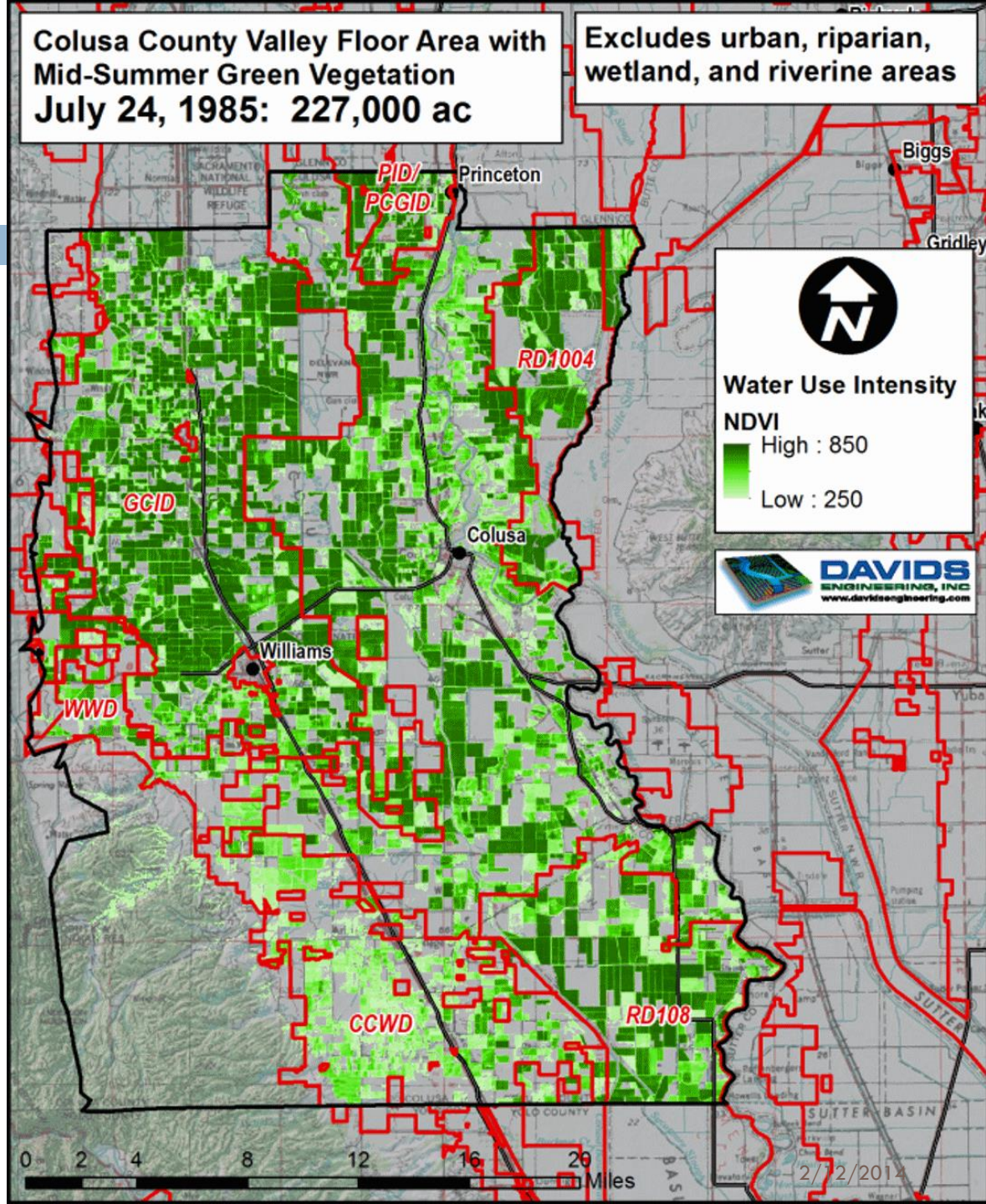


Water-Use Intensity by County Relative to 1985

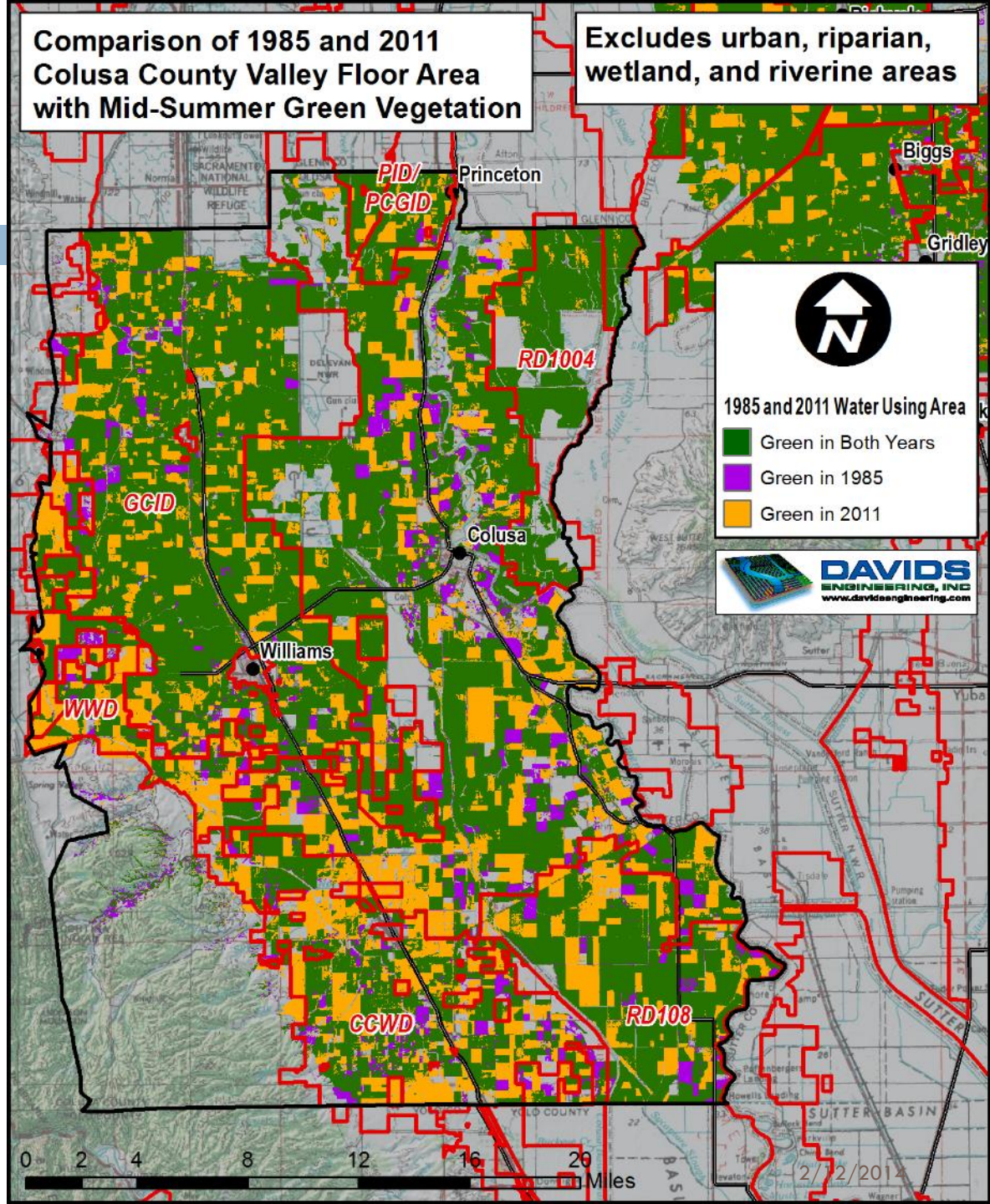
26



Colusa County Changes in Extent and Intensity over Time



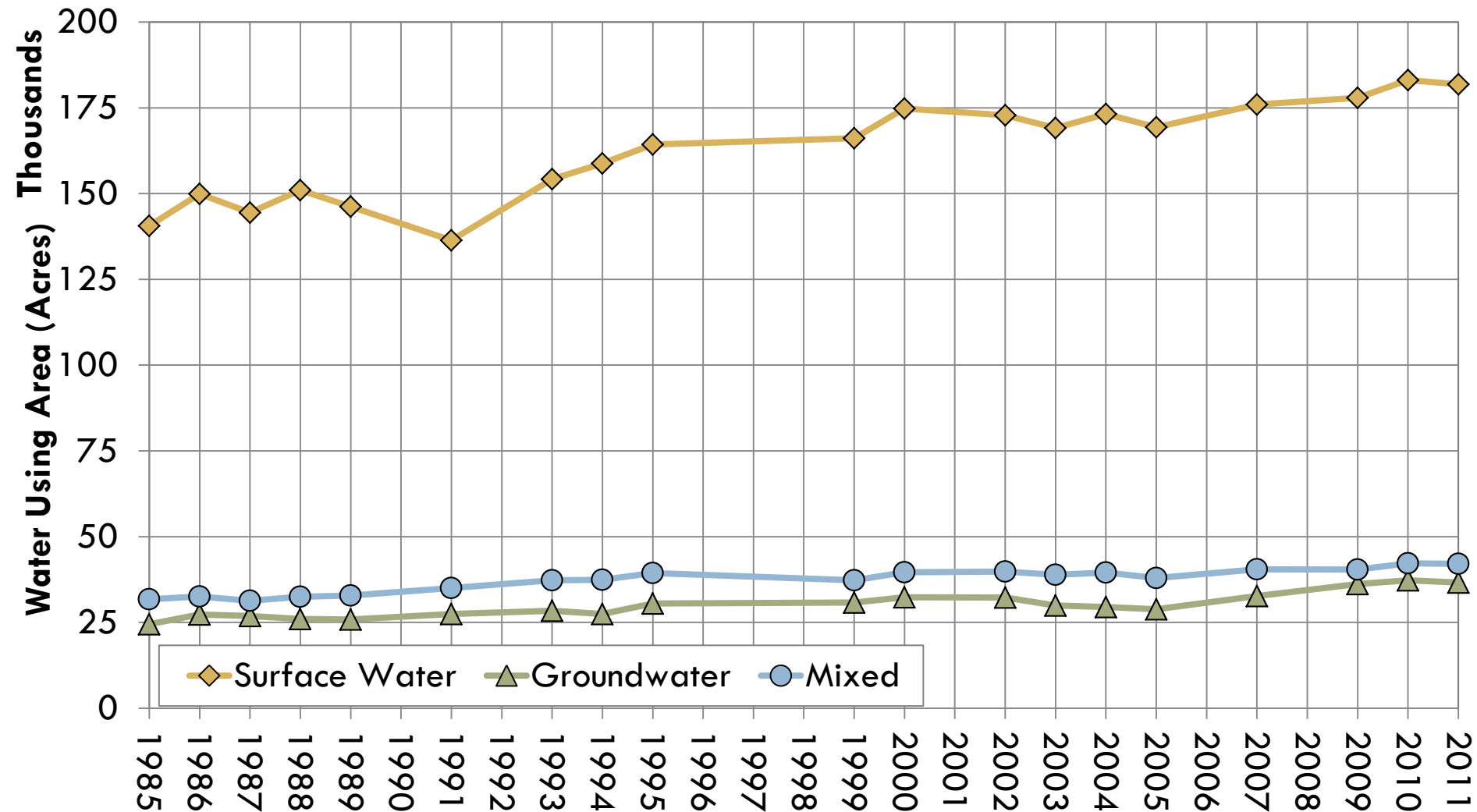
Colusa County Comparing 2011 to 1985



Colusa County Water-Using Area by DWR Water Source

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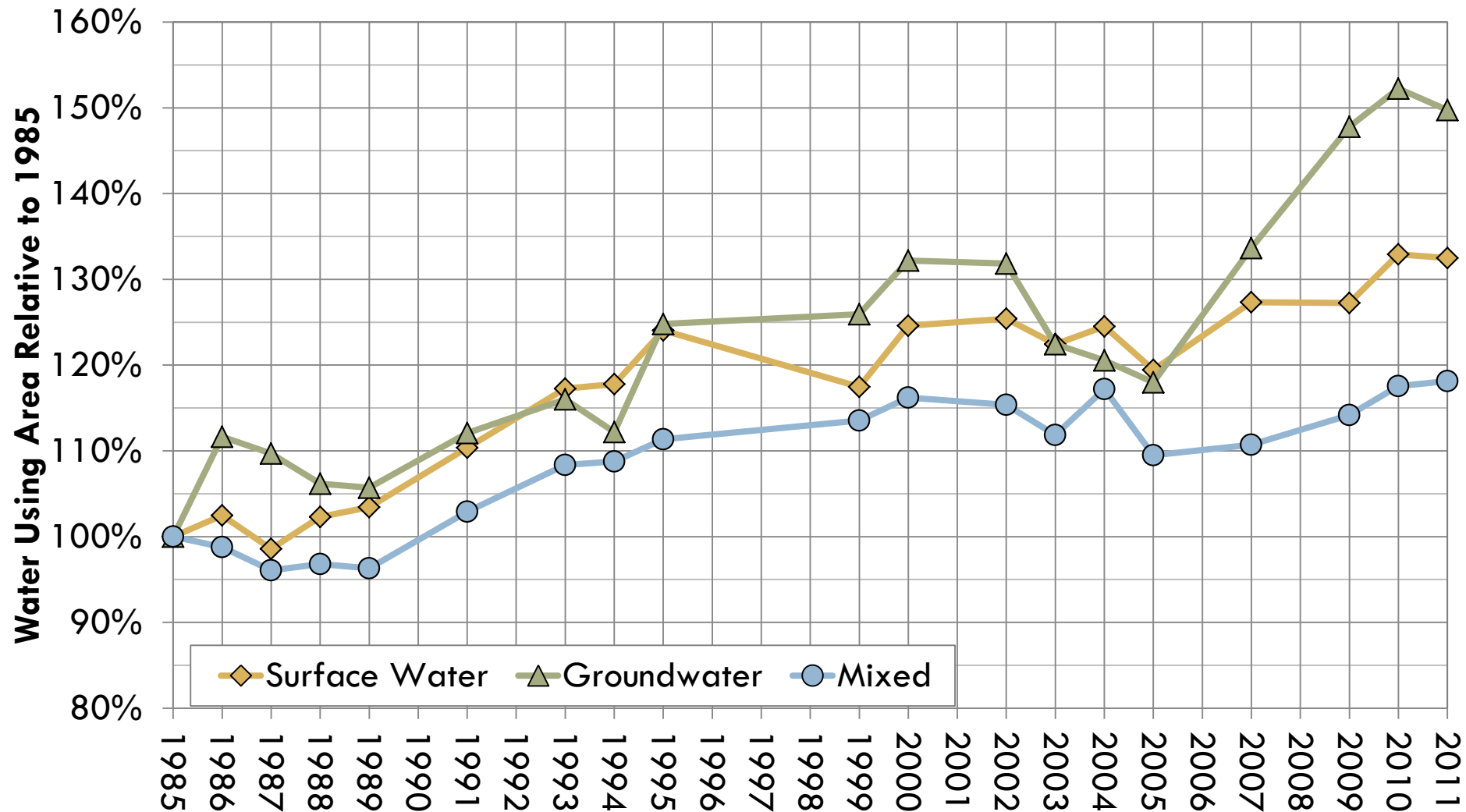
(Excludes riparian, wetland, riverine, and developed)



Colusa County Relative Water-Using Area by DWR Water Source

30

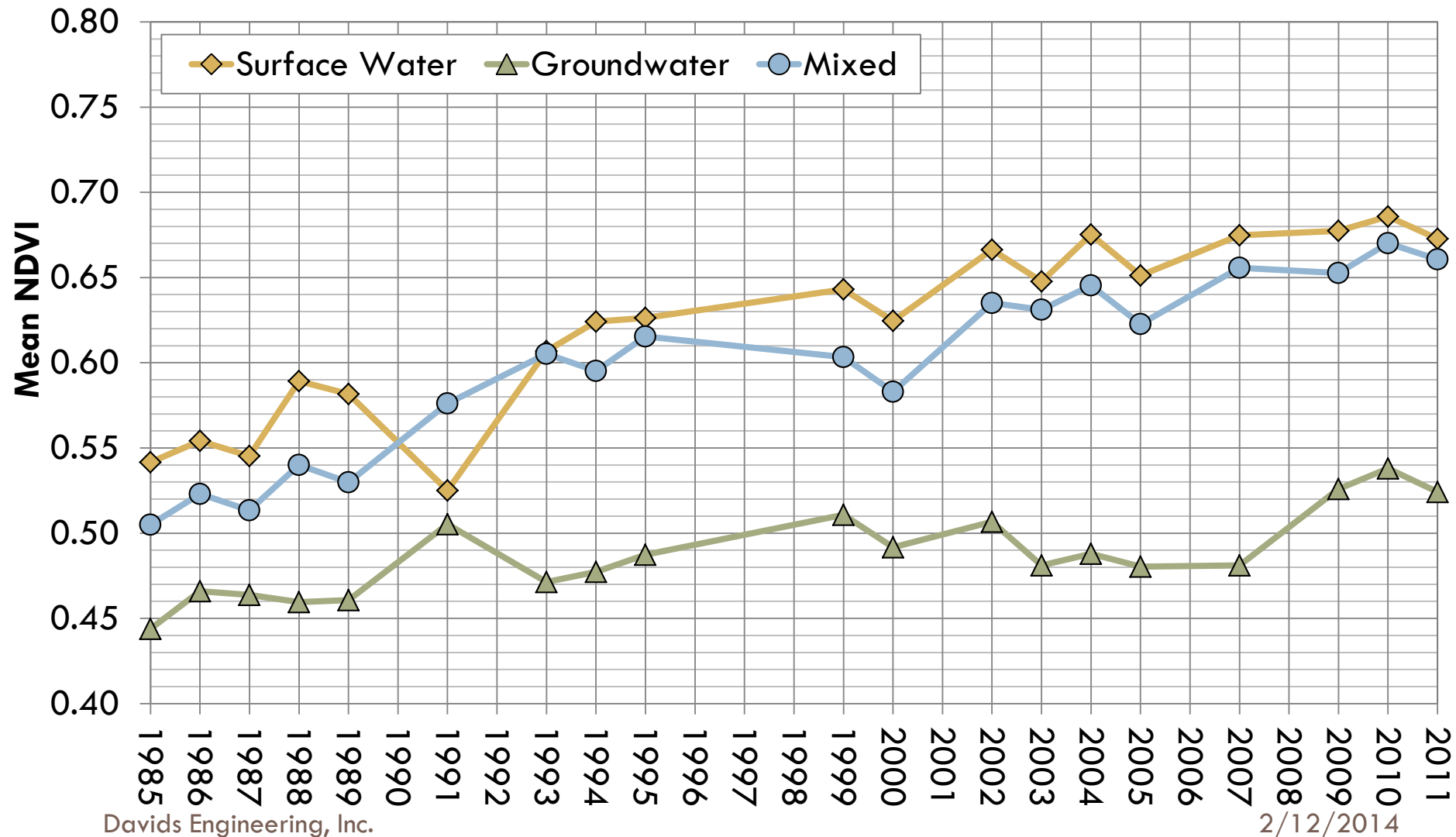
(Excludes riparian, wetland, riverine, and developed)



Colusa County Water-Use Intensity by DWR Water Source

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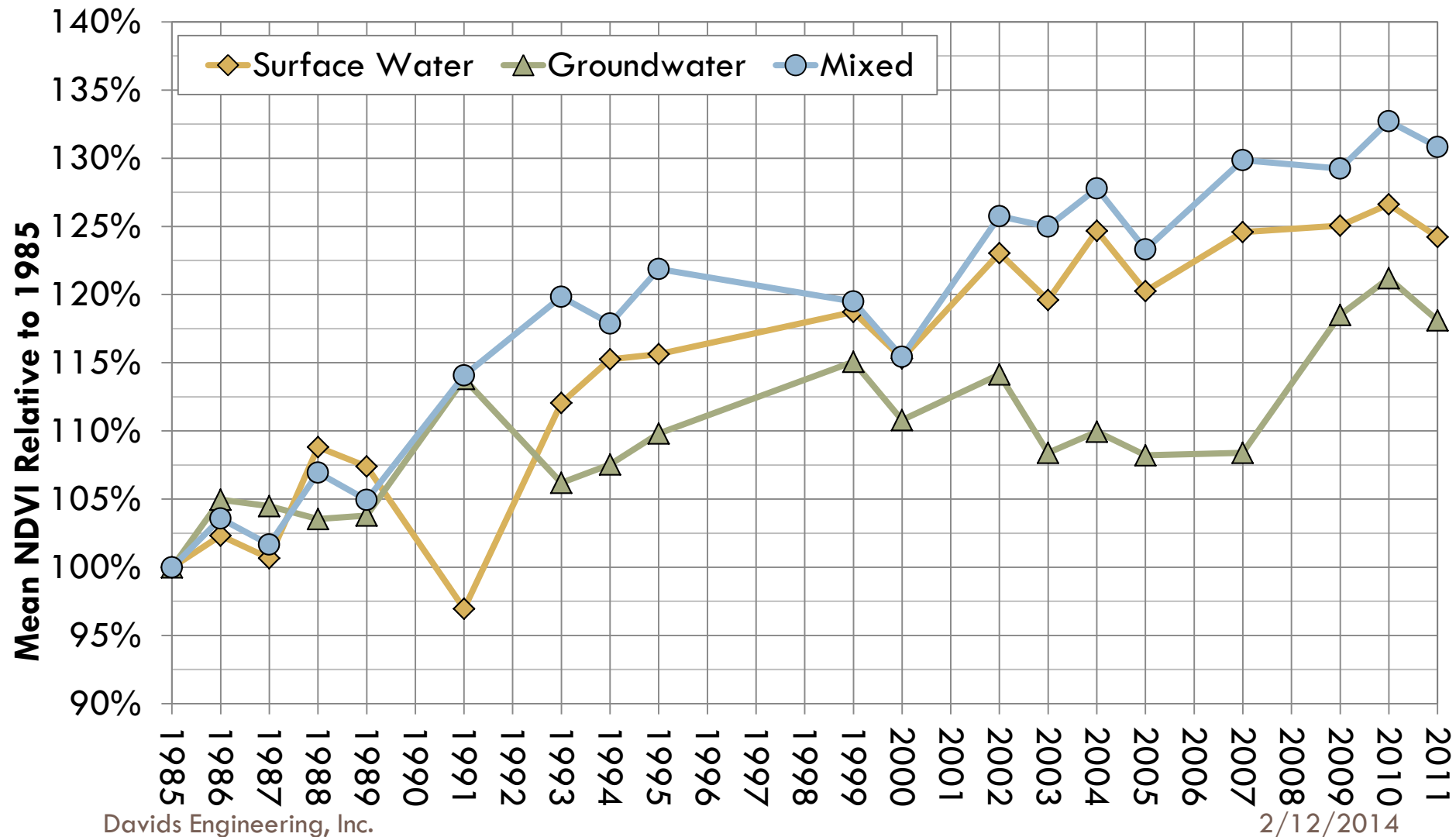
(Excludes riparian, wetland, riverine, and developed)



Colusa County Relative Water-Use Intensity by DWR Water Source

32

(Excludes riparian, wetland, riverine, and developed)



Summary: Colusa County Changes 1985 to 2011

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- Colusa County consumptive water use has increased due to both increased acreage and intensity:
 - Water using area has increased by about 66,000 acres (30%)
 - Per-acre water use intensity has increased by about 24% (NDVI 0.52 to 0.64 NDVI)
- Most increase has occurred in areas using surface water, to a lesser extent in areas using groundwater
- Largest relative changes among all Valley counties

Potential Study Refinements

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- Additional comparisons with independent acreage estimates
- Evaluate imagery for entire crop seasons in selected years to evaluate NDVI progression
- Translate change in NDVI to change in water consumption
- Evaluate additional surface water versus groundwater demand
- Map and more closely evaluate areas where new irrigated acreage is being developed

Thank You!

Discussion