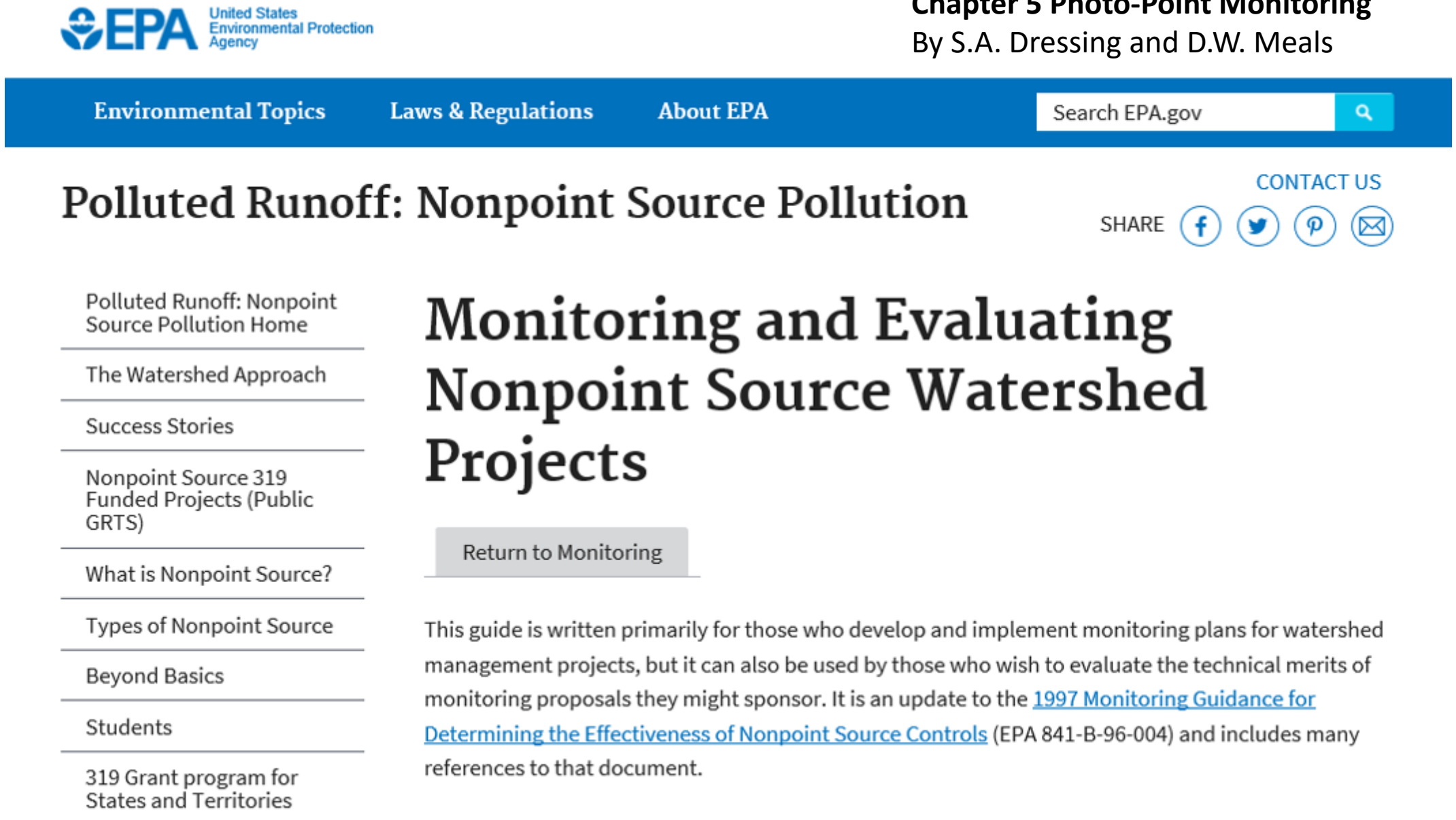
Photo-Point Monitoring

Using photographs taken at a specific site to monitor conditions or change

Frederick C. Hall

Steve Dressing, Tetra Tech



https://www.epa.gov/nps/monitoring-and-evaluating-nonpoint-source-watershed-projects

Photo-Point Monitoring Procedure

- Set objectives
- Select method
- Select monitoring areas
- Establish, mark, and assign identification numbers to photo and camera points
- Identify a witness site
- Record site information and create a site locator field book
- Determine timing and frequency of photographs
- Define data analysis plans
- Establish data management system
- Take and document photos

Objectives

Assessment

- Document trash levels on beaches or in urban settings
- Document stream features
- Document algal blooms in waterbodies
- Identify sources of sediment plumes
- Document livestock activity near waterbodies
- Identify gullies and areas of streambank instability
- Identify areas in greatest need of urban runoff control measures

Objectives

Planning

- Help locate areas where streambank protection and stream restoration are needed
- Document livestock operation needs to assist in budget development
- Provide evidence of watershed problems and potential solutions for public outreach
- Provide photos to assist the design of urban runoff control measures

Objectives

Implementation

- Document tree growth in riparian zone over time
- Document implementation of rain gardens
- Document stream restoration activities
- Document and track changes in percent residue at representative agricultural sites across a watershed

Objectives

New Delhi Television

Evaluation

- Document changes in streambank cover or stream profile as a result of stream restoration
- Demonstrate the effects of different grazing management systems on pasture condition
- Illustrate how a stream handles high-flow events before and after restoration
- Document changes in beach trash over time

Three Methods

- **Comparison photography**: Typically involves the creation of a photo guide from a set of standard photos taken to represent the expected range of an attribute (or condition) of interest (e.g., utilization of grazing plants)
- **Repeat photography**: Photos are taken of the subject over time at the same location to document change or monitor activity
- **Opportunistic photography**: Photos are not taken from a permanently marked location, and they are not part of a repeat photography effort

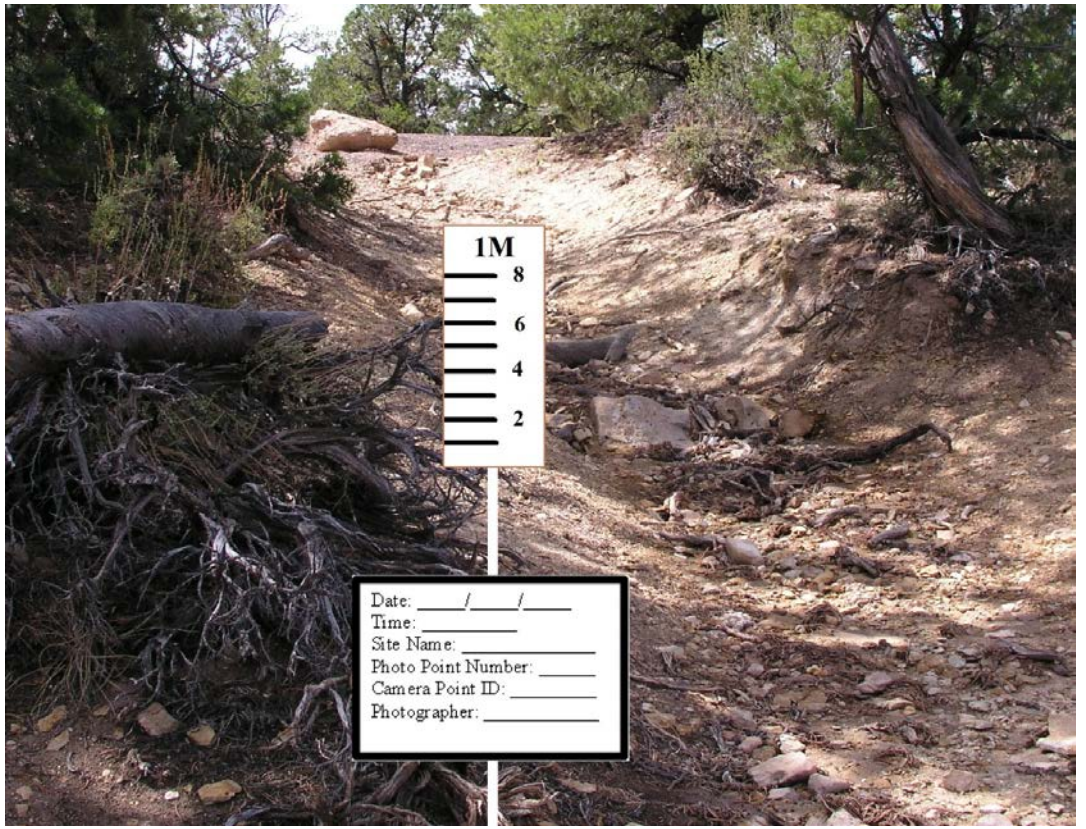
Qualitative Applications

- Document implementation of practices
  - E.g., growth of vegetation associated with stream/streambank restoration or grazing management
- Corroborate or help interpret findings from more quantitative monitoring methods

USDA-NRCS

Quantitative Applications

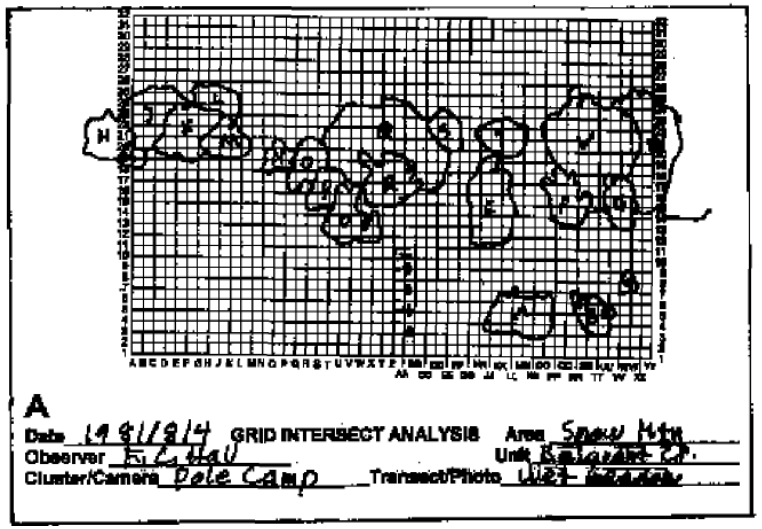
- **Measure**: Meter boards (field rulers mounted vertically) or other size control boards (e.g., Robel poles) to provide a reference
- **Count**: Visual observation of images or count digital image pixels that fall within a specified color range



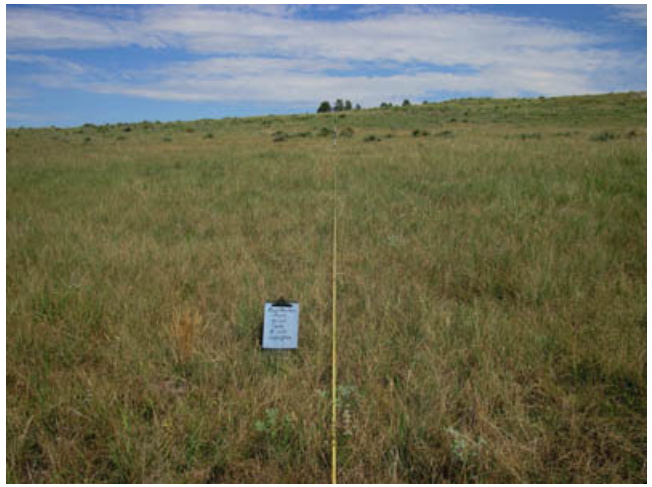
http://www.dnr.state.mn.us/mcvmagazine/issues/2015/mar-apr/grasshopper-sparrow-project.html

Quantitative Applications

- **Photo grid analysis**: involves placing a standardized grid over a photo and counting the number of intersects between the grid lines and features of interest
- **Transect photo sampling** (various approaches): Photo points are established along a transect to obtain more quantitative information



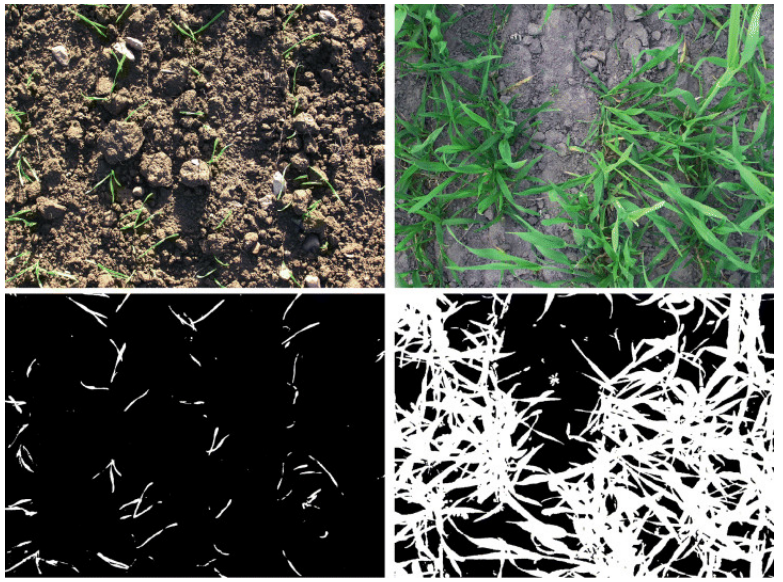
Hall



University of Nebraska National Drought Mitigation Center

Quantitative Applications

- **Digital Image Analysis**: Uses computers to analyze digital images
  - E.g., convert color images to grayscale to determine the proportion of pixels in digital images that are green to estimate crop soil cover
  - Challenges for watershed project applications:
    - Evaluate lighting, camera angle, size of the area photographed, and the growth stage of plants to quantify their effects on the accuracy or precision of the method
    - True value to compare against the DIA-based results to assess the accuracy of the method
  - Tools include MATLAB Image Processing Toolbox, Mathematica, and a wide range of image processing products developed for various applications



Rasmussen et al., 2007

Selecting Areas

- Appropriate for stated objectives and consistent with data analysis plans
- Problem assessment using opportunistic photography
  - Site selection ~ that for synoptic (stream walk) or windshield survey
- Project implementation (e.g., BMPs, restoration) or evaluation
  - Select an area that is most likely to undergo the physical transformations that can be tracked in order to support these objectives
  - Usually only a portion of the area of interest can be monitored
    - Can findings be extrapolated to areas not monitored?
    - Statistical analysis of photo-based data is not common
      - Need representative sample
      - Need a measurable variable from the photos with known distribution and an estimate of the standard deviation

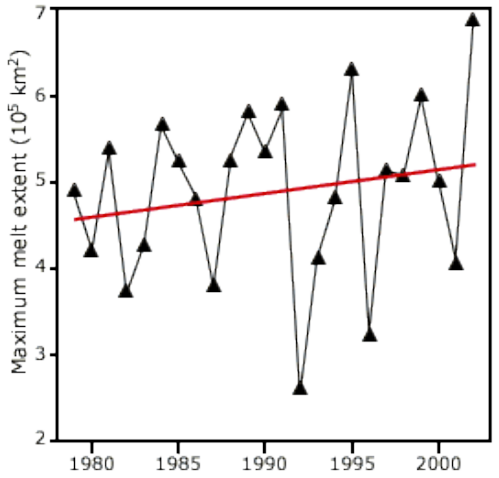
Identifying Photo Points and Camera Points

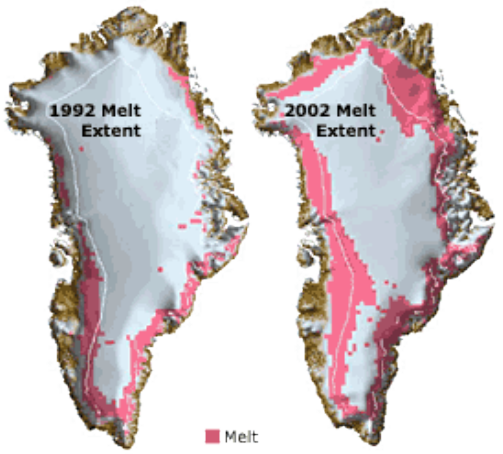
- Various definitions, but Hall says:
  - Photo point is what you point the camera at when you take the photograph
  - Camera point is a permanently marked location for the camera

Photo illustrating photo points (A and B) and camera points (1 and 2). Photos of A and B are taken from cameras located at 1 and 2.

Scale and Timeframe

- **Scale**
  - Landscape – distant scenes with areas generally greater than 10 ha
  - General – specific topics monitored on areas 0.25 to 10 ha
  - Closeup – specific topics on areas under 0.25 ha
  - Function of monitoring objectives
- **Timeframe**
  - Landscape - long-term commitment during which repeat photos are taken as infrequently as every 20 years or so
  - General and closeup - more consistent with watershed project timeframes



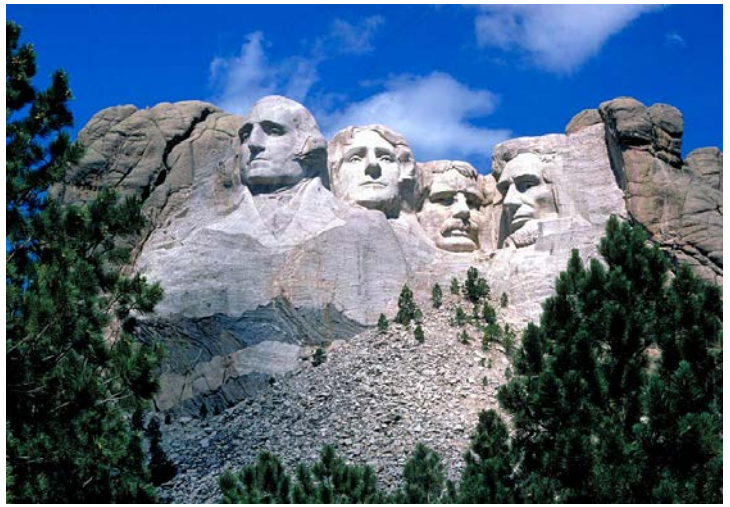


NASA

Frequency and Timing of Photographs

- Based on monitoring objectives, planned data analyses, features to be photographed, and expectations regarding detectable change in features
- Problem assessment/planning - one-time or multiple photographs at various times during the year to characterize seasonal, flow-related, or other significant variability
- Implementation tracking/project evaluation - multiple years, with the frequency and timing of photos based on seasonal and other variability
- Native vegetation - at least 1x/yr at the end of the growing season, or 2x/yr to show seasonal differences
- Restoration projects - Generally seasonal, annual, or biennial (at same time of year, perhaps high- and low-flow conditions)

Documentation



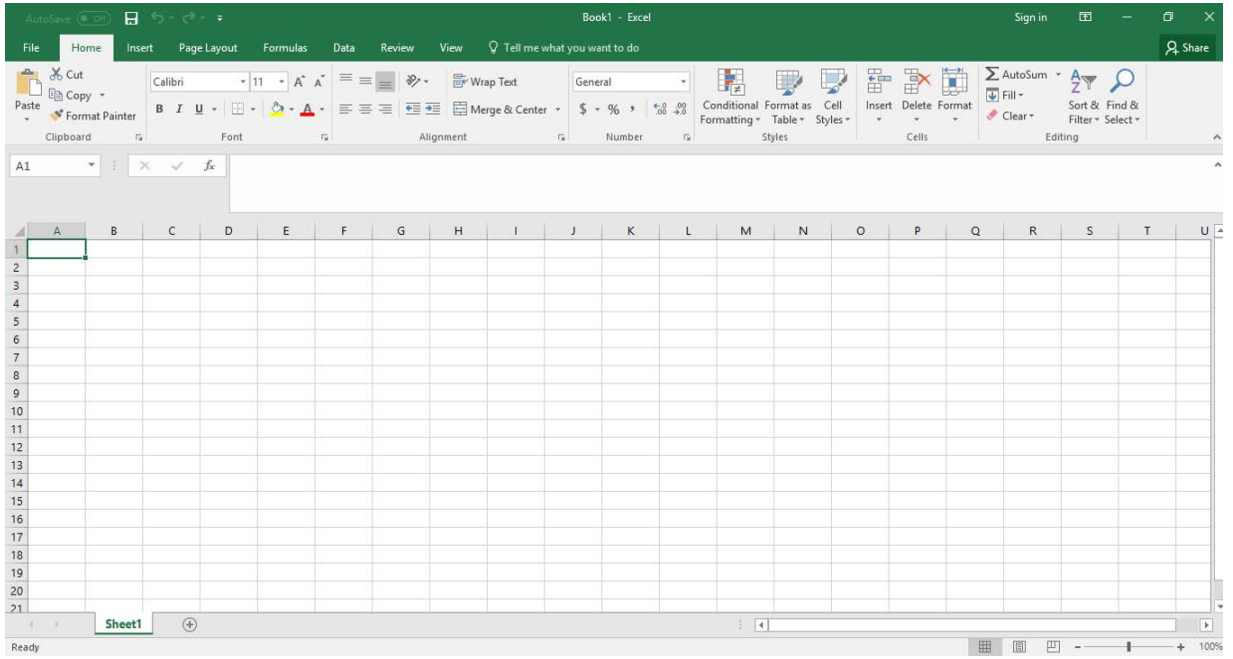
- **Witness Site**: An object that can be easily identified when returning to the monitoring area (e.g., a large rock, a structure)
  - Measure and document the distance and direction from the witness site to the camera points, photo points, or both
  - May use a permanent witness site tag with this info
- **Site Info**: Information on why site was selected, maps, aerial photographs, date, observer name(s), location, site description, objectives, identification numbers, and locations of the witness site, photo points, and camera points, including distances and directions between points

Documentation

- **Camera Settings**
  - Distance from the camera to the meter board or subject
  - Camera direction
  - Vertical and horizontal position
  - Left-right orientation
  - Focal length (helpful but not critical as images can be cropped)
  - Every photo and camera point should be geolocated, photographed, and permanently marked (e.g., fenceposts)
  - GPS can help with site location, but marking of photo and camera points may be necessary if the resolution of the GPS system is 10-15 feet or so

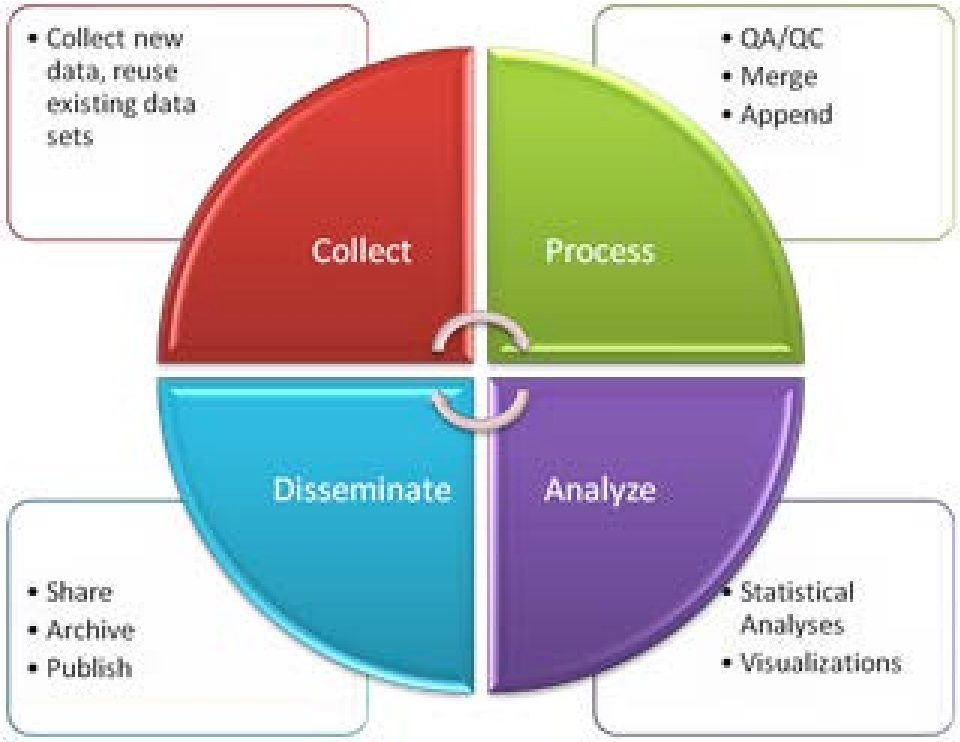
Documentation

- **Field Book**
  - Help others find the monitoring location, witness site, and photo and camera points
  - Include copies of the original photo-point photographs, and other important site information recorded
  - Physical or digital (physical backup recommended)



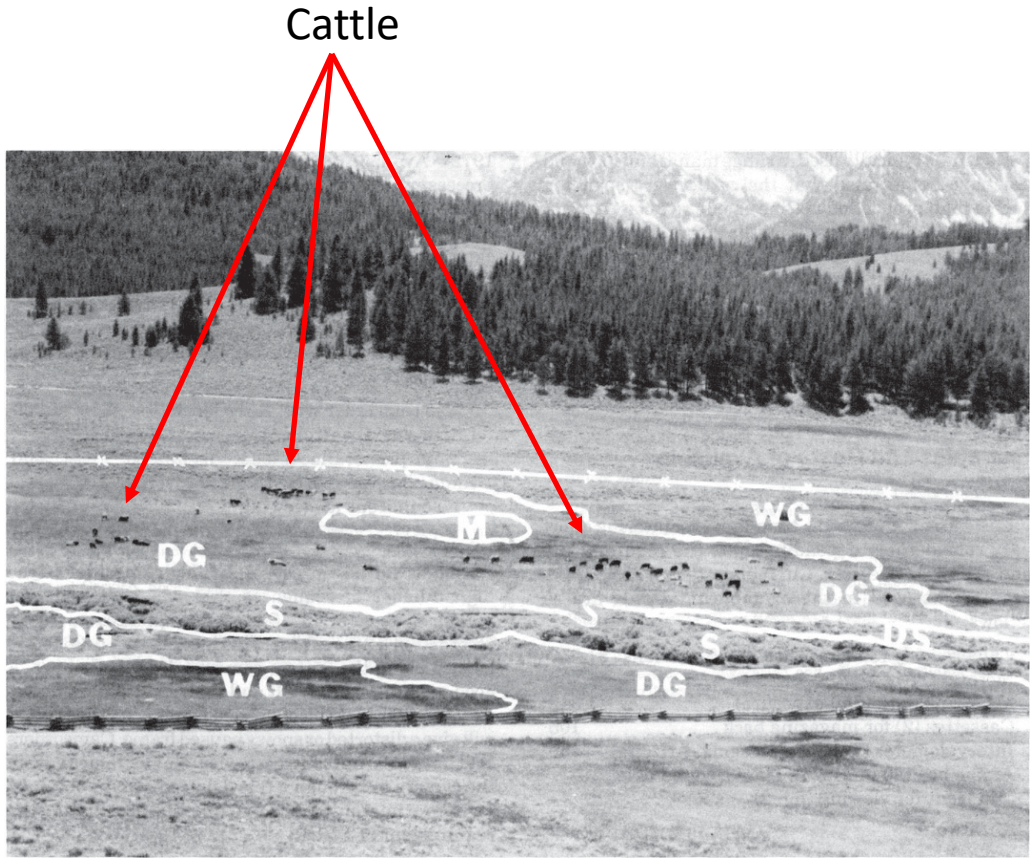
Data Analysis

- Establish plans for analysis before taking the photos
- Qualitative analysis is most common
- Statistical analysis is rare



Quantitative Data Analysis

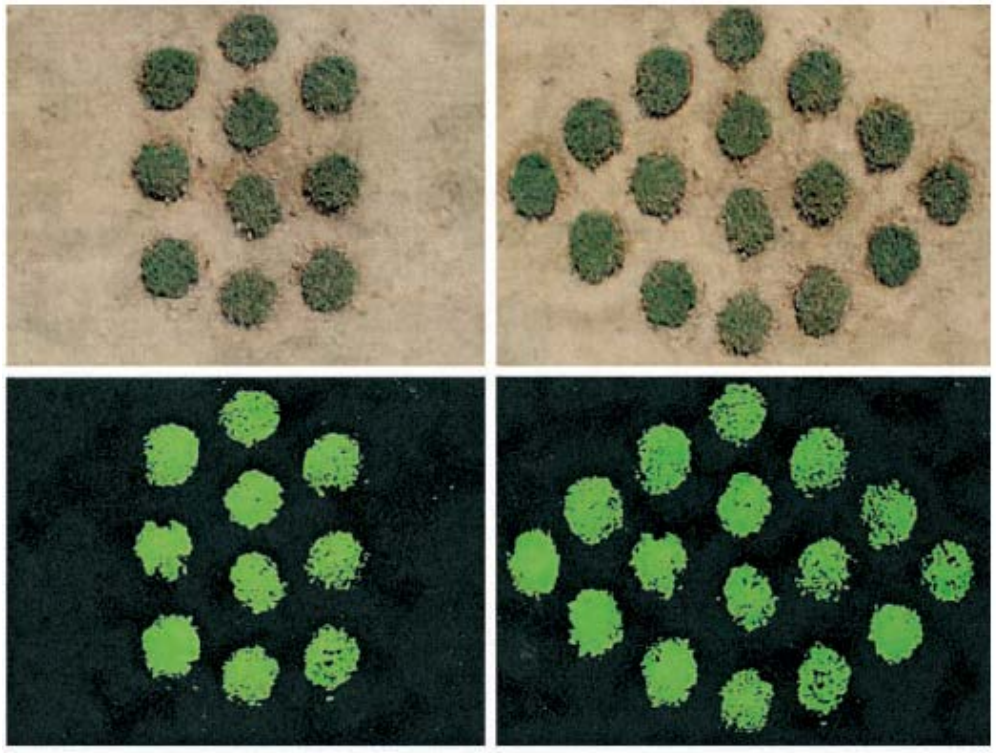
- Kinney and Clary (1998) performed quantitative analysis of differences in grazing patterns in various areas of a riparian meadow using analysis of variance
  - Photos analyzed to count number of cattle within each of five vegetation-soil categories that were delineated within the study area and superimposed on individual photographs
  - Created a database with counts that were converted to a density measure that was associated with both year and class variables (e.g., vegetation-soil category, pasture number)



Time-lapse photo of pasture illustrating concentration of cattle on the dry graminoid (DG) portion of the meadow. Other sites are dry shrub (DS), wet graminoid (WG), mixed types (M), and streamside (S).

Quantitative Data Analysis

- Richardson et al. 2001 compared digital image analysis against subjective analysis (SA) and line-intersect analysis (LIA) in determining turf cover % on study plots
  - DIA - the percentage of green pixels in images of turfgrass taken from a digital camera mounted on a monopod was calculated to determine the turf cover % in each image
    - DIA performed far better than either SA or LIA in determining the percent cover of study plots
    - The variance for DIA was only 0.65, while the variances for LIA and SA were 13.18 and 99.12, respectively



DIA was shown to be very accurate through calibration with turf plugs of known cover

Key Resources

- Dressing, S.A., D.W. Meals, J.B. Harcum, J. Spooner, J.B. Stribling, R.P. Richards, C.J. Millard, S.A. Lanberg, and J.G. O'Donnell. 2016. Monitoring and Evaluating Nonpoint Source Watershed Projects. EPA 841-R-16-010. U.S. Environmental Protection Agency, Washington, DC.
- Hall, Frederick C. 2001. *Ground-Based Photographic Monitoring.* General Technical Report PNW-GTR-503. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. Accessed February 11, 2016. http://www.fs.fed.us/pnw/publications/pnw_gtr503/.
- Hall, Frederick C. 2002. *Photo Point Monitoring Handbook.* General Technical Report PNW-GTR-526. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, OR. Accessed February 10, 2016. http://www.fs.fed.us/pnw/pubs/gtr526/.
- Hamilton, R.M. n.d. *Photo Point Monitoring, A Weed Manager's Guide to Remote Sensing and GIS — Mapping & Monitoring*. U.S. Department of Agriculture, Forest Service, Remote Sensing Applications Center, Salt Lake City, UT. Accessed February 10, 2016. http://www.fs.fed.us/eng/rsac/invasivespecies/documents/Photopoint_monitoring.pdf.
- Kinney, J.W. and W.P. Clary. 1998*Time-Lapse Photography to Monitor Riparian Meadow Use.* USDA Forest Service Research Note RMRS-RN-5. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Boise, ID. Accessed February 10, 2016. http://www.fs.fed.us/rm/pubs/rmrs_rn005.pdf.
- Richardson, M.D., D.E. Karcher, and L.C. Purcell. 2001. Quantifying turfgrass cover using digital image analysis. *Crop Science* 41:1884-1888.

Next – Example Applications

Photo Monitoring of Nonpoint Source Projects in New Mexico

EPA Webinar
September 2017

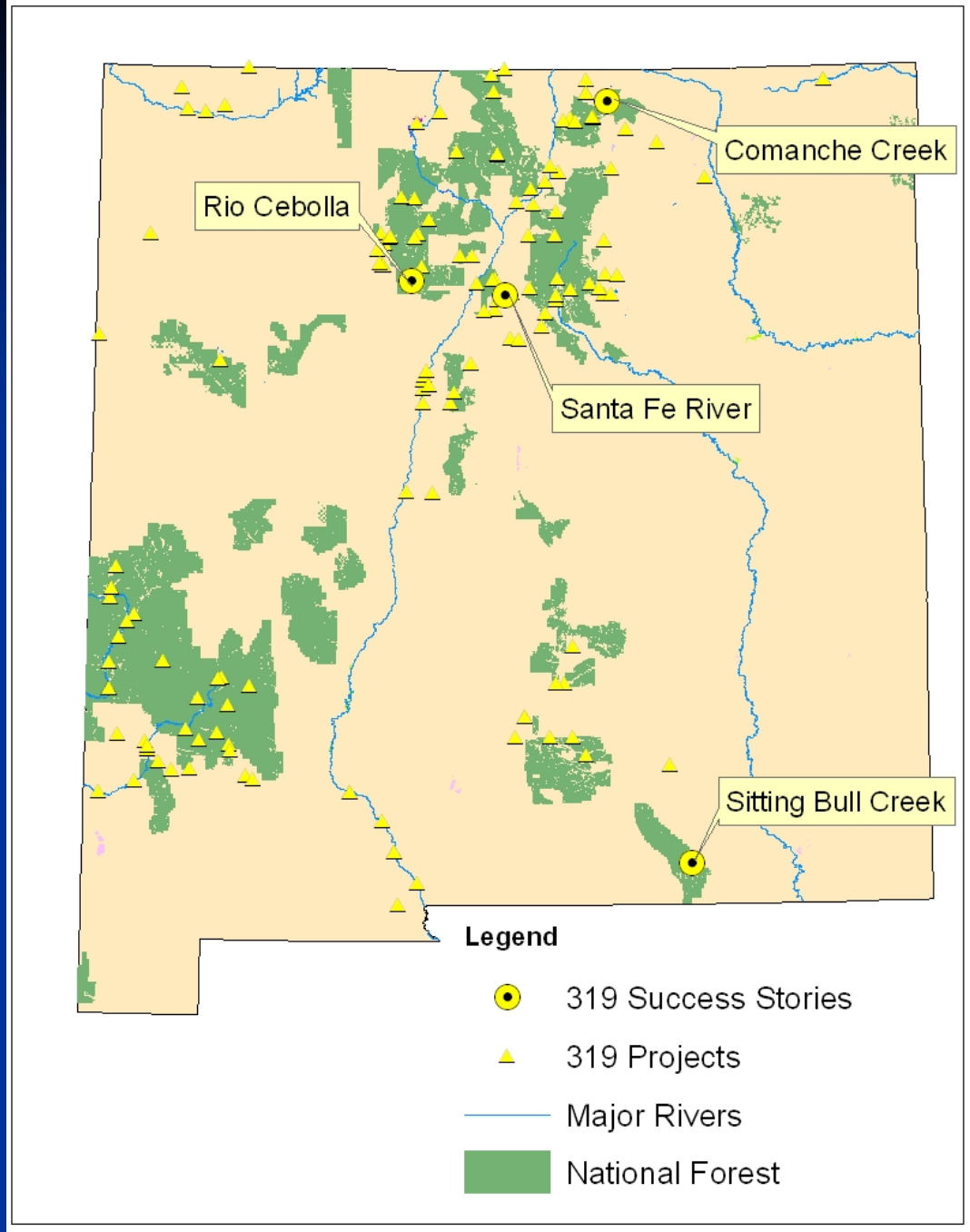
NM Environment Department

Surface Water Quality Bureau

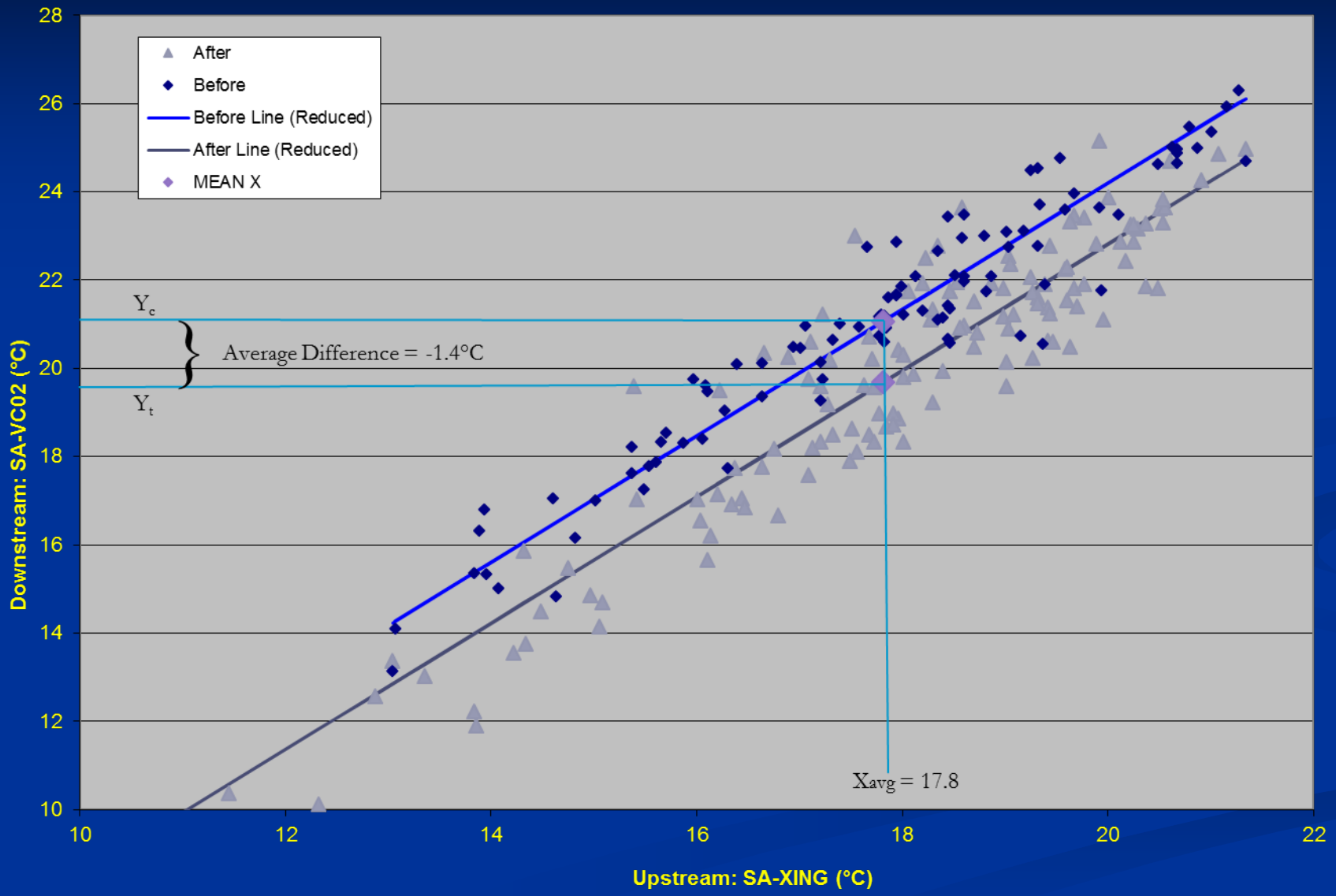
Daniel Guevara
Watershed Scientist

Photo Monitoring Objectives

- Implementation: To illustrate restoration measures
  - In-stream structures
  - Fenced exclosures with plantings
- Evaluation: To document the effects of stream restoration projects
  - Riparian vegetation growth over time


Comanche Creek
Rio Cebolla
Santa Fe River
Sitting Bull Creek
Legend
319 Success Stories
319 Projects
Major Rivers
National Forest

San Antonio Creek ANCOVA : Daily Max Temp (°C) 2009 vs 2011




8/6/2004 7:38am


Santa Fe River Riparian Restoration
Wild Earth Guardians 319 Project
1/28/2000

Santa Fe River Water Quality 303d List Timeline

- Before:
  - 1998-2000 Listed for pH, DO, nutrients, sediment
- After:
  - 2008 De-listed for pH
  - 2010: De-listed for turbidity, sediment
  - 2012: De-listed for DO
  - 2014: nutrients remain, E. coli added

Photo Pt P : 1997

Photo Point P : 2004

Photo Pt G : 1997

Photo Point G : 2004

Photo Pt F : 2000

Photo Pt F : 2001

Photo Point F : 2004


Bluewater Creek NM 2009


06.14.2010 12:41


Bluewater Creek NM 2016


Bluewater Creek NM 2016


Nikon
COOLPIX
L6
LETSGODIGITAL


Otter
BOX


Nikon
D5300
Nikon
AF-S DX NIKKOR
18-140mm 1:3.5-5.6 G ED VR

Conclusions

- Repeat photography has been very effective in documenting project success

- Update methods and protocols

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PHOTO-POINT MONITORING: EXPLANATION AND APPLICATION

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NPS TECHNICAL EXCHANGE WEBISODE

WEDNESDAY, SEPTEMBER 13, 2017

PRESENTATION OVERVIEW

- Introduction
- In-Field Experience with Monitoring Hardware
- Photo-Point Monitoring Evaluation Objectives
  - Quantify Water Quality/Quantity
  - Document and Support QAQC Activities
  - Collect Supporting Data

INTRODUCTION

- Edge-of-Field Runoff Monitoring
- Research Program at Univ. of WI-Platteville
- Developing and Field-Testing of Prototype Runoff Monitoring Systems
- Wisconsin, Minnesota, Iowa, Michigan, and Arkansas

MONITORING HARDWARE

- Game Camera
- Cell Phone
- Custom Raspberry Pi Camera
- Internet Protocol Camera

EVALUATION CRITERIA (REMOTELY LOCATED CAMERA)

1. Robust Operation
2. Rugged Design
3. Simple Application
4. Flash or Infrared Capability
5. Overlay Text
6. Image Upload to Cloud
7. Remote Access and Configuration
8. 12V / Low Power
9. SD Card Storage

GAME CAMERA + EYEFI CARD + WIFI

1. Robust –/+ moderate failure rate
2. Rugged + very durable
3. Simplicity + easily configured
4. Flash or Infrared + good flash
5. Overlay Text + yes
6. Upload to Cloud +/- with wifi card, unreliable
7. Remote Access and Configuration - no
8. 12V / Low Power + yes
9. SD Card Storage + yes

CELL PHONE
+ TL APP + DROPBOX + DROPSYNC

1. Robust – lapse often quit
2. Rugged – poor performance in temp extremes
3. Simplicity – configuration is complex
4. Flash or Infrared + with good quality photos
5. Overlay Text – post processing
6. Upload to Cloud + yes
7. Remote Access and Configuration - no
8. 12V / Low Power +
9. SD Card Storage +

CUSTOM RASPBERRY PI CAMERA + ETHERNET + INTERNET

1. Robust - / +
2. Rugged ? untested
3. Simplicity - complicated
4. Flash or Infrared – poor quality flash, not native
5. Overlay Text +
6. Upload to Cloud +
7. Remote Access and Configuration -/+ via AWS
8. 12V / Low Power +
9. SD Card Storage +

IP CAMERA

+ RELAY/PLC + ETHERNET + INTERNET

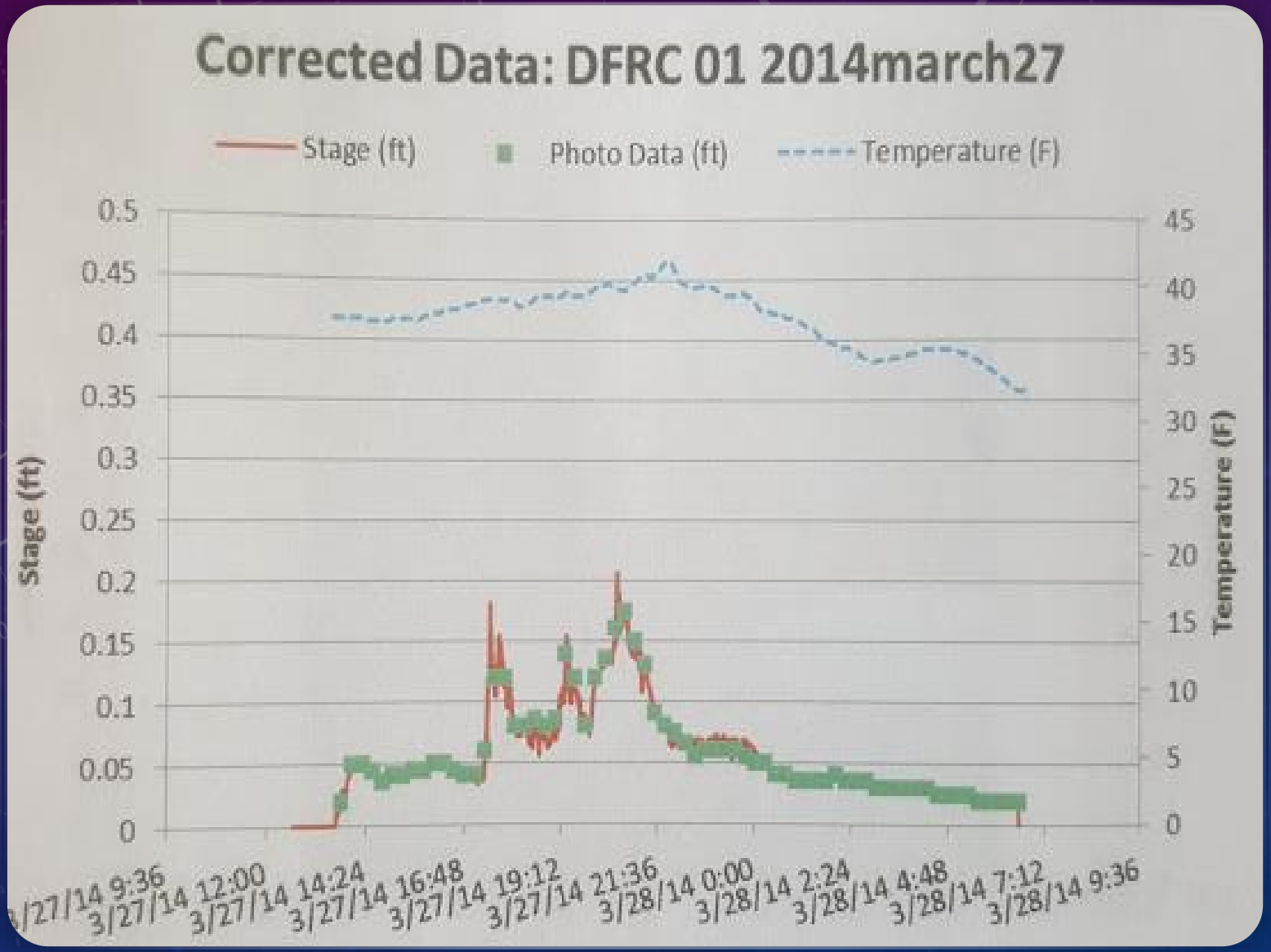
1. Robust + rarely fails
2. Rugged + outdoor rated
3. Simplicity – ip configurations
4. Flash or Infrared +
5. Overlay Text +
6. Image Upload to Cloud +
7. Remote Access and Configuration +
8. 12V / Low Power – relay required
9. SD Card Storage +

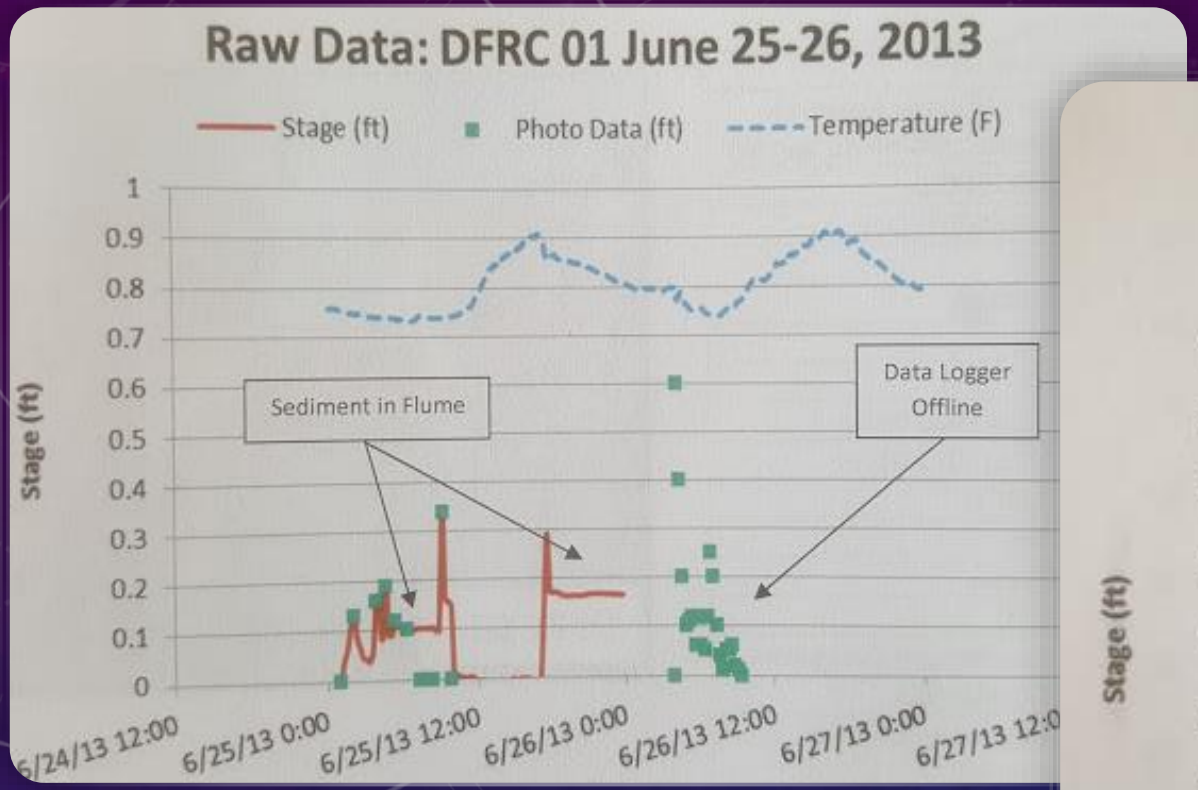
PTZ IP CAMERA
+ ETHERNET / MODEM

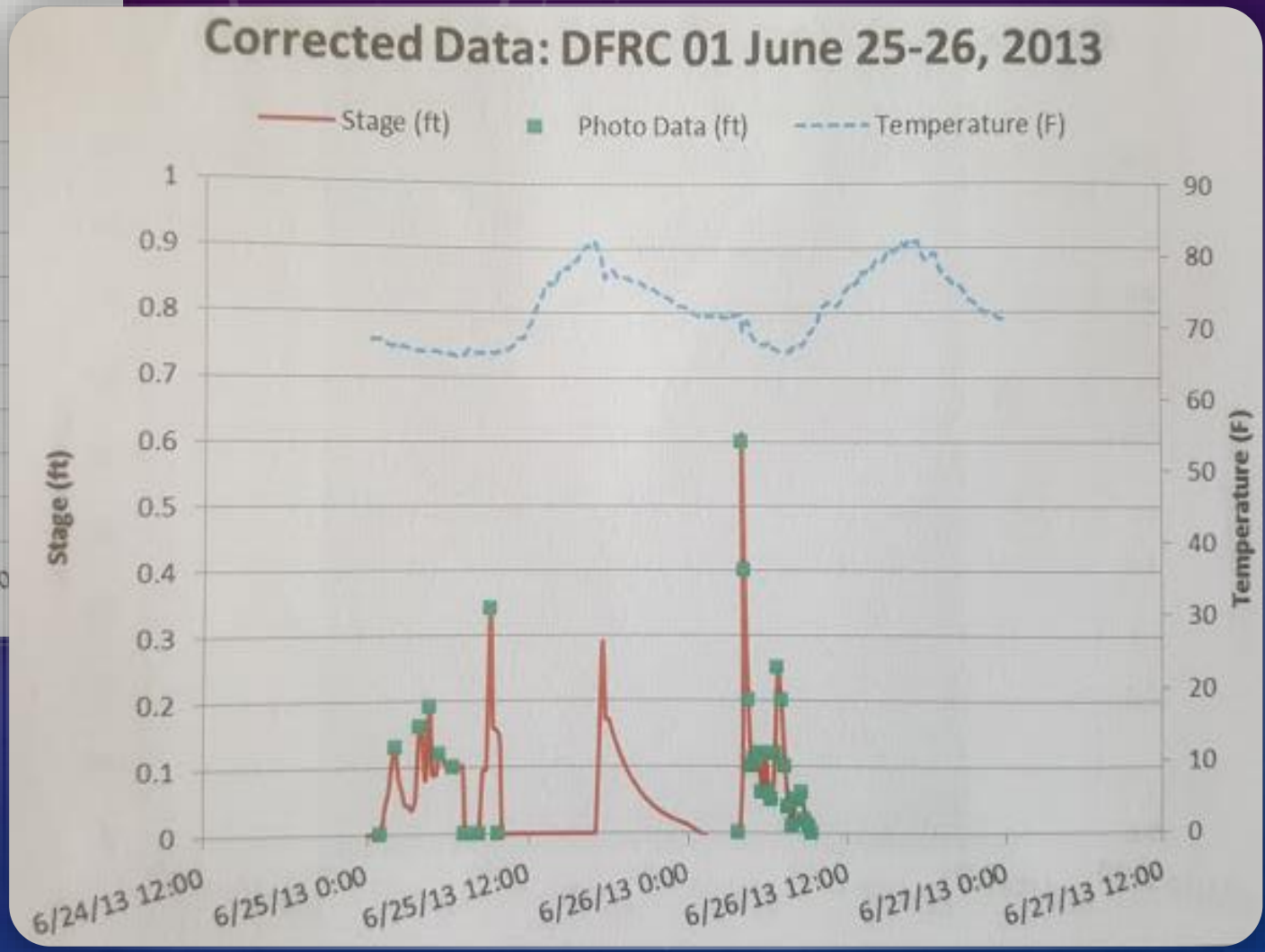
- Not used for time-lapse
- Used for Real-Time:
  - Hardware Status
  - Environmental Conditions
  - Remote Support

QUANTITATIVE MONITORING: MEASURE DISCHARGE

FLOW MEASUREMENT: VALIDATE SENSOR READINGS

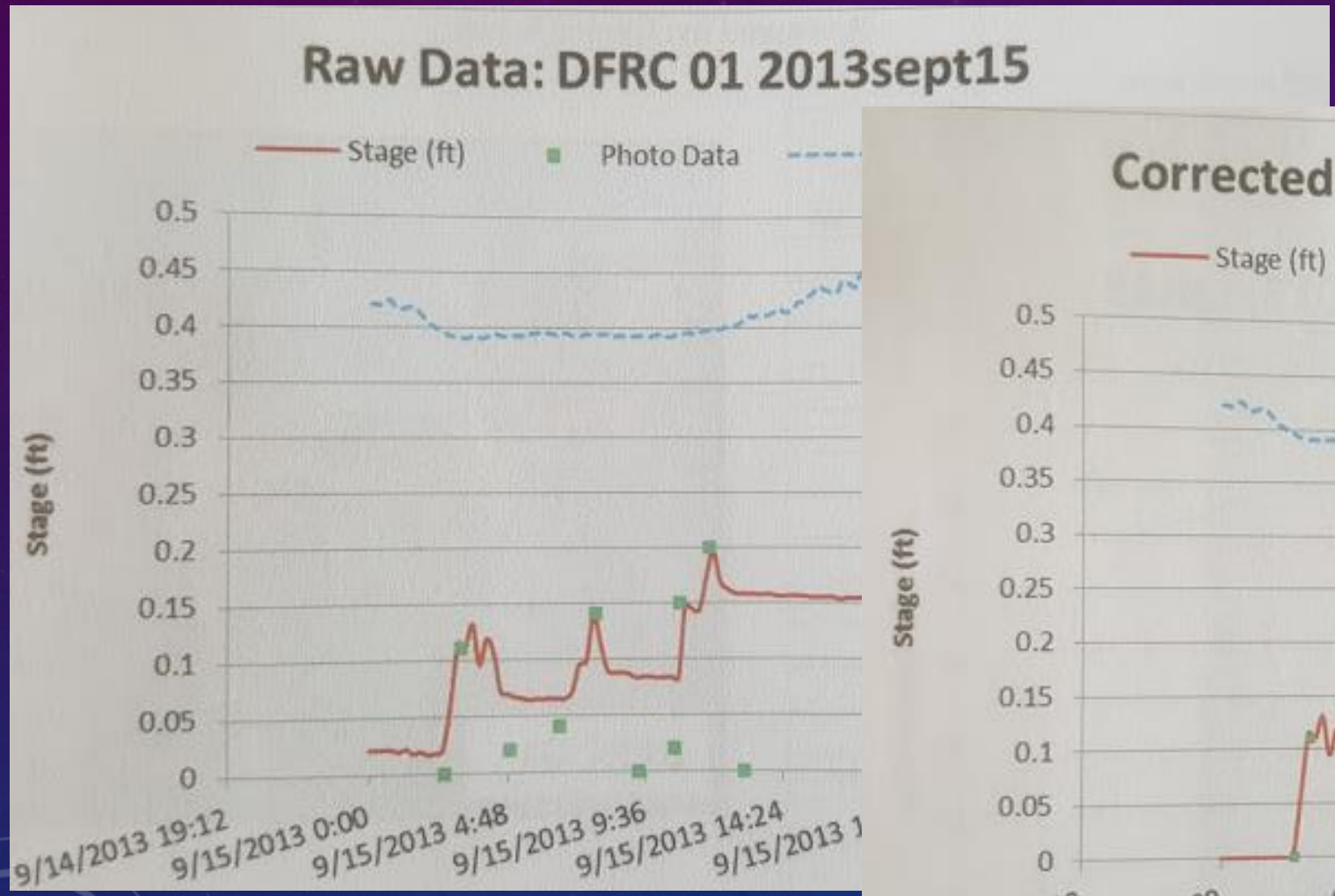


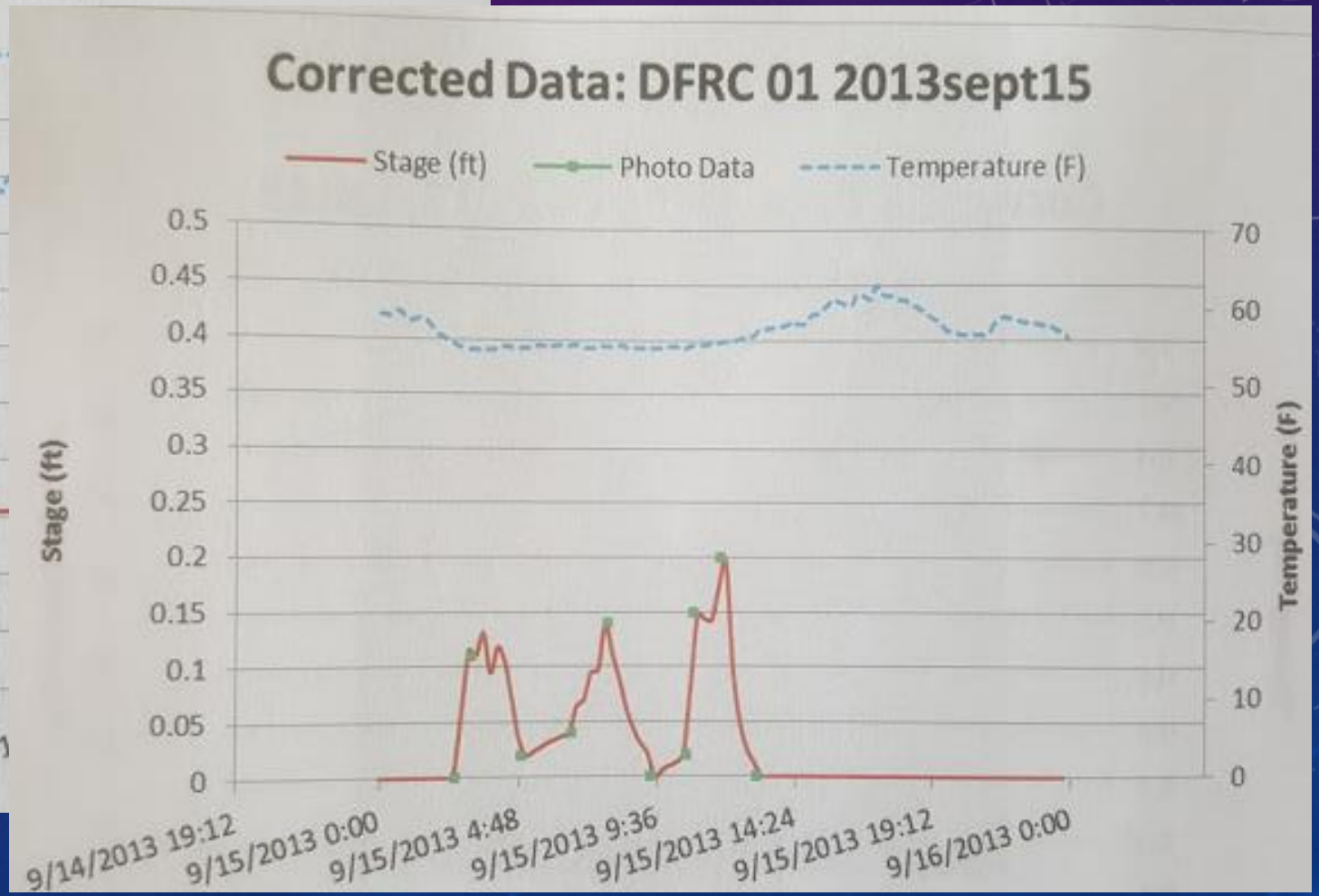


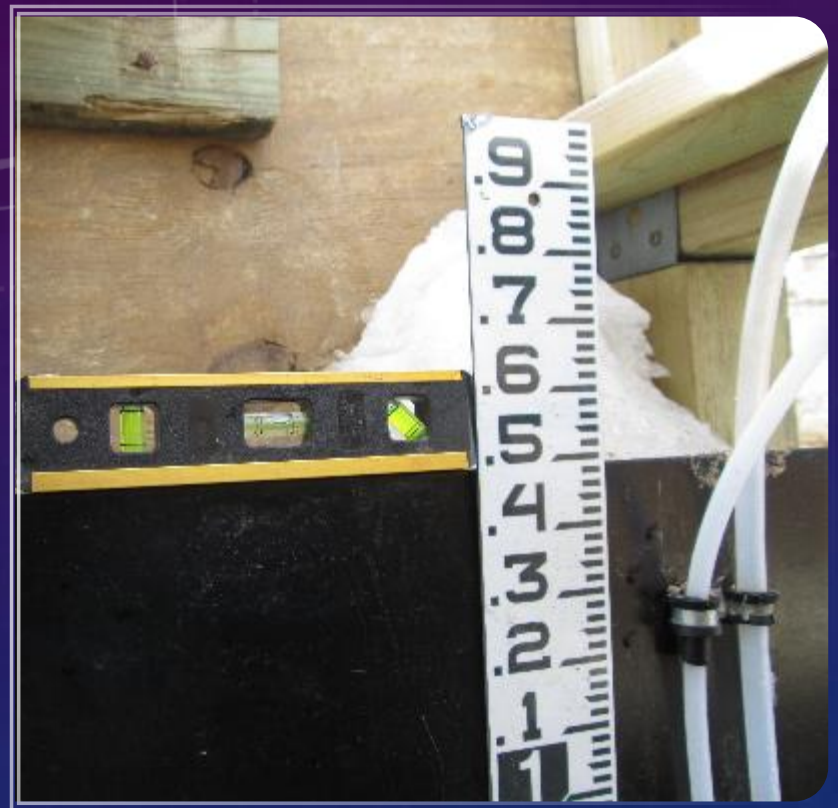


FLOW MEASUREMENT: REDUNDANT DATA SOURCE

FLOW MEASUREMENT: POST EVENT CORRECTING DATA







QUANTITATIVE MONITORING: SUPPORT QAQC

QUALITATIVE MONITORING: RECORD UNUSUAL OBSERVATIONS

QUALITATIVE MONITORING: AGRONOMIC DATA

QUALITATIVE MONITORING: AGRONOMIC DATA

QUALITATIVE MONITORING: WATER QUALITY

THANK YOU FOR YOUR ATTENTION.

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