Yield Monitoring Systems: Understanding how we Estimate Yield

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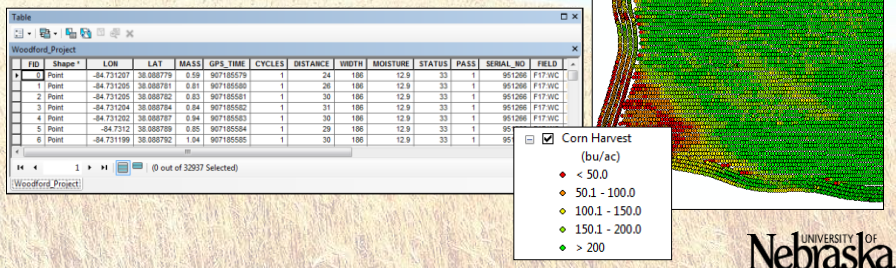

Discussion Topics

- Yield monitor components
- Calibrating the yield monitor
- Moisture sensing
- Yield monitor output
- Estimating crop yield
- Making yield maps

Basic Yield Monitor Components

Mass Flow Sensor

Moisture Sensor

Header Sensor

GPS System

Field Computer

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Yield Monitor Component Functions

Field Computer

- Monitors all sensors
- Displays harvest functions
- Logs data for storage and transfer

GPS System

- Provides field position

Header Status Sensor

- Logs data when down
- Stops logging when up

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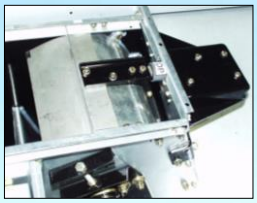
Yield Monitor Component Functions

Mass Flow Sensor

- Impact plate sensor (most popular)
- Mounted in clean grain elevator
- Grain impacts plate
- Force of impact deflects load cell
- Voltage output from load cell
- Voltage is proportional to mass flow



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Calibrating the Yield Monitor

Why calibration is necessary:

- We only know the voltage output from the sensor
- We need to relate that to something real (lbs or bu)

Calibration procedure is specific to each yield monitor

- Collect mass of grain per time
- Computer records sensor output
- Enter grain mass into computer
- Computer develops equation to estimate mass flow from voltage output

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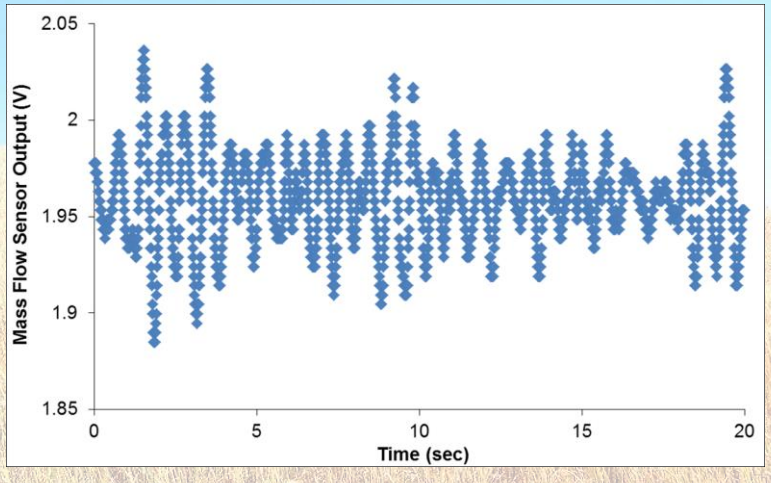
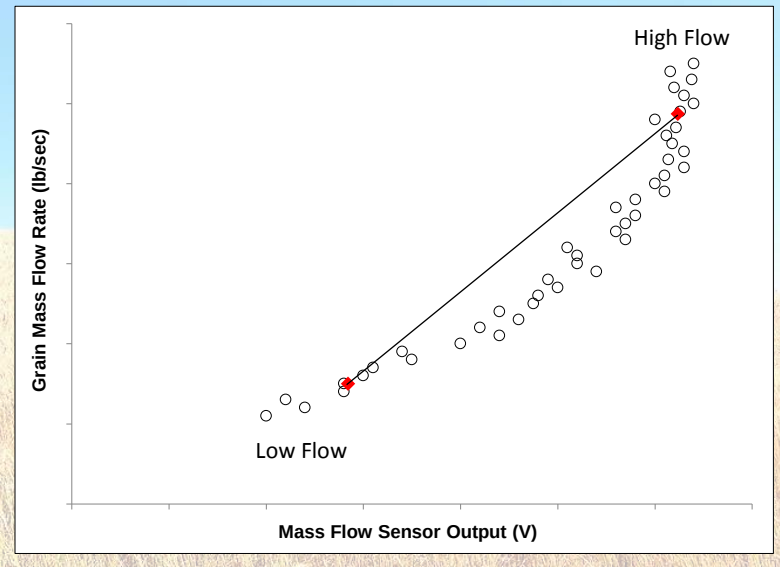
Static Mass Flow Sensor Measurements

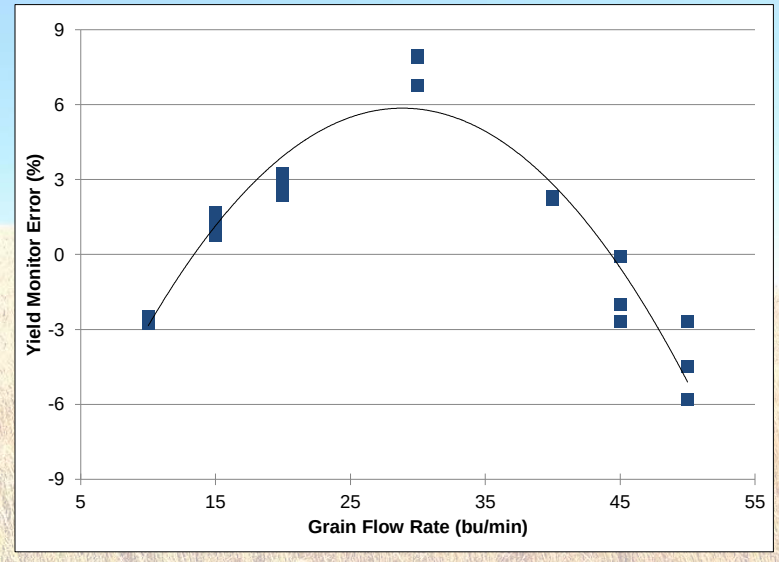
Sensor output at a constant mass flow rate:



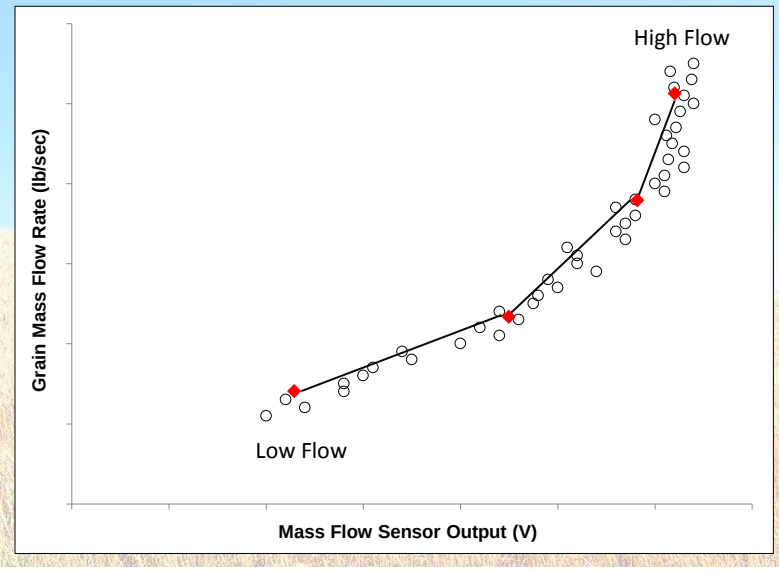
Two-Point Calibration



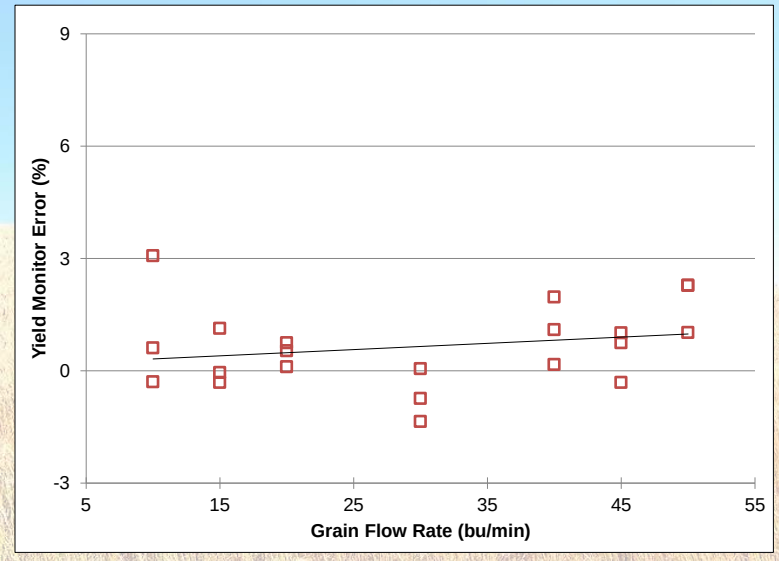
Two-Point Calibration Errors



Multi-Point Calibration



Multi-Point Calibration Errors



Calibration Notes

Mass Flow Sensor

- Accurate calibration is critical!
- Our goal is to calibrate mass flow rate
- Yield estimations come later
- Errors from 1 to 3% are expected (field average)
- Conduct at least one calibration per crop per year
- Test weights may affect accuracy…recalibrate

Moisture Sensing

Moisture is necessary for marketable yield

- Different sensor types:
  - Flow-through
  - Single-sample
- Electrical resistance of grain measured
- Indirectly proportional to MC
- Affected by temperature (measured), bulk density and surface moisture
- Manual entry not recommended

Output from the Yield Monitor Computer

Text file (.txt or .csv) format:

Bowman_Raw_NSY - Notepad

File Edit Format View Help

```
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Output from the Yield Monitor Computer

What important data are in those columns:

- GPS location (latitude and longitude)
- Mass flow rate (lb/sec)
- Logging interval (sec)
- Distance traveled (in or ft)
- Header cut width (in or ft)
- Moisture content (%)

Where's the bushels???

J	K	L	M	N	O	P	Q
Pass #	Monitor Id	Field Name	Load #	Crop	GPS Status	PDOP	Altitude (ft)
1	2006220985	F161:Lacanne 40	L1:	CORN	7	0	1156.3
1	2006220985	F161:Lacanne 40	L1:	CORN	7	0	1157
1	2006220985	F161:Lacanne 40	L1:	CORN	7	0	1157.6
2	2006220985	F161:Lacanne 40	L1:	CORN	7	0	1161.2
2	2006220985	F161:Lacanne 40	L1:	CORN	7	0	1161.2
2	2006220985	F161:Lacanne 40	L1:	CORN	7	0	1160.9
2	2006220985	F161:Lacanne 40	L1:	CORN	7	0	1160.9
3	2006220985	F161:Lacanne 40	L1:	CORN	7	0	1160.6

	A	B	C	D	E	F	G	H	I
1	Longitude	Latitude	Flow Rate (lb)	Time (sec)	Logging Interval	Travel Distance (in)	Header Width (in)	Moisture (% wb)	Header Status
2	-93.00001	44.294522	6.52	1258824694	2	82	360	19.4	33
3	-92.999988	44.294525	11.46	1258824	2	83	360	19.1	33
4	-92.999961	44.294531	21.15	1258824	2	87	360	19.3	33
5	-92.999895	44.294535	12.45	1258824	2	103	360	19.4	33
6	-92.99986	44.294535	23.41	1258824714	2	111	360	18.4	33
7	-92.999818	44.294534	33.95	1258824716	2	128	360	18.5	33
8	-92.999781	44.294533	28.98	1258824718	2	93	360	18.3	33
9	-92.999743	44.294538	9.8	1258824732	2	118	360	19.6	33

Estimating our Crop Yield

We need a little more information:

- Adjusting the crop moisture content to a marketable value
- What is the moisture content for that?
- We know our mass flow rate (lb/sec) but we want bushels…we need to estimate the density

Grain	Moisture (%)	Grain Density (lb/bu)
Corn	15	56
Soybeans	13	60
Wheat	13.5	60

Estimating our Crop Yield

We use the general formula for yield (bu/ac):

$$Yield\left(\frac{bu}{ac}\right) = (43{,}560)\left(\frac{m * t}{d * w * \rho}\right)\left(\frac{100 - MC_{harvest}}{100 - MC_{market}}\right)$$

Where:

- m = mass flow rate (lb/sec)
- $MC_{harvest}$ = % moisture content at harvest
- MC_{market} = % marketable moisture content
- t = logging interval (sec)
- d = travel distance (ft)
- w = header cut width (ft)
- ρ = grain density (lb/bu)
- 43,560 = conversion from ft^2 to acres

Estimating our Crop Yield-Example

The yield data output shows a mass flow rate of 15.1 (lb/sec) of corn at a moisture content of 19.3% when traveling 54 inches in a one second logging interval. The header cut width of the combine was 240 inches (8 row header at 30 inches). What is the resulting yield in marketable bu/ac?

$$Yield\left(\frac{bu}{ac}\right) = (43{,}560)\left(\frac{m * t}{d * w * \rho}\right)\left(\frac{100 - MC_{harvest}}{100 - MC_{market}}\right)$$

	A	B	C	D	E	F	G	H	I
1	Longitude	Latitude	Flow Rate (lb)	Time (sec)	Logging Interval	Travel Distance (in)	Header Width (in)	Moisture (% wb)	Header Status
2	-93.00001	44.294522	6.52	1258824694	2	82	360	19.4	33
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4	-92.999961	44.294531	21.15	1258824698	2	87	360	19.3	33
5	-92.999895	44.294535	12.44	1258824712	2	103	360	19.4	33
6	-92.99986	44.294535	23.41	1258824714	2	111	360	18.4	33
7	-92.999818	44.294534	33.95	1258824716	2	128	360	18.5	33
8	-92.999781	44.294533	28.98	1258824718	2	93	360	18.3	33
9	-92.999743	44.294538	9.8	1258824732	2	118	360	19.6	33

Estimating our Crop Yield-Example

Let's start by putting in the MC market & density

- MC_{market} = 15 %
- Density = 56 lb/bu

$$Yield\left(\frac{bu}{ac}\right) = (43{,}560)\left(\frac{m * t}{d * w * 56}\right)\left(\frac{100 - MC_{harvest}}{100 - 15}\right)$$

Now the mass flow and logging interval

- Mass flow rate = 15.1 lb/sec
- Logging interval = 1 sec

$$Yield\left(\frac{bu}{ac}\right) = (43{,}560)\left(\frac{15.1 * 1}{d * w * 56}\right)\left(\frac{100 - MC_{harvest}}{100 - 15}\right)$$

Estimating our Crop Yield-Example

We can input our moisture content while harvesting:

- $MC_{harvest}$ = 19.3 %

$$Yield\left(\frac{bu}{ac}\right) = (43{,}560)\left(\frac{15.1 * 1}{d * w * 56}\right)\left(\frac{100 - 19.3}{100 - 15}\right)$$

Finally, we can input our travel distance and header cut width…can't we? What about the units?

- Travel distance = 54 inches = 4.5 feet
- Header cut width = 240 inches = 20 feet

$$Yield\left(\frac{bu}{ac}\right) = (43{,}560)\left(\frac{15.1 * 1}{4.5 * 20 * 56}\right)\left(\frac{100 - 19.3}{100 - 15}\right)$$

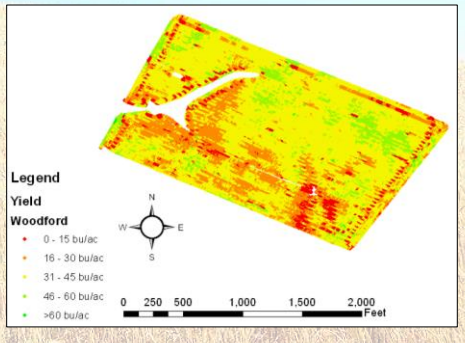
Now we're ready! **= 123 bu/ac**

Creating the Yield Map

We really only need 3 pieces of information:

- Latitude
- Longitude
- Yield

But, we have to have software (GIS) like SMS



Summary

- Yield monitor components and their functions
- Importance of yield monitor calibration
- Estimating yield from the yield monitor output

- Moving forward…