Farming and Technology: A Dairyman's Perspective

Jeffrey Bewley, Amanda Sterrett, Randi Black, Barbara Wadsworth, Di Liang, Karmella Dolecheck, Matthew Borchers, Lauren Mayo, Nicky Tsai, Maegan Weatherly, Melissa Cornett, Samantha Smith, Megan Hardy, and Jenna Klefot

Technological Marvels

- Tremendous technological progress in dairy farming (i.e. genetics, nutrition, reproduction, disease control, cow comfort)
- Modern dairy farms have been described as "technological marvels" (Philpot, 2003)
- The next "technological marvel" in the dairy industry may be in Precision Dairy Farming

1. Changing Dairy Landscape

- Fewer, larger dairy operations
- Narrow profit margins
- Increased feed and labor costs
- Cows are managed by fewer skilled workers

2. Consumer Focus

- Continuous quality assurance
- “Natural” or “organic” foods
- Greenhouse gas reductions
- Zoonotic disease transmission
- Reducing the use of medical treatments
- Increased emphasis on animal well-being

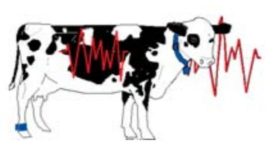
3. Information Era

- Unlimited on-farm data storage
- Faster computers allow for more sophisticated on-farm data mining
- Technologies adopted in larger industries have applications in smaller industries

4. Cow Challenges

1. Finding cows in heat
2. Finding and treating lame cows
3. Finding and treating cows with mastitis
4. Catching sick cows in early lactation
5. Understanding nutritional status of cows
   a. Feed intake
   b. Body condition (fat or thin)
   c. Rumen health (pH/rumination time)

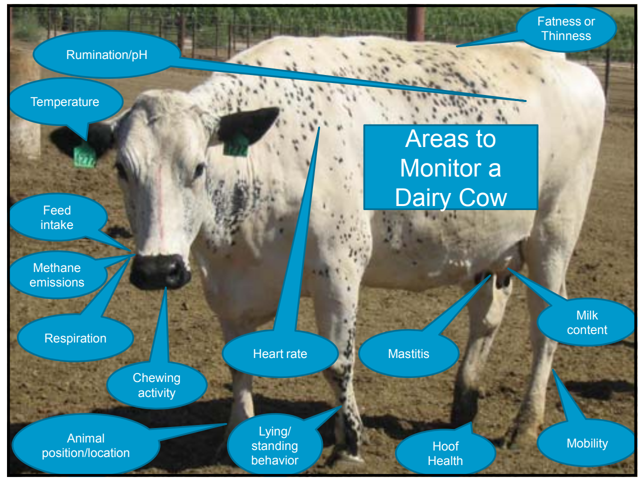
Precision Dairy Management



The use of automated, mechanized technologies toward refinement of dairy management processes, procedures, or information collection

Precision Dairy Monitoring

- Using technologies to measure physiological, behavioral, and production indicators
- Focus on preventive health and performance at the cow level
- Make more timely and informed decisions



Precision Dairy Farming Benefits

- Improved animal health and well-being
- Increased efficiency
- Reduced costs
- Improved product quality
- Minimized adverse environmental impacts
- More objective (less observer bias and influence)

Electrical Conductivity

- Ion concentration of milk changes, increasing electrical conductivity
- Inexpensive and simple equipment
- Wide range of sensitivity and specificity reported
- Results improve with quarter level sensors
- Improved results with recent algorithms
- Most useful when combined with other metrics

Brandt et al., 2010; Hogeveen et al., 2011

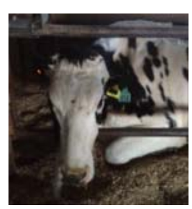
Milk Color

- Color variation (red, blue, and green) sensors in some automatic milking systems
- Reddish color indicates blood (Ordolff, 2003)
- Clinical mastitis may change color patterns for three colors (red, green and blue)
- Specificity may be limited

www.lely.com

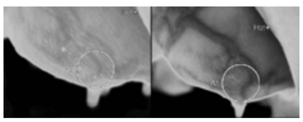
Temperature

- Not all cases of mastitis result in a temperature response
- Best location to collect temperature?
- Noise from other physiological impacts



Thermography

- May be limited because not all cases of mastitis result in a temperature response
- Difficulties in collecting images



Before Infection After Infection

Agricam

Hovinen et al., 2008; Schutz, 2009

Automated CMT or WMT

- CellSense (New Zealand)
- Correlation with Fossomatic SCC 0.76 (Kamphuis et al., 2008)
- Using fuzzy logic, success rates (22 to 32%) and false alerts (1.2 to 2.1 per 1000 milkings), when combined with EC were reasonable (Kamphuis et al., 2008)

Mastiline

- Uses ATP luminescence as an indicator of the number of somatic cells
- Consists of 2 components
- In-line sampling and detection system, designed for easy connection to the milk hose below the milking claw
- Cassette containing the reagents for measuring cell counts

Spectroscopy

- Visible, near-infrared, mid-infrared, or radio frequency
- Indirect identification through changes in milk composition
- AfiLab uses near infrared
  - Fat, protein, lactose, SCC, and MUN
- May be more useful for detecting high SCC cows than quantifying actual SCC

DeLaval Herd Navigator™

Milk measurements

- Progesterone
  - Heat detection
  - Pregnancy detection
- LDH enzyme
  - Early mastitis detection
- BHBA
  - Indicator of subclinical ketosis
- Urea
  - Protein status

Estrus Detection

- Efforts in the US have increased dramatically in the last 2 years
- Producer experiences are positive
- Changing the way we breed cows
- Only catches cows in heat
- Real economic impact


SCR HR Tag/AI24


GEA Rescounter II

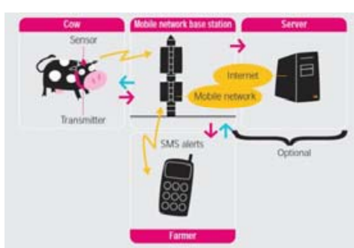

DairyMaster MooMonitor/ SelectDetect


AFI Pedometer +


BouMatic HeatSeeker II


Track a Cow

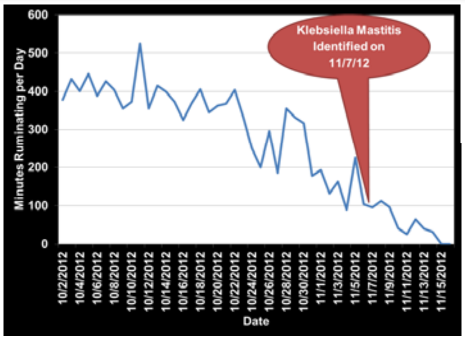
ANEMON animal estrus monitoring



SCR HR Tag

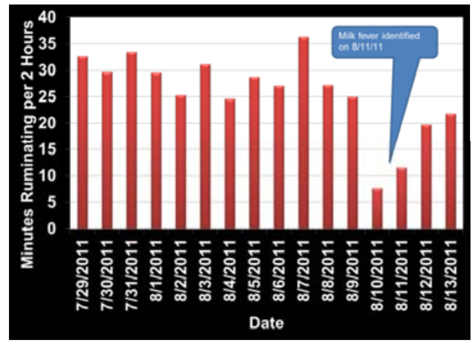
- **Measures rumination time**
- **Time between cud boluses**
- **Monitor metabolic status**

SCR Rumination Time



Amanda Sterrett et al.

SCR HR Tag for Milk Fever Detection



Amanda Sterrett et al. , Unpublished Data

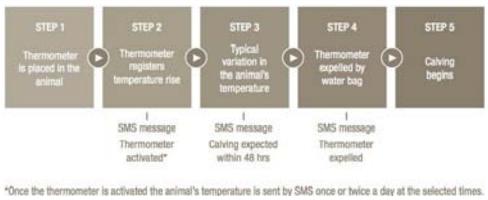
Lying Behavior Monitors

- On-farm evaluation of lying time:
  - Identification of cows requiring attention (lameness, illness, estrus)
  - Assessment of facility functionality/cow comfort
  - Potential metric to assess animal well-being

Rumen pH

- Illness
- Feeding/drinking behavior
- Acidosis

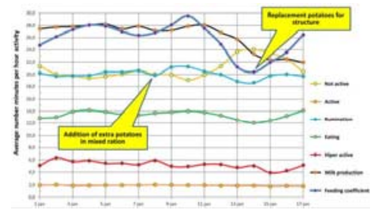
Vel'Phone Calving Detection



Medria ELEVAGE Monitoring solutions

CowManager Sensoor

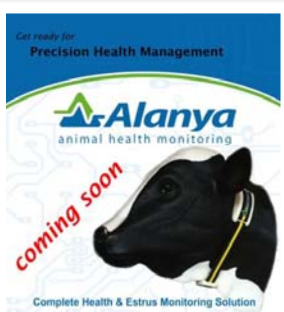
- Temperature
- Activity
- Rumination
- Feeding Time



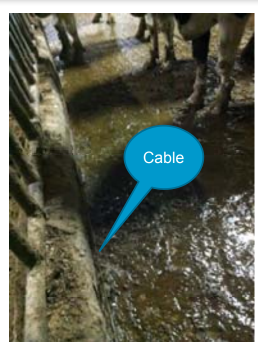
CowManager

Alanya Animal Health

- Behavioral changes
- Temperature
- Lying/Standing Time
- Grazing Time
- Lameness
- Estrus Detection (multiple metrics)
- Locomotion Scoring

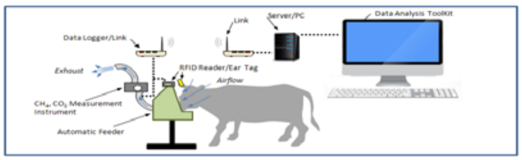


ENGS Track a Cow: Feeding Time



C-LOCK INC.

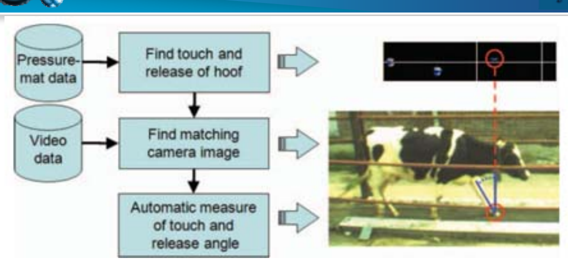
- Greenfeed measures methane (CH_4)
- Select for cows that are more environmentally friendly
- Monitor impacts of farm changes (rations) on greenhouse gas emissions



StepMetrix

- Lameness detection
- BouMatic

Belgian Lameness System



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http://dx.doi.org/10.3168/jds.2011-4547
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Automatic measurement of touch and release angles of the fetlock joint for lameness detection in dairy cattle using vision techniques

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Real Time Location Systems

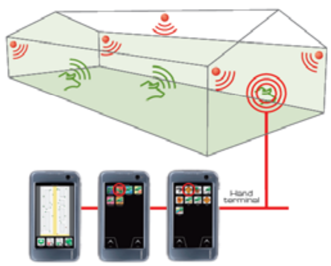
- Using Real Time Location System (RTLS) to track location of cows (similar to GPS)
- Better understand distribution of animals within barns
- Information used to design better barns and modify existing barns

- Behavior monitoring-implications for estrus detection, time at feedbunk, social interactions

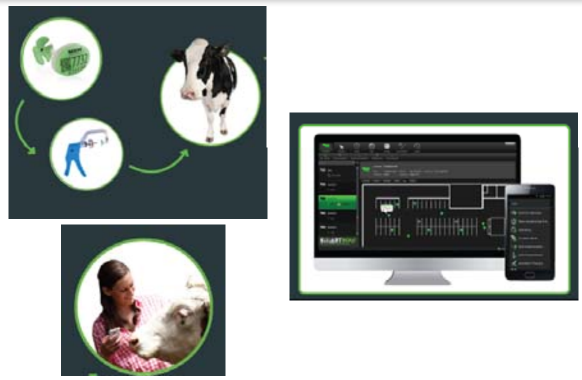
Randi Black et al.

GEA CowView

- Feeding time
- Waiting time
- Resting time
- Mounting
- Distance Covered



SmartBow



UK Coldstream Dairy Monitoring Capabilities

Technology	Parameter(s) Measured
SmartBow	Position, Movement
VelPhone	Calving Time, Vaginal Temperature
Alanya	Temperature, Lying Time, Activity, Locomotion, Behavior
AfiLab	Fat, Protein, Lactose
Pedometer Plus	Lying Time, Steps
HR Tag	Rumination Time, Neck Activity
Track-a-Cow	Lying Time, Time at Feedbunk
Mastiline	Somatic Cell Count
CowManager Sensoor	Rumination Time, Feeding Time, Ear Skin Temperature, Activity
IceQube	Lying Time, Steps, Locomotion
Anemon	Vaginal Temperature, Estrus
TempTrack	Reticulorumen Temperature
FeverTag	Tympanic Temperature
AccuBreed	Mounting Activity
CowScout	Leg Activity

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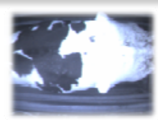
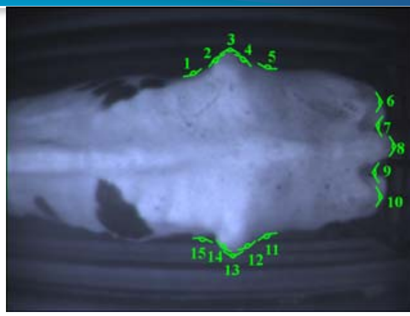
Automated Body Condition Scoring



- **Reduced labor requirements**
- **Less stressful on animal**
- **More objective, consistent measure**
- **Increased observation frequency**
- **Early identification of sick animals**
- **Tracking BCS trends of individual animals and management cohorts**

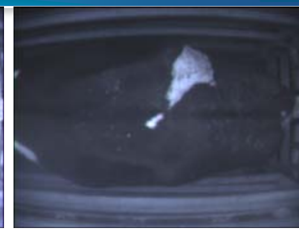
Body Condition Scoring



- 100% of predicted BCS were within 0.50 points of actual BCS.
  - 93% were within 0.25 points of actual BCS.

Bewley et al., 2008

Body Condition Scoring

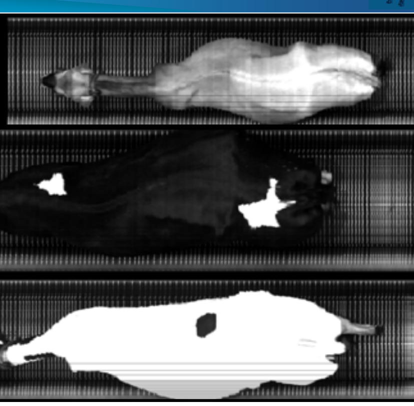


BCS	2.50
Predicted BCS	2.63
Posterior Hook Angle	150.0°
Hook Angle	116.6°

BCS	3.50
Predicted BCS	3.32
Posterior Hook Angle	172.1°
Hook Angle	153.5°

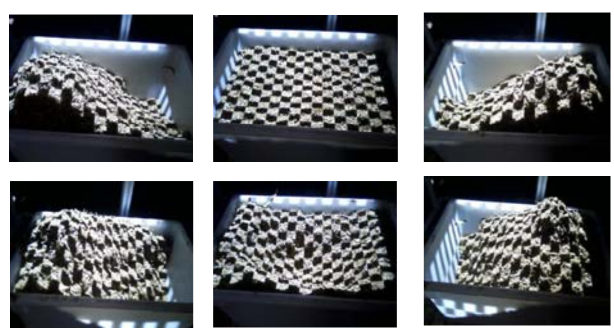
Bewley et al., 2008

Now, Automation



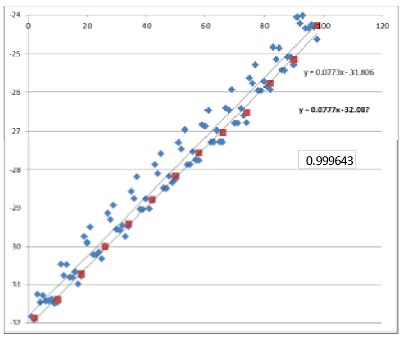
Lau, Shelley, Sterrett, and Bewley, 2013

Feed Intake: 3D Imaging



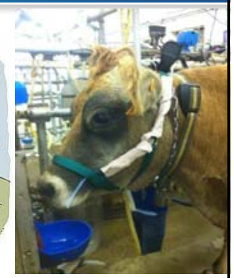
Lau, Shelley, Sterrett, and Bewley, 2013

Early Test Results



Lau, Shelley, Sterrett, and Bewley, 2013

Cow Sleep Monitoring

- Sleep Quality = Improved Immunity?
- New Way to Measure Cow Comfort?

Donohue, Llhamon, O'Hara, Klefot, and Bewley, 2013

What Are the Limitations of Precision Dairy Farming?

PDF Reality Check

- **Maybe not be #1 priority for commercial dairy producers (yet)**
- **Many technologies are in infancy stage**
- **Not all technologies are good investments**
- **Economics must be examined**
- **People factors must be considered**

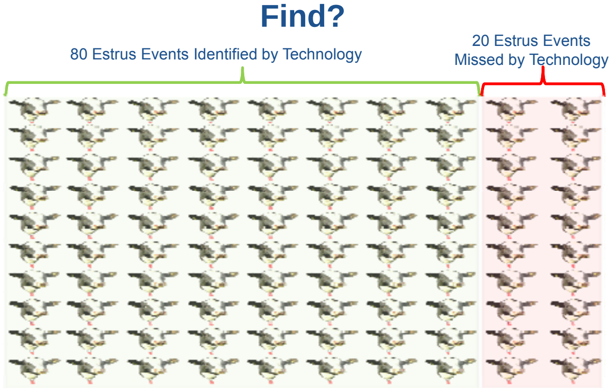
Ideal Technology

- Explains an underlying biological process
- Can be translated to a meaningful action
- Cost-effective
- Flexible, robust, reliable
- Simple and solution focused
- Information readily available to farmer
- Commercial demonstrations

Data Handling

- Industry needs to establish guidelines for farmers to follow
- What questions should they be asking?
- What to do with information provided?

How Many Cows With Condition Do We Find?



Example: 100 estrus events

How Many Alerts Coincide with an Actual Event?

Example: 100 estrus events

Sensitivity/Specificity Battle

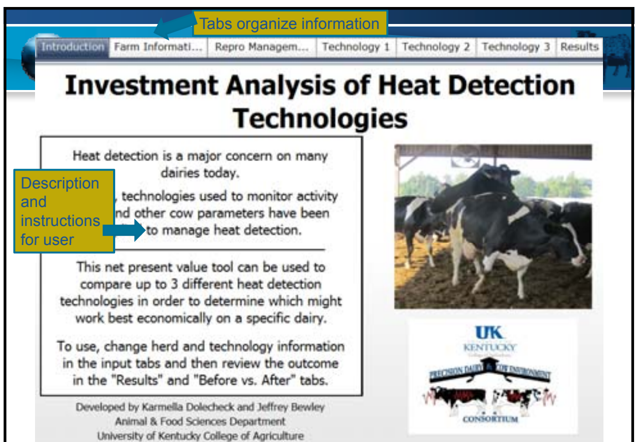
- ↑ Sensitivity by lowering threshold, BUT…
  - ↓ Specificity (more false positives)
- ↑ Specificity by raising threshold, BUT…
  - ↓ Sensitivity (more missed events)
- Trade off between the two

What's the Sweet Spot?

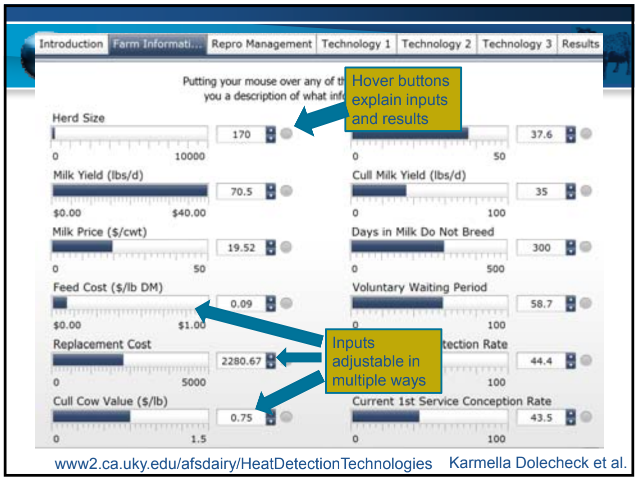
- Cost of missed event
  - High for estrus
  - Lower for diseases?
- Cost of false positive
  - Low for estrus
  - High for mastitis
- Farm dependent

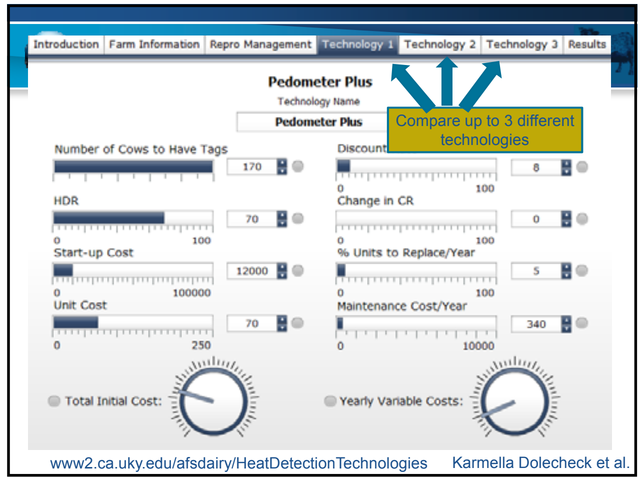
Economic Considerations

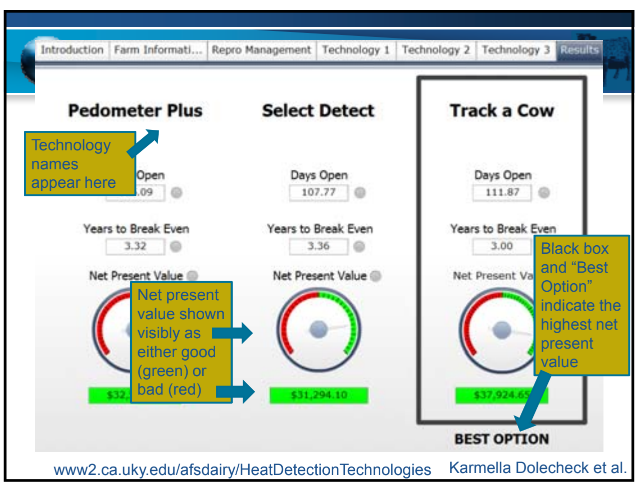
- Need to do investment analysis
- Not one size fits all
- Economic benefits observed quickest for heat detection/reproduction
- If you don't do anything with the information, it was useless
- Systems that measure multiple parameters make most sense
- Systems with low fixed costs work best for small farms

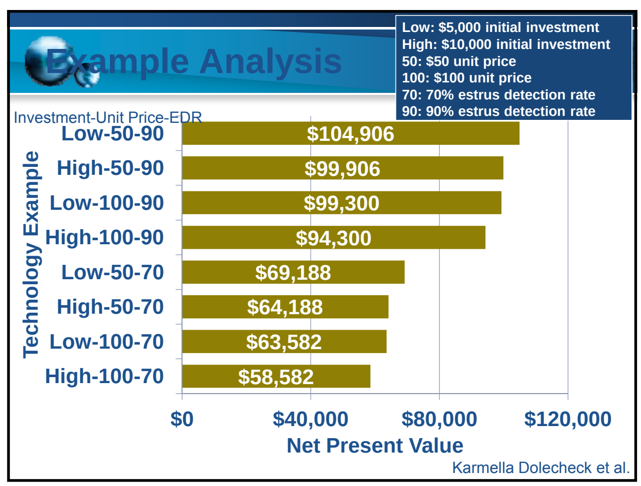


www2.ca.uky.edu/afsdairy/HeatDetectionTechnologies Karmella Dolecheck et al.


Introduction
Farm Informati...
Repro Management
Technology 1
Technology 2
Technology 3
Results
Hover buttons explain inputs and results
Herd Size
Milk Yield (lbs/d)
Milk Price ($/cwt)
Feed Cost ($/lb DM)
Replacement Cost
Cull Cow Value ($/lb)
Cull Milk Yield (lbs/d)
Days in Milk Do Not Breed
Voluntary Waiting Period
Current 1st Service Conception Rate
Inputs adjustable in multiple ways
www2.ca.uky.edu/afsdairy/HeatDetectionTechnologies
Karmella Dolecheck et al.


Introduction
Farm Information
Repro Management
Technology 1
Technology 2
Technology 3
Results
Pedometer Plus
Technology Name
Compare up to 3 different technologies
Number of Cows to Have Tags
HDR
Start-up Cost
Unit Cost
Change in CR
% Units to Replace/Year
Maintenance Cost/Year
Total Initial Cost:
Yearly Variable Costs:
www2.ca.uky.edu/afsdairy/HeatDetectionTechnologies
Karmella Dolecheck et al.


Introduction
Farm Informati...
Repro Management
Technology 1
Technology 2
Technology 3
Results
Pedometer Plus
Select Detect
Track a Cow
Technology names appear here
Days Open
Years to Break Even
Net Present Value
Net present value shown visibly as either good (green) or bad (red)
Black box and "Best Option" indicate the highest net present value
BEST OPTION
www2.ca.uky.edu/afsdairy/HeatDetectionTechnologies
Karmella Dolecheck et al.


Example Analysis
Low: $5,000 initial investment
High: $10,000 initial investment
50: $50 unit price
100: $100 unit price
70: 70% estrus detection rate
90: 90% estrus detection rate
Investment-Unit Price-EDR
Technology Example
Low-50-90
High-50-90
Low-100-90
High-100-90
Low-50-70
High-50-70
Low-100-70
High-100-70
$104,906
$99,906
$99,300
$94,300
$69,188
$64,188
$63,582
$58,582
$0
$40,000
$80,000
$120,000
Net Present Value
Karmella Dolecheck et al.

Technology Pitfalls

- “Plug and play,” “Plug and pray,” or “Plug and pay”
- Technologies go to market too quickly
- Not fully-developed
- Software not user-friendly
- Developed independently without consideration of integration with other technologies and farmer work patterns

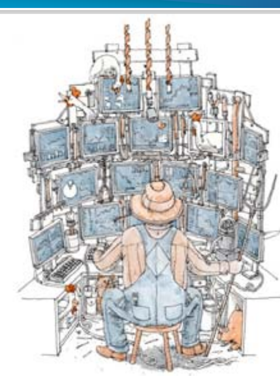
Technology Pitfalls

- Too many single measurement systems
- Lack of large-scale commercial field trials and demonstrations
- Technology marketed without adequate interpretation of biological significance of data
- Information provided with no clear action plan

Lessons Learned

- Be prepared for little things to go wrong
- Be careful with early stage technologies
- Need a few months to learn how to use data
- Data integration is challenging

UK Herdsman Office

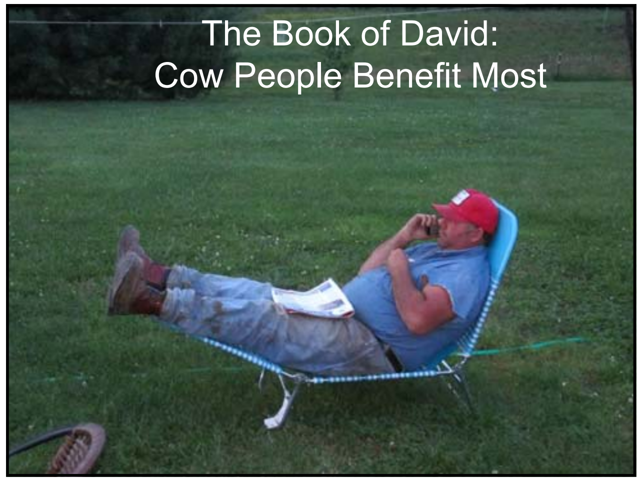


From Purdue to Poor Due

PURDUE UNIVERSITY

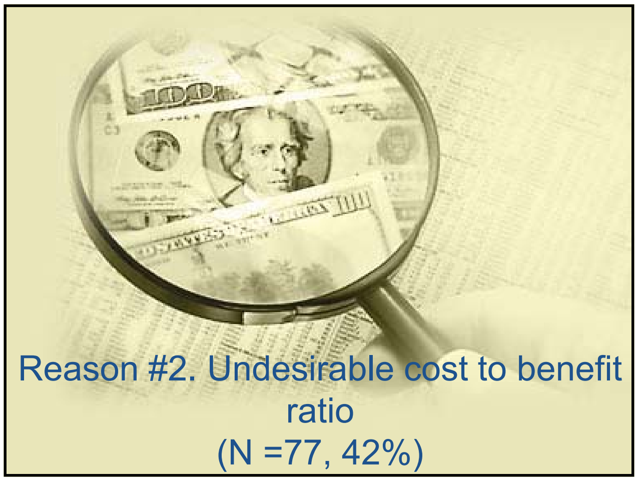
Did I get the wrong PhD?

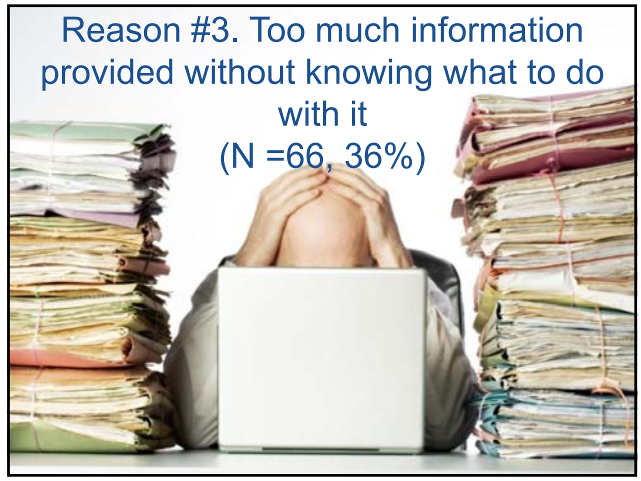
The Book of David: Cow People Benefit Most



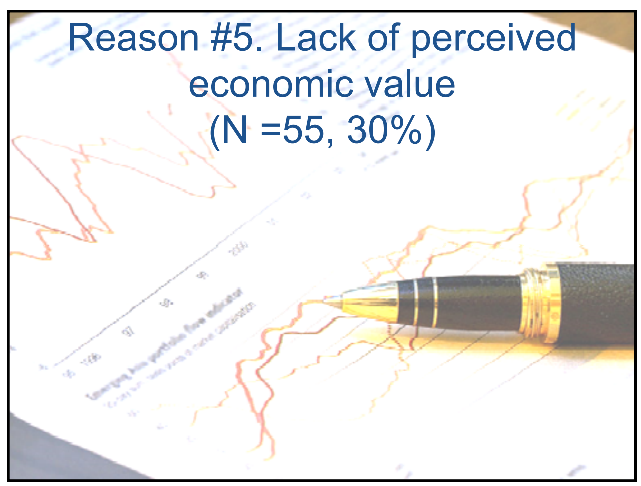
Why Have Adoption Rates Been Slow?

Rebecca Russell


Reason #2. Undesirable cost to benefit ratio
(N =77, 42%)


Reason #3. Too much information provided without knowing what to do with it
(N =66, 36%)


Reason #4. Not enough time to spend on technology
(N =56, 30%)

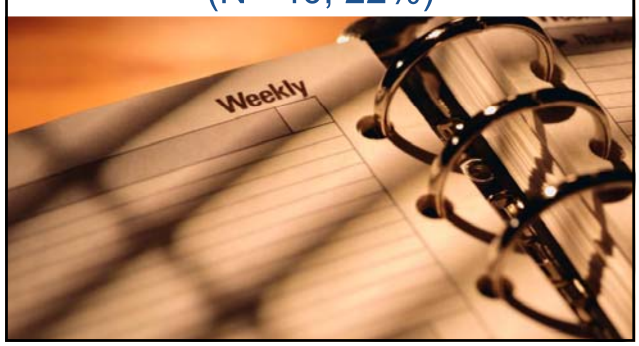

Reason #5. Lack of perceived economic value
(N =55, 30%)

Reason #6. Too Difficult or Complex to Use
(N =53, 29%)

Reason #7. Poor technical support/training
(N =52, 28%)

Reason #8. Better alternatives/easier to accomplish manually
(N =43, 23%)

Reason #9. Failure in fitting with farmer patterns of work
(N =40, 22%)



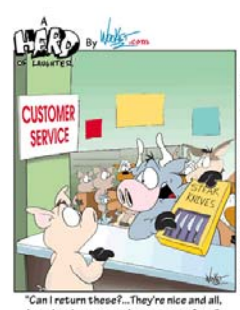
Reason #10. Fear of technology/computer illiteracy (N =39, 21%)

Reason #11. Not reliable or flexible enough (N =33, 18%)

Reason #99. Wrong College Degree (N =289, 100%)

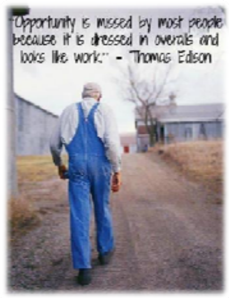
Customer Service is Key

- More important than the gadget
- Computer literacy
- Not engineers
- Time limits
- Failure of hardware and software



Cautious Optimism

- Critics say it is too technical or challenging
- We are just beginning
- Precision Dairy won't change cows or people
- Will change how they work together
- Improve farmer and cow well-being



Path to Success

- Continue this rapid innovation
- Maintain realistic expectations
- Respond to farmer questions and feedback
- Never lose sight of the cow
- Educate, communicate, and collaborate

Future Vision

- New era in dairy management
- Exciting technologies
- New ways of monitoring and improving animal health, well-being, and reproduction
- Analytics as competitive advantage
- Economics and human factors are key

Questions?

UK UNIVERSITY OF KENTUCKY College of Agriculture
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