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UNIVERSITY OF MINNESOTA

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College of Veterinary Medicine

VETERINARY CONTINUING EDUCATION



ST. PAUL, MINNESOTA  
UNITED STATES OF MINNESOTA


## **Economics of Reproduction**

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Presentation notes follow -

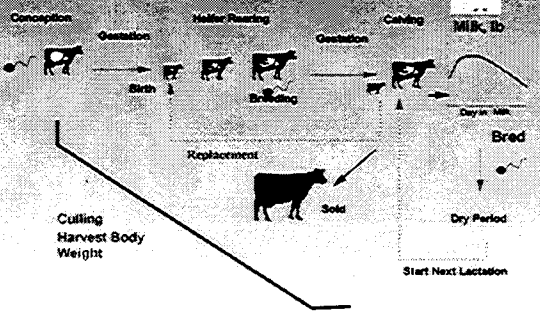
## Economic Impact of Reproduction: Womb to the Tomb

David T. Galligan  
James D. Ferguson



University of Pennsylvania,  
School of Veterinary Medicine

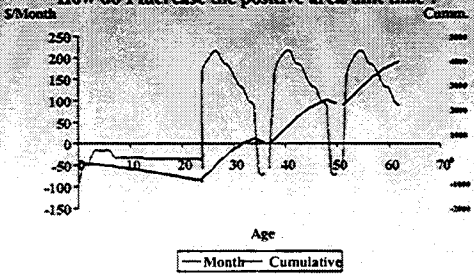
## Biological Life Cycle of a Cow



Basic unit of measure is "averages"

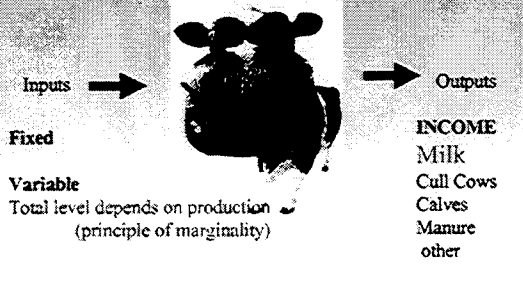
## Cash Flows of a Cow's Life Month and Cumulative

How do I increase the positive area/unit time?

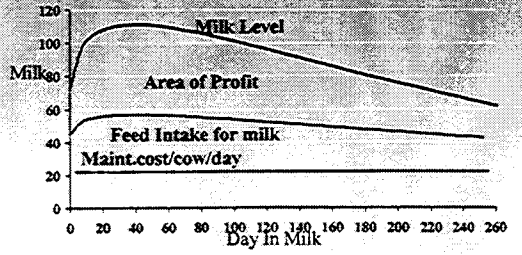


Basic units of measures are "marginal values"

## Production Process

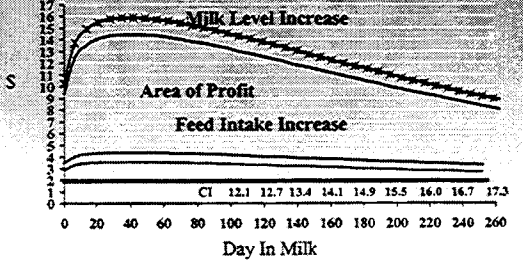


## Lactation Curve Control Cost or increase Milk Level



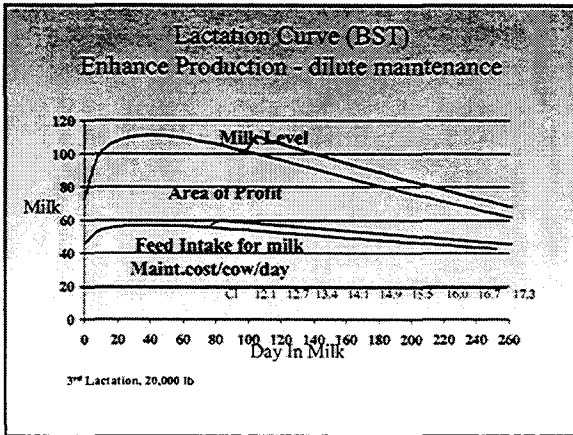
3<sup>rd</sup> Lactation, 20,000 lb

## Lactation Curve Economic Values



CI	12.1	12.7	13.4	14.1	14.9	15.5	16.0	16.7	17.3
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3<sup>rd</sup> Lactation, 20,000 lb  
Marginal Cost (\$0.03/lb) < Marginal Return \$0.13/lb



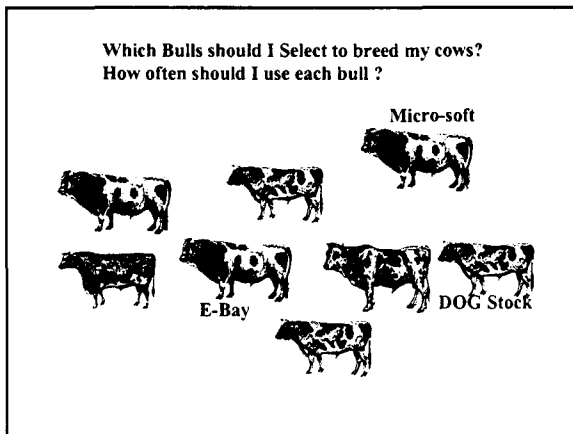
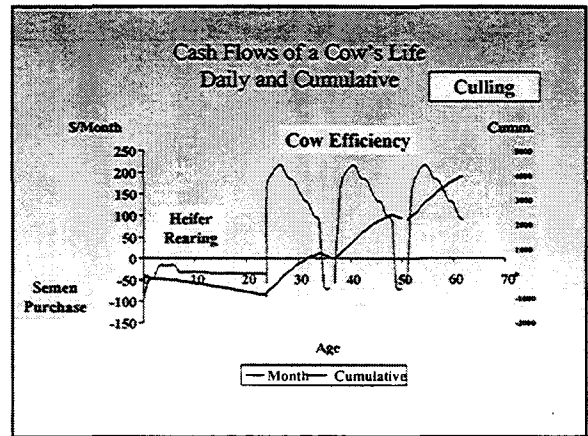
### Basic Concepts

- Can ignore "Fixed Cost" when making a marginal decisions - Tactical Decisions
- 1 more kg milk - ignore maintenance cost of the cow and dairy
- 1 more cow to herd - ignore maintenance cost of the dairy operation

Where maintenance cost is any cost that will be paid Irrespective of the decision!

### General Economic Concepts for Reproduction

- Reproduction works by dilution of maintenance cost (marginal milk, calves)
- It is a "Lost Opportunity Cost" to the producer
- He never gets a "bill" for poor reproductive efficiency - losses are hidden
- BUT the TREATMENT HAS A "VISIBLE" BILL



### Financial Return from Sires

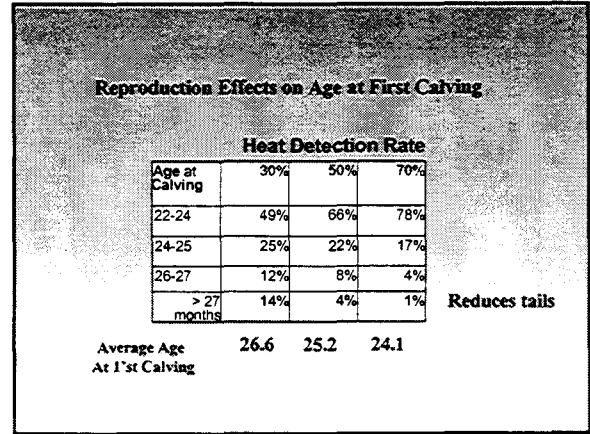
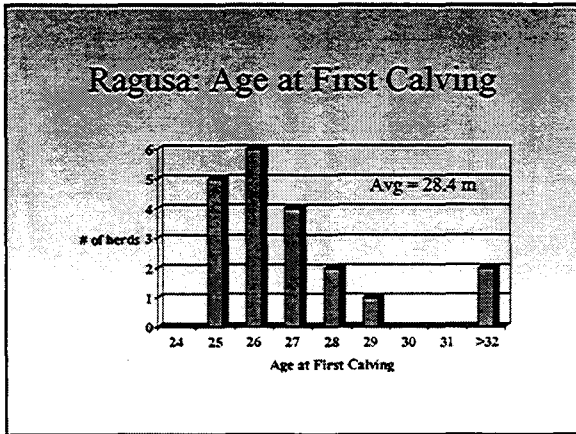
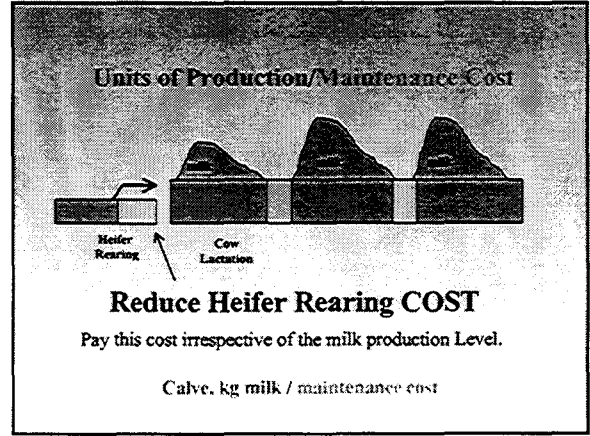
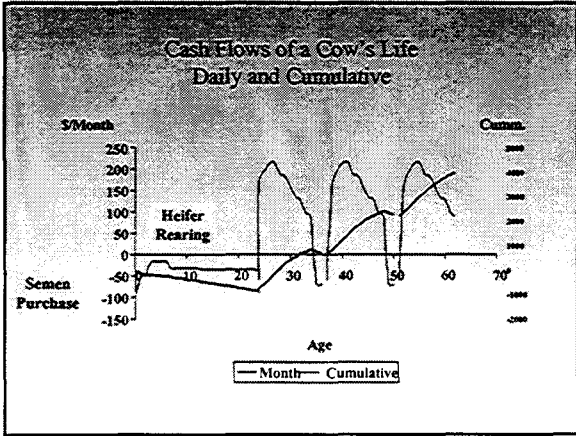
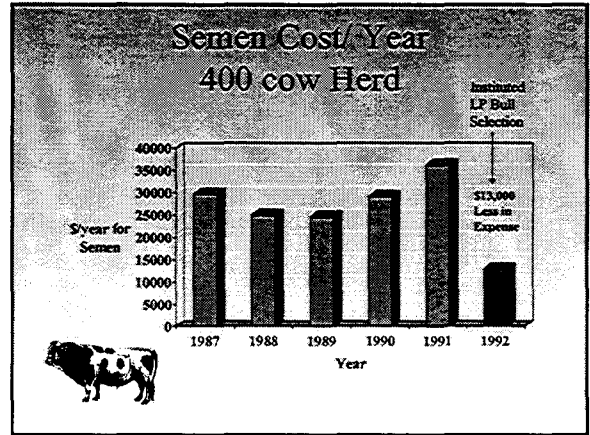
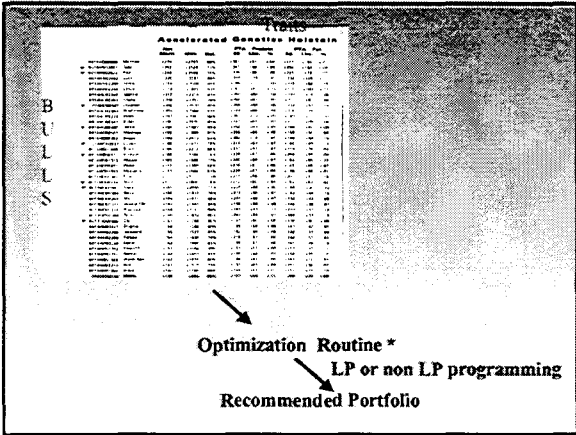
Profit = Returns due to improved milk yield - Cost

Definitely Paid

	Cumulative
Conception Failure	50%
Heifer calf	50% 25%
Cow aborts	95% 24%
Survival to Calving	90% 21%

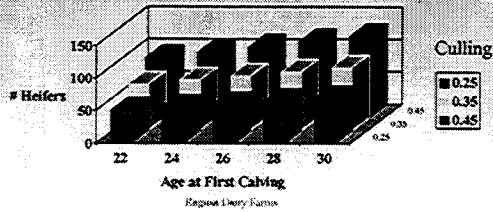
Every 5 straws produces a female replacement animal.

5 X average semen cost = semen cost/milking heifer



## Where is your Herd ?

Heifer Herd Size to Maintain 100 Cow Herd

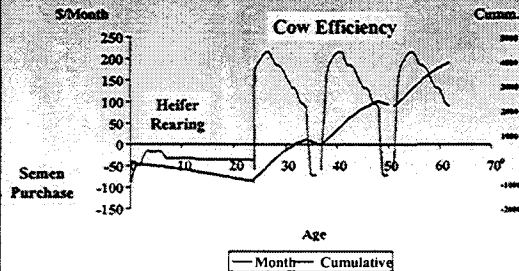


$2 \times \text{culling Rate} \times \text{herd} \times \text{Age at First/24} \times (1 + \text{mortality})$   
All these herds make the same amount of milk

## Control Heifer Maintenance Cost

- Grow them quickly to 340 kg at about 14 to 15 months
- Get them bred quickly at 14 months
- Calve at 570 kg (after calving)
- Cost of a Day Open on Heifers is much greater than Cost of Day Open in cows
- High heifer rearing cost inflate the cost of all diseases that result in culling

## Cash Flows of a Cow's Life Daily and Cumulative



## Outline of Cow Efficiency

- Traditional vs. New Focus
- Goal of reproductive programs
- How to Measure Reproduction

## Traditional Focus of Reproductive Programs

- **Traditional** - Find problem cows, "fix" them so that they conceive earlier than if they were ignored
- Had to process all cows to find "problem" cows
- Diagnosis (sensitivity/specificity) poor
- Treatments - (uterine infusions) - questionable efficacy
- **MOST IMPORTANTLY** - these programs ignored how fast healthy cows conceived.

## New Focus of Reproductive Programs

- **New Focus** - Use a systematic breeding program that ensures all cows the opportunity to get pregnant fast.
- Provide a "net" that if a cow is reproductively healthy, she has a high probability of conceiving.

## Biological Goal of Reproduction

- Getting cows pregnant

## Economic Goal of Reproductive Programs

Getting cows pregnant at a rate that captures maximum net economic benefits.

(Pregnancy Rate measures the speed at which cows become pregnant on a given reproductive program.)

## Reproductive Cost

- Direct (cost of semen, cull cow value)
- Opportunity (time dimensional)

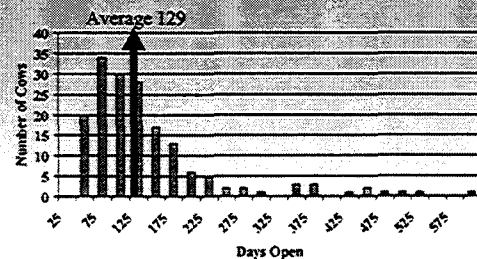
## How to Measure Reproduction

- What are we trying to measure
- Problems with “incomplete” information
  - animals have not yet been bred or conceived
  - culled animals

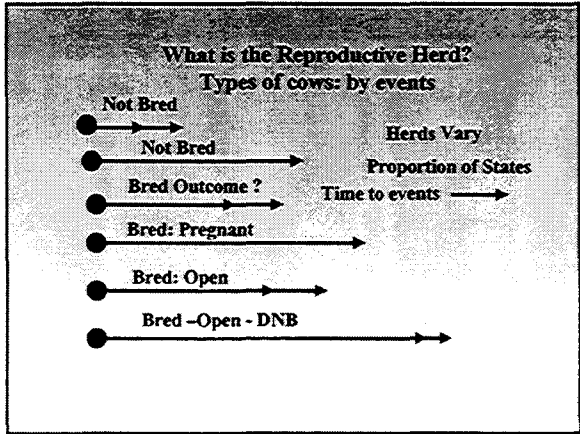
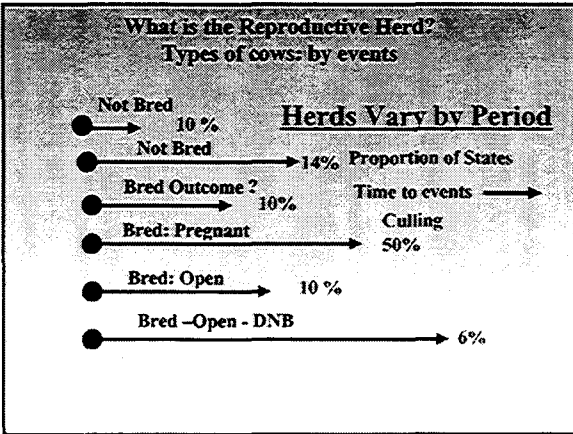
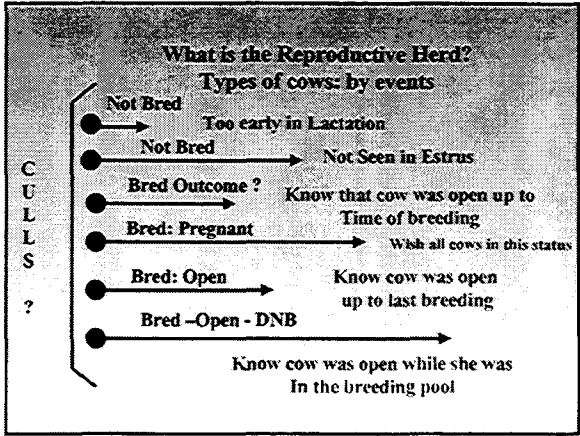
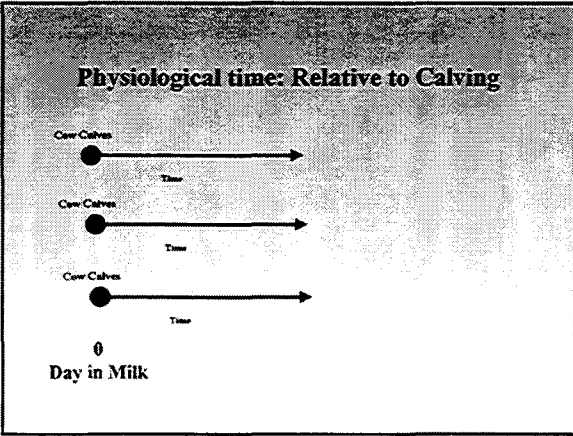
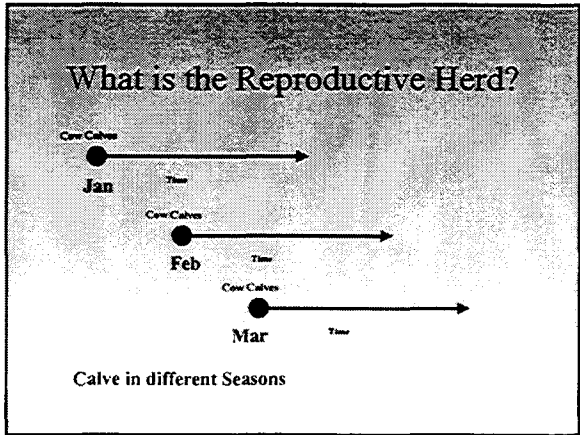
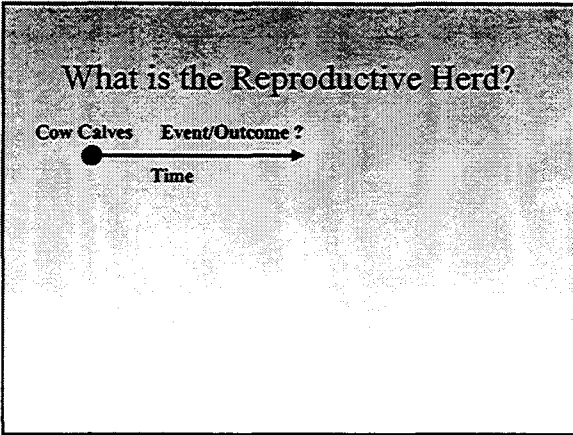
## Two Dimensions to Reproductive Measures

- Events (pregnancy, bred)
- Time to Events (days to pregnancy, days to first breeding)
- Need to integrate both into a measure system.
- Traditional measures focused on either events of time (not both)

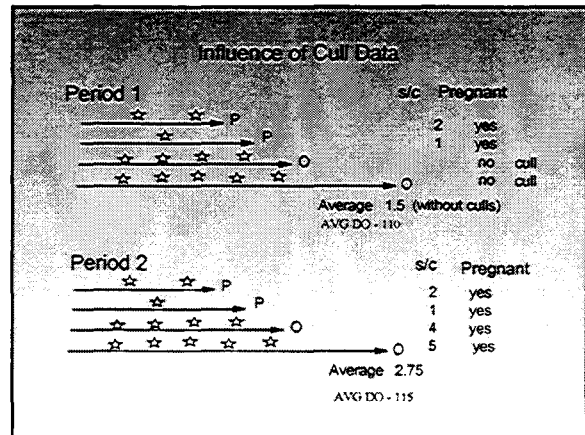
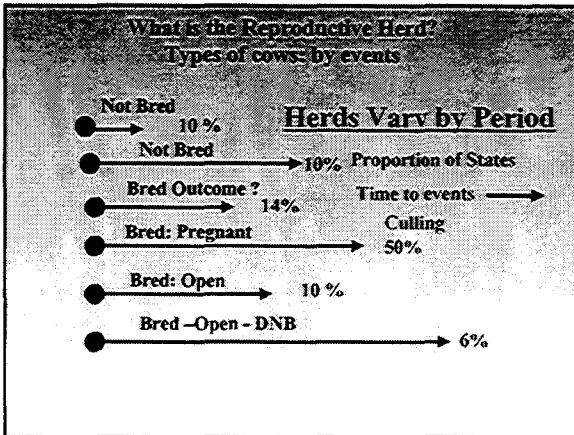
## Days Open Distribution



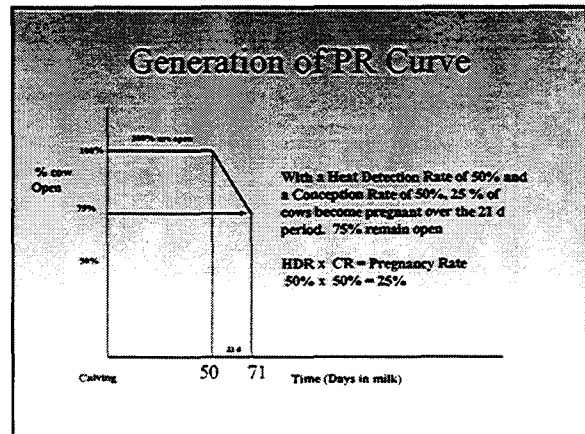
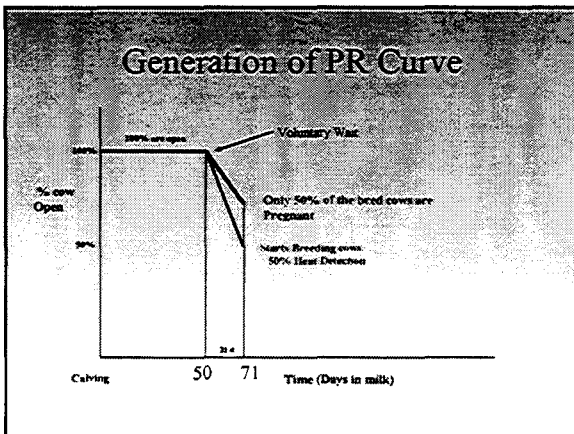
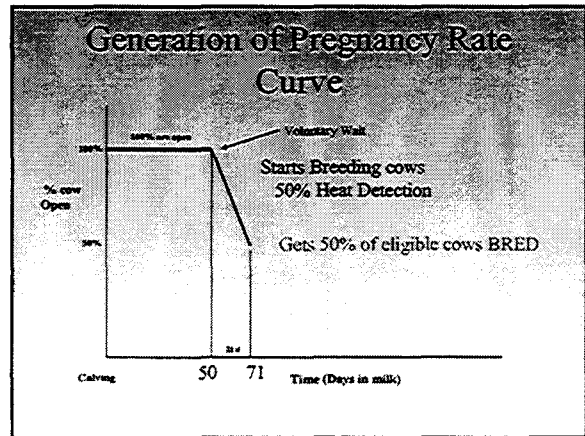


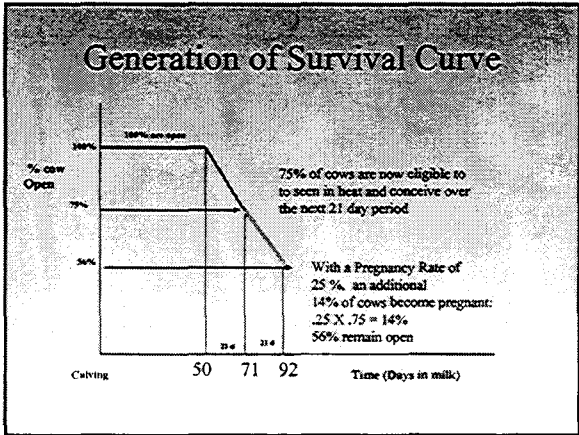






- ### Need a System of Measurement
- Accounts for the time elements
  - Accounts for cows having the event
  - Accounts for cows with incomplete records - culls, cows not seen in heat, cows not pregnant, cows that become DNB, cows bred but not confirmed.
  - System: Time-Event Analysis or Survival Analysis





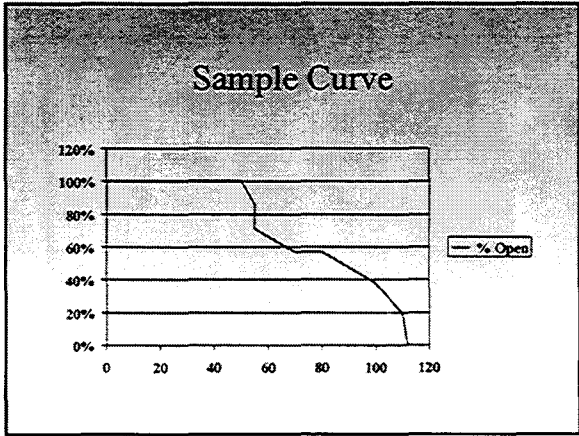
### Sample Calculation

**Kaplan Meier**

DIM	Pregnant	Censored for Preg.	Available Instant Preg Rate	Propor. Open	Cumm. Open
55	1	0	7	14%	86%
55	1	0	6	17%	83%
70	1	0	5	20%	80%
80	0	1	4	0%	100%
100	1	0	3	33%	67%
110	1	0	2	50%	60%
112	1	0	1	100%	0%

Pregnant = cows that conceived  
 Censored = cows open, cows last breeding date status unknown  
 cows up to point of becoming a DNB, cows culled

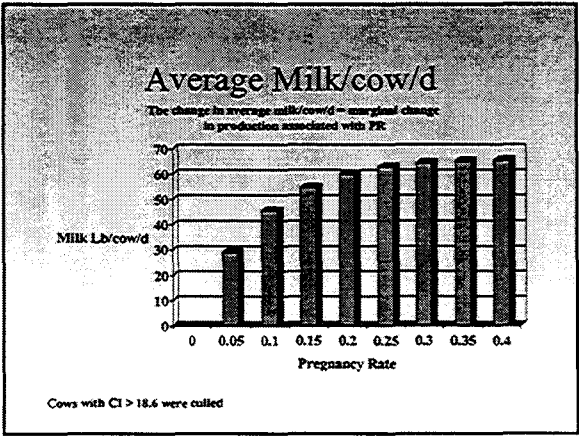
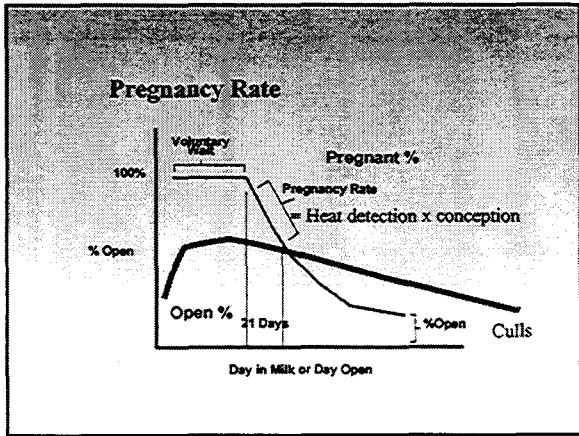
Notice how cow at 80 DIM is in the calculation, up to her point of censoring

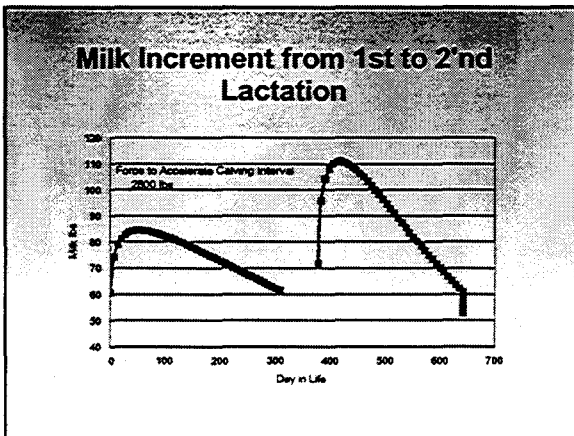
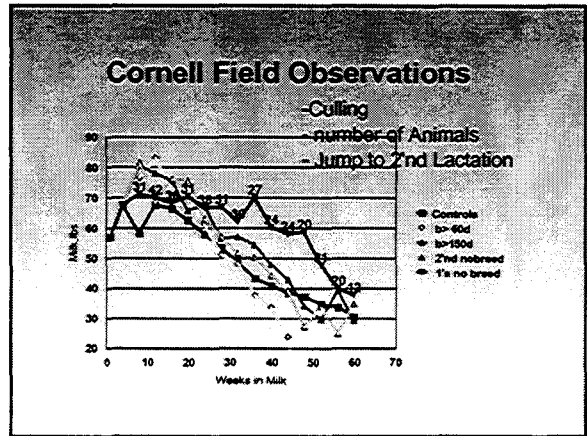
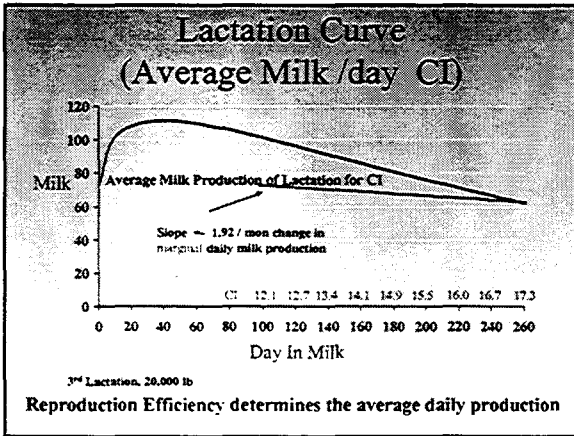
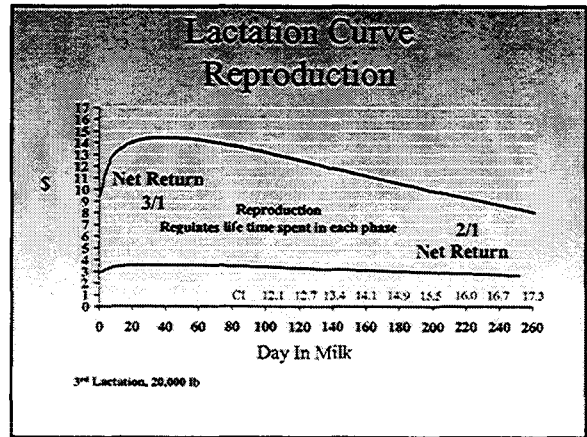
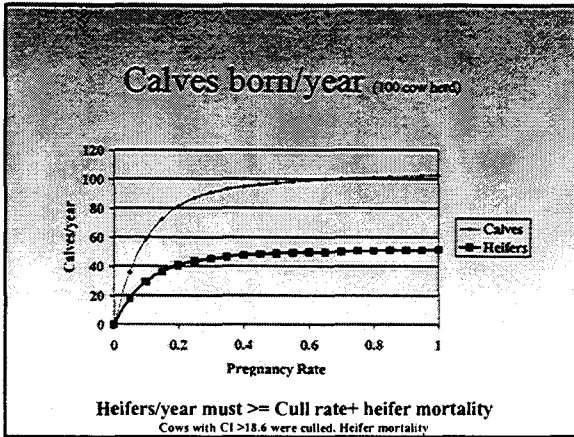


### To Measure Reproductive Efficiency

Pregnancy rate = the SPEED at which cows become pregnant every 21 days  
 = Heat Detection X Conception

It is not the Conception Rate: # cows pregnant/ # inseminated

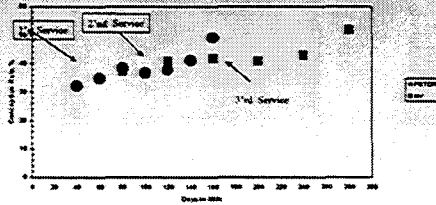




### Issues of Production and Reproduction

- Does Milk Production influence reproduction
- Does day in milk influence reproduction

### Insemination with time postcalving



Ferguson: 6000 records, 34 herds

### CR with time postcalving

- 1.2 to 1.6% increase in CR every 21 days from 40 days postcalving
- This pattern is not as apparent in all herds

### Milk production and fertility in lactating cows

Evidence suggests slightly lower CR with higher milk production around first insemination

At first AI

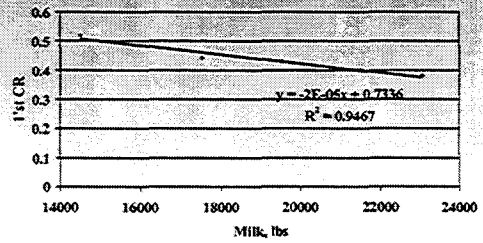
-1.2 to -1.5% CR decrease with 10 lb higher production at first insemination

NY 145,000 records

-1.6 to -1.8 % CR decrease with 10 lb higher production at first insemination

PA 6,000 records

### Production and First Service CR



Nebel and McGilliard, JDS 1993, 76:3257-3268

### Higher milk production and fertility

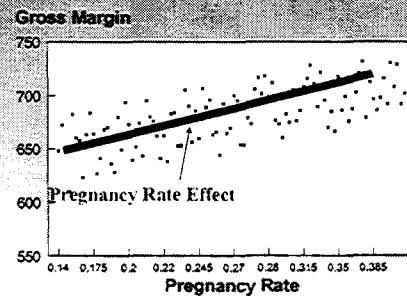
Is selection for higher milk production antagonistic for fertility?

No evidence of this.

CR in heifers today same as 30 years ago

>60%

### Pregnancy Rate

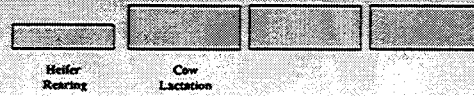


Developed from Marsh et al, 1987

### What is Important

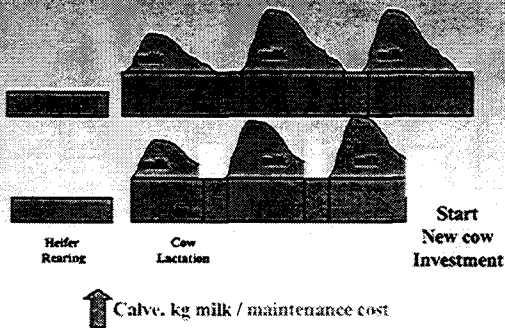
- The proportion of cows that get pregnant at each time interval.
- The "speed" (velocity) at which cows get pregnant
- The Pregnancy Rate = the proportion of cows that get pregnant every 21 days.
- Influences production of marginal milk  
Influences production of marginal calves  
Via - truncation

### Cow Maintenance Cost (Fixed)



The producer pays these cost, irrespective of the milk production level of the herd.

### How Reproduction Works



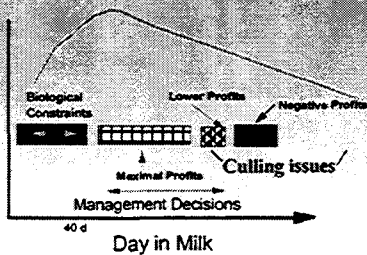
### Economic Mechanics of Production and Reproduction

- Dilution of Maintenance cost over more pounds of product (milk/calves/cull cows)

We are in the business of diluting maintenance Cost!!!

Product/unit maintenance = universal currency

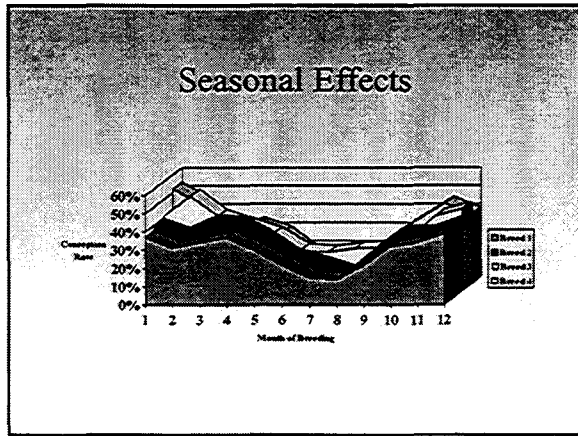
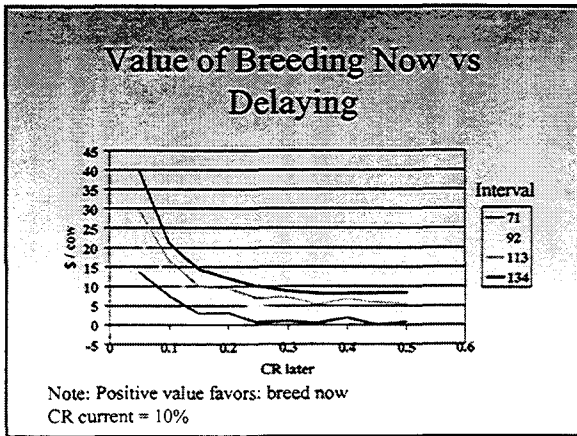
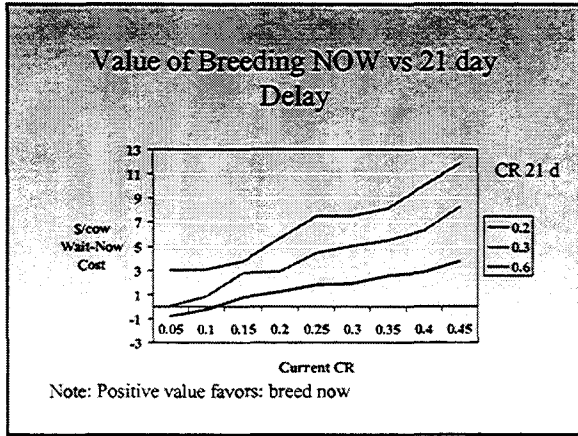
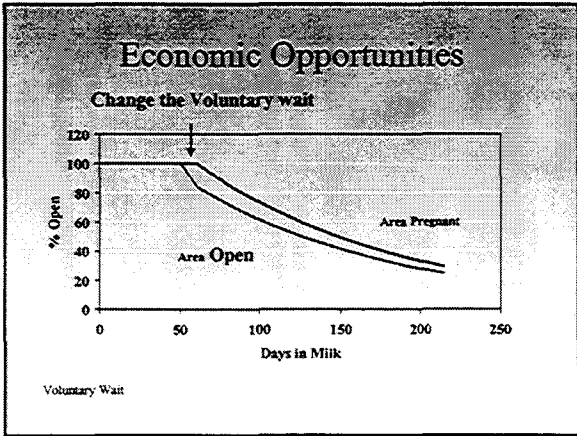
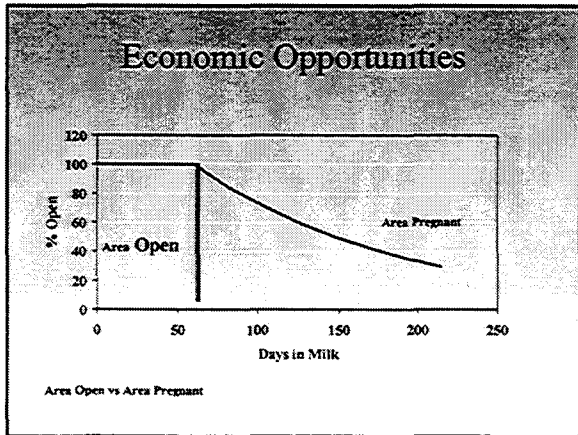
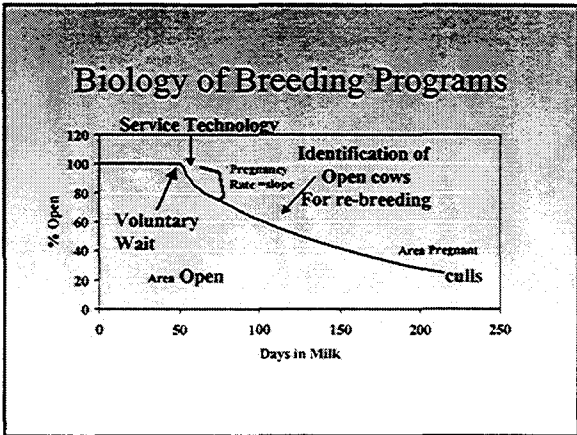
### Biological Constraints on reproduction during Lactation:



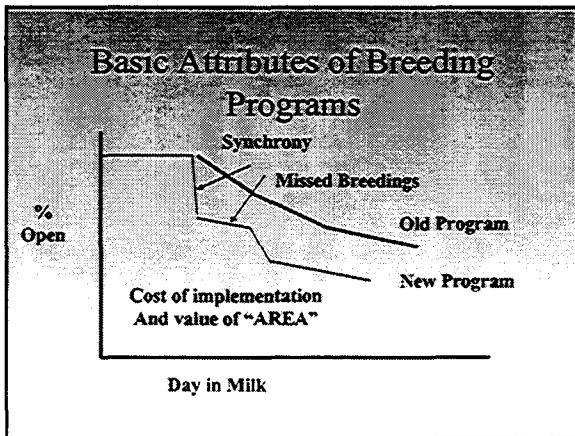
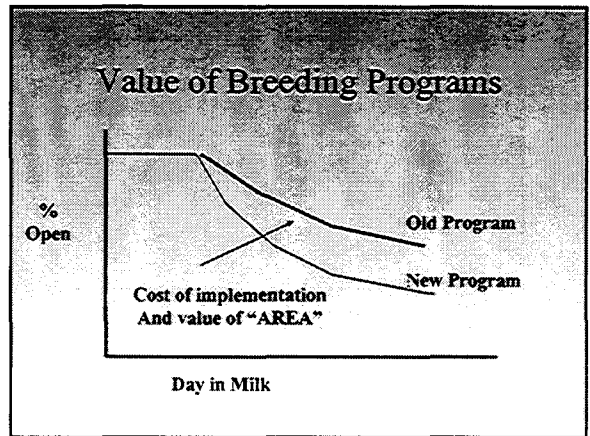
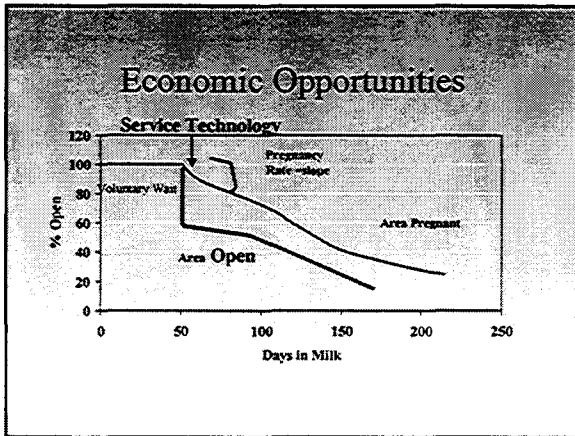
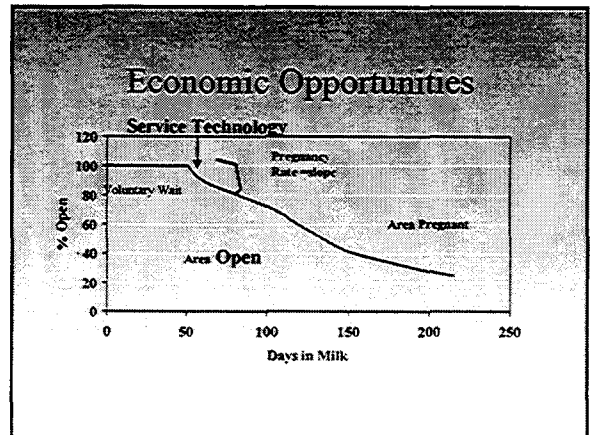
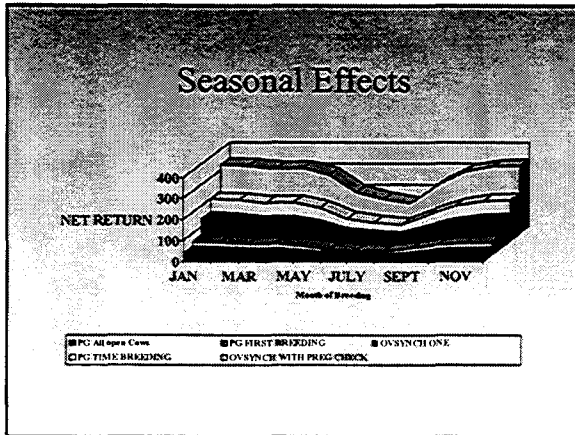
### Decision Points in Reproduction

- Adjusting Voluntary Wait
- Rate of drop (systematic breeding programs)
- Rebreeding (when, how identified)
- Culling (how long to try breeding)





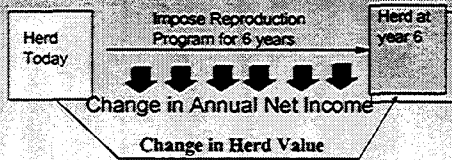




### How to Value the Area Difference

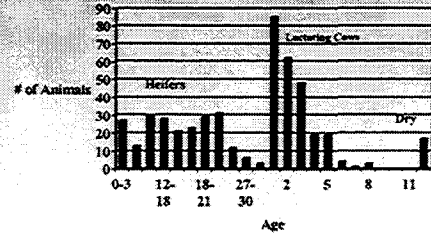
- Used Dairy ORACLE to simulate the economic value of cows conceiving at various days in milk.
- Used the Pregnancy rate curves to determine the proportion of cows conceiving at a given day in milk

Net Present Value of a "flow of cow units" exposed to a reproduction program.

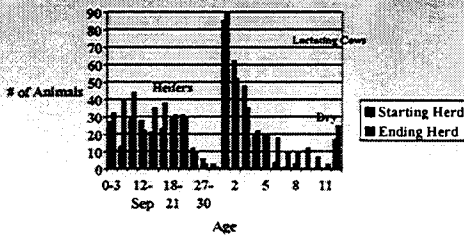


$$\text{Net Present Value} = \text{Time Discounted Annual Net Income} + \text{Ending Value of Herd} - \text{beginning Value of herd}$$

### Starting Herd Inventory

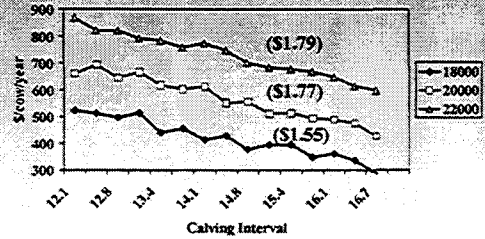


### Starting and Ending Herd Inventory

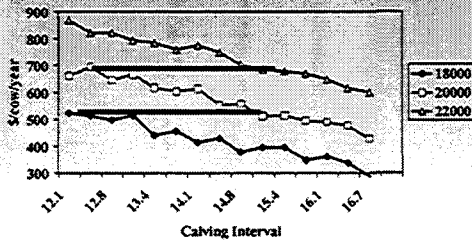


### Annuity value/cow/year

(slope = Value of Days Open)

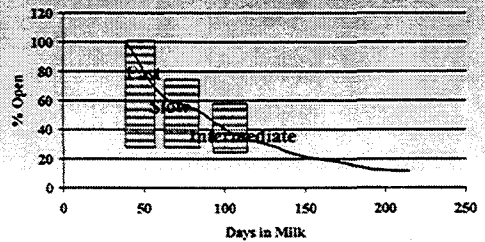


### Annuity value/cow/year

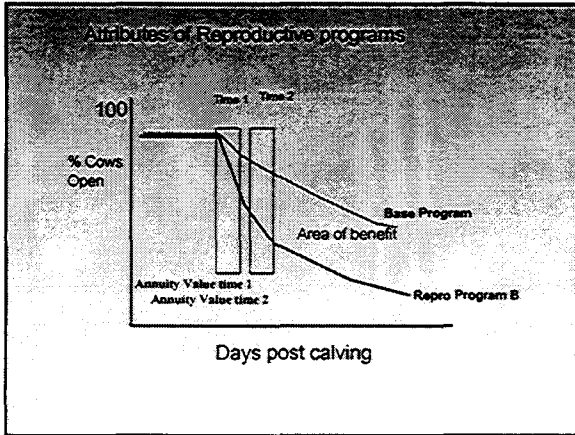


3 months in extended CI requires an Additional 2000 lbs of milk production to maintain Value/cow

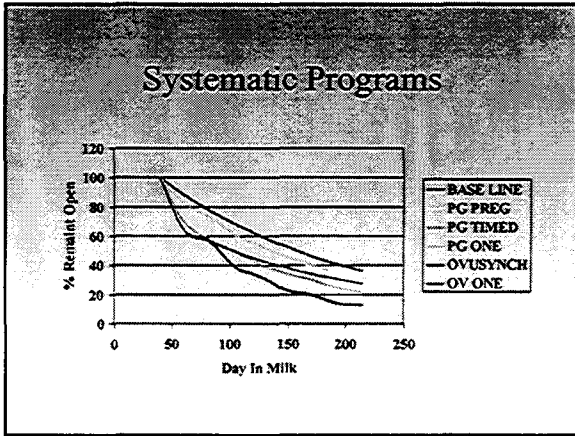
### Economic value of a Breeding Program



Value of a given breeding program is the value of pregnant cows at various stages.



- ### Systematic Breeding Programs
- Base Line – HDR x CR
  - PG for 1<sup>st</sup> breeding only (HD)
  - PG for all open cows (HD)
  - PG TARGET for all (timed breeding)
  - Ovsynch one (first breeding only)
  - Ovsynch preg check (all open cows)



### Inputs to Systematic breeding program Evaluator

INPUTS	
NUM	100
VWP	50
HDR	0.4
CR	0.4
CULL VALUE	\$500
PREG VALUE	\$1,000
SEMEN	\$10.00
Prostaglandin	\$2.00
GnRH	\$4.50

### Biological Parameters of breeding programs

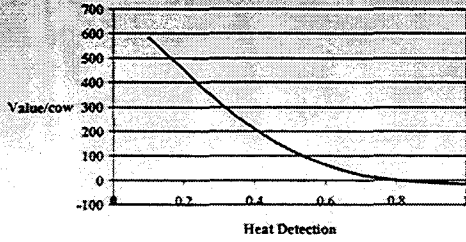
Prostaglandin	Prostaglandin TIME	OVUSYNCH
First Syn 0.6	First Syn 0.6	First Syn 0.9
Scnd Syn 1	Scnd Syn 0.77	CR ADJUST 1
	CR ADJUST 0.9	
CR 0.4	0.36	0.36

### Economic Value of Breeding Programs at baseline HDR 40% and CR 40%

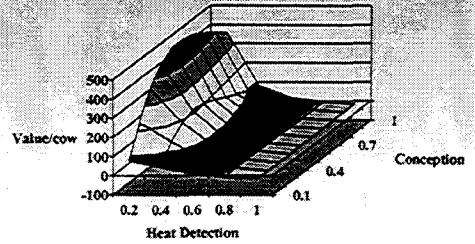
	IORC/yr	Return Rate	DIFF
BASLINE HERD	\$682		
PG FIRST BREEDING	\$725	2.5	\$43
PG All open Cows	\$708	1.1	\$26
PG TIME BREEDING	\$792	5.9	\$111
OVUSYNCH ONE	\$764	3.1	\$83
OVUSYNCH WITH PREG CHECK	\$882	4.0	\$200

Diff = the potential dollars/cow/year above baseline  
 Note: Rate of return should not be used to rank programs

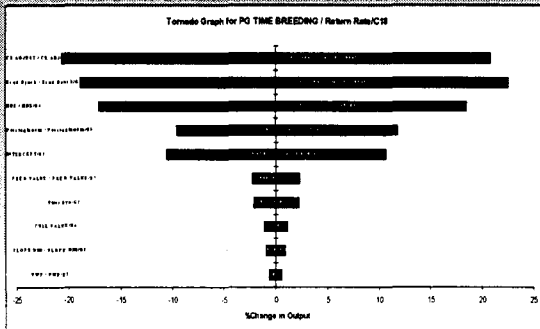
### OvuSynch - preg (CR = 40%)



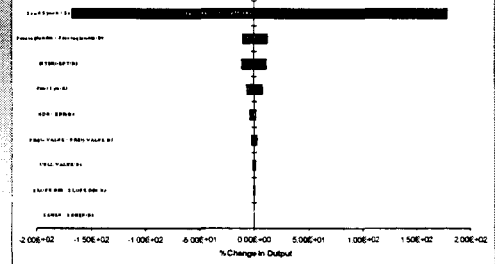
### OvuSynch - preg



### Sensitivity Analysis



### Tornado Graph for PO FIRST BREEDING / Return Rate/C16



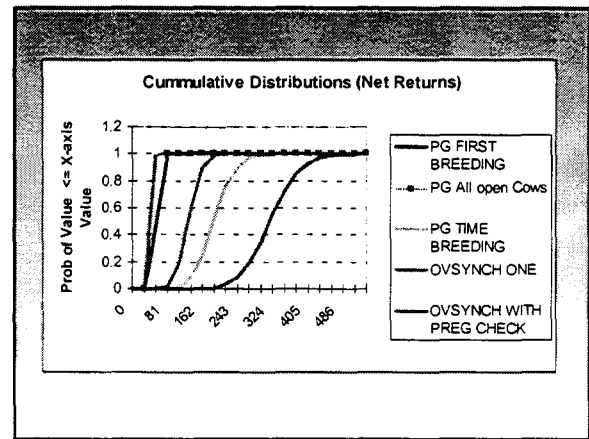
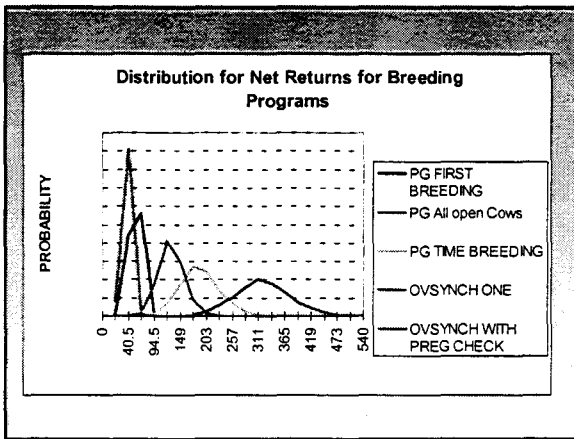
### Value of Breeding Programs

- Average Return
- Variability

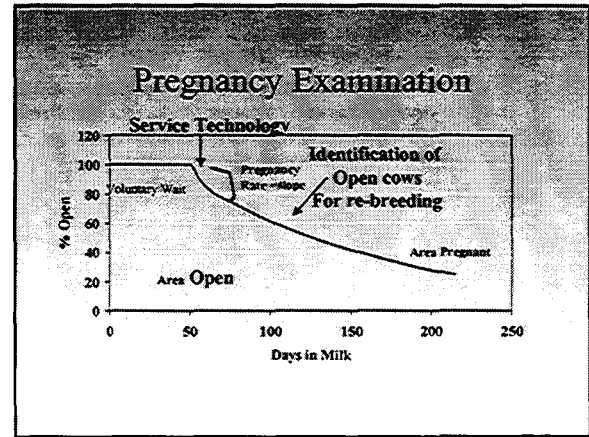
Breeding programs are a series of "games of chance".

( synchrony, heat detection, conception)  
Games are sometimes separated by time

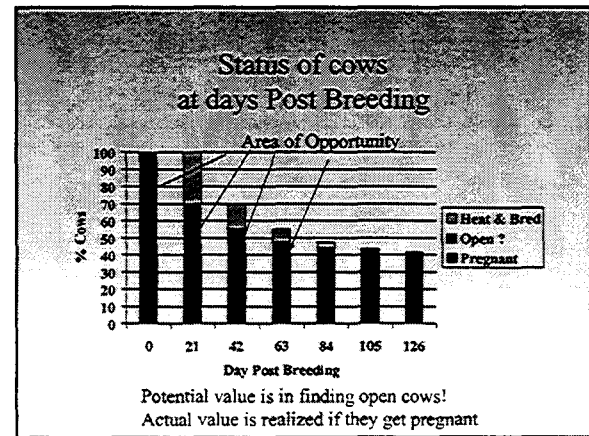
### Break to Simulation Breeding Model



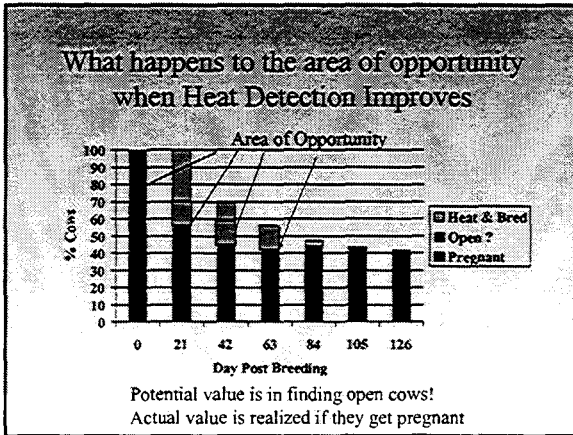
- ### Conclusions
- Systematic breeding programs offer economic opportunity for producers
  - Higher returns are available at lower heat detection rates
  - Increased conception increase returns on all programs
  - Higher economic risk (variability) is associated with timed breeding programs but they are first order dominant.



- ### Value of Pregnancy Examination
- When can the test be done – post breeding
  - When can subsequent rebreeding occur
  - What is the success of subsequent rebreeding
  - Measured above baseline program – rectal palpation (with or without heat detection at 21 days post breeding).





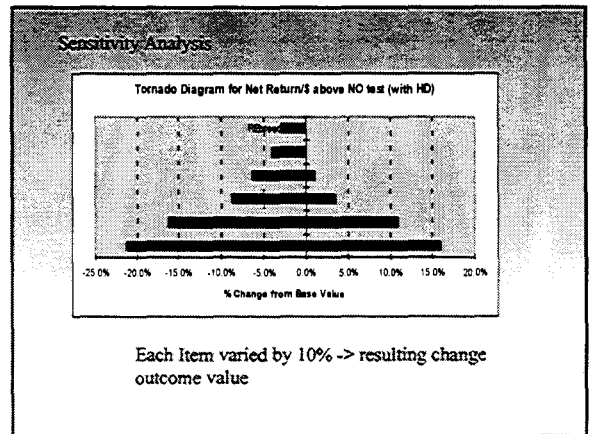
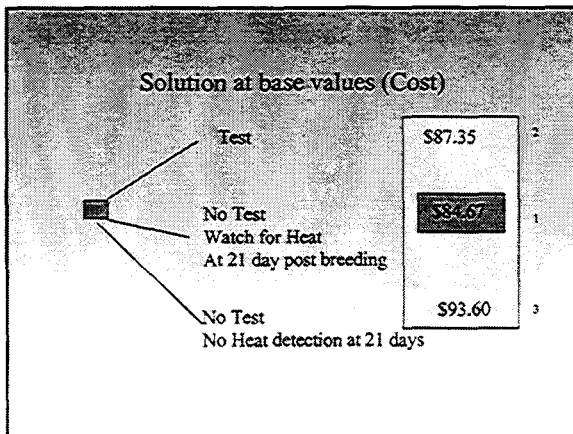
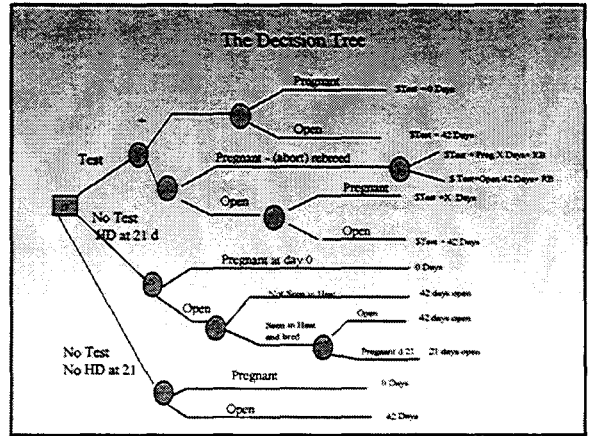
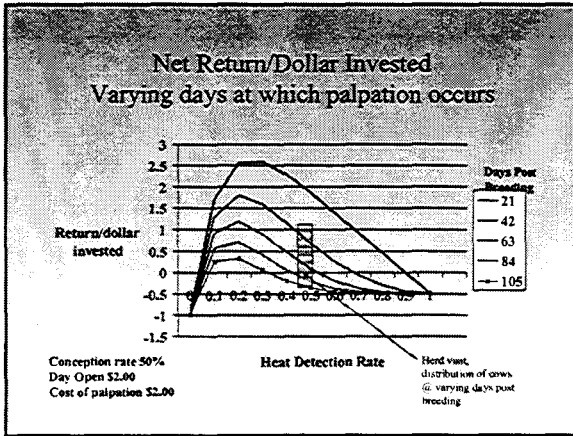


### Expected Pregnant on Exam at Day X

$$1 - \frac{CR_{pregnant}}{CR_{pregnant} + (1 - CR_{pregnant})(1 - HDR) \text{ (Day X/21)}}$$

Open Missed Not seen in heat

As CR, Heat Detection Rate or DAY X increase – so does % expected Pregnant





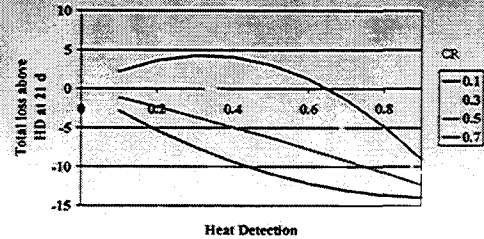
## Conceptual Issues

A Rebreding Cost is charged to branches where only an extra breeding occurs (ie breeding a pregnant cow).

Breedings on open cows are not charged a breeding cost since they would have been rebred anyway at a later date.

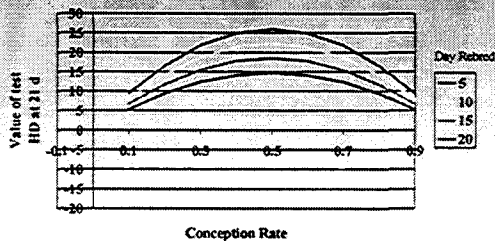
The value of the information is in the change in time post breeding that open cows are rebred.

## Value of test above HDR 21 and Rectal



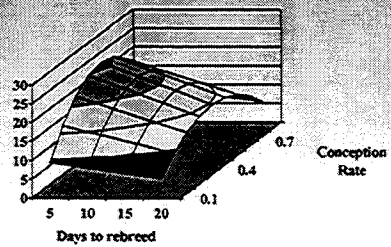
Note : Cost of Test \$0, Sensitivity 95, Specificity 47, CR 40, HDR 40  
Day of test 1, day rebred 17  
Positive value favors testing

## Value of Perfect test above 21 d HD



Note : Cost of Test \$0, Sensitivity 100, Specificity 100, CR 40, HDR 40  
Day of test 1, day rebred 17  
Positive value favors testing

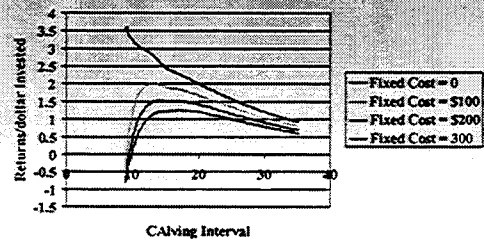
## Value of Perfect Test Above HDR @ 21 d

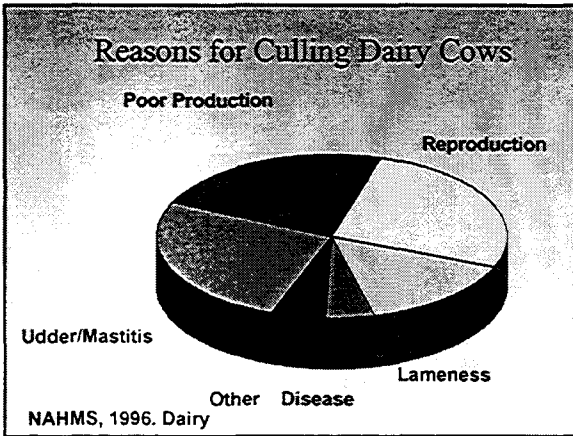
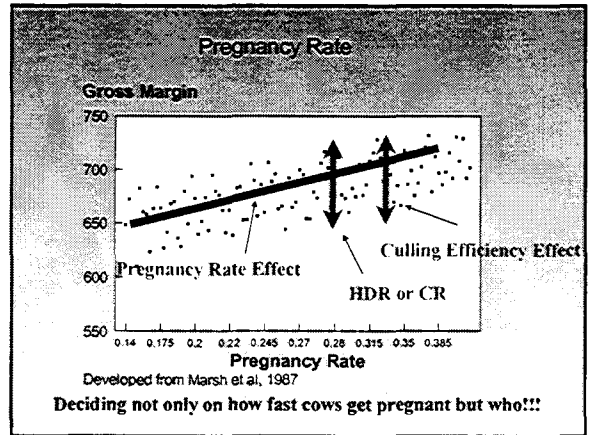
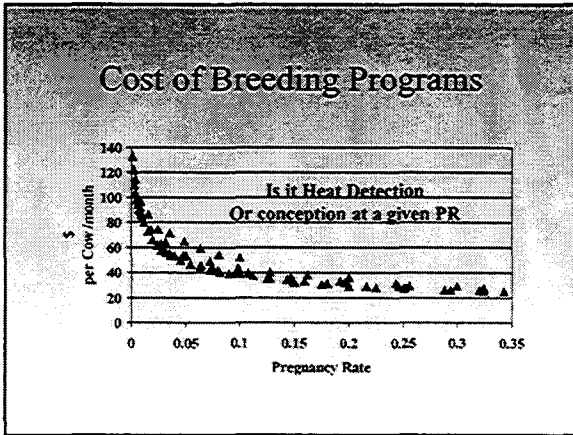


## What would make one want to extend a Calving Interval ?

- If there are additional cost associated with re-calving: metabolic problems etc.

## Fixed Lactational Cost with varying CI





### Cost of Culling

- Cow leaves too Early – returns on rearing cost are not optimized (immediate direct cost) either deliberately or by “accident”.
- Cow leaves too Late – returns from a better replacement animal not realized (lost opportunity)

Every cow has an optimal time of culling.

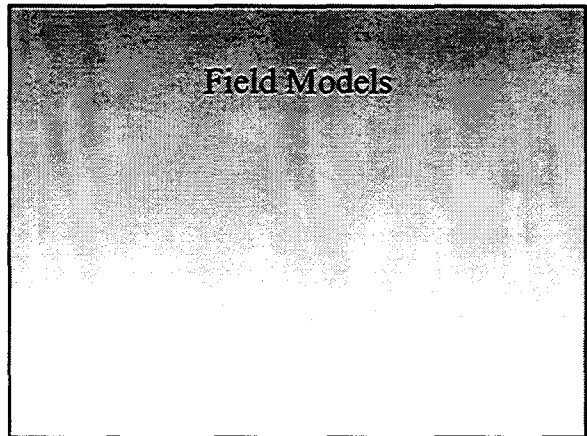
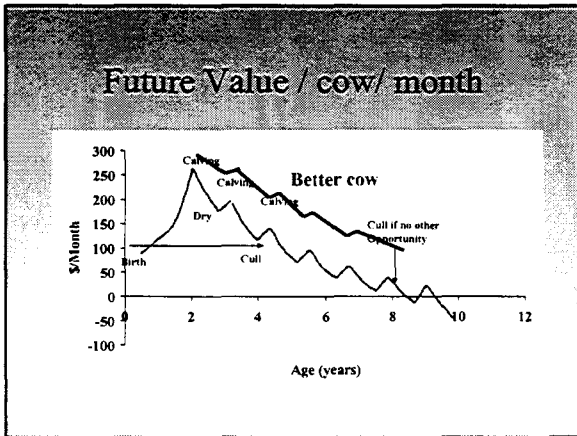
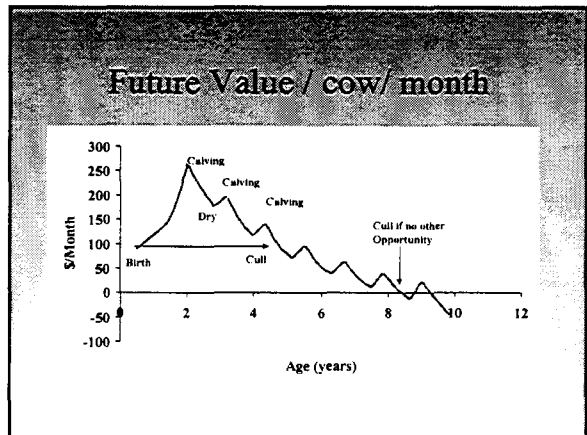
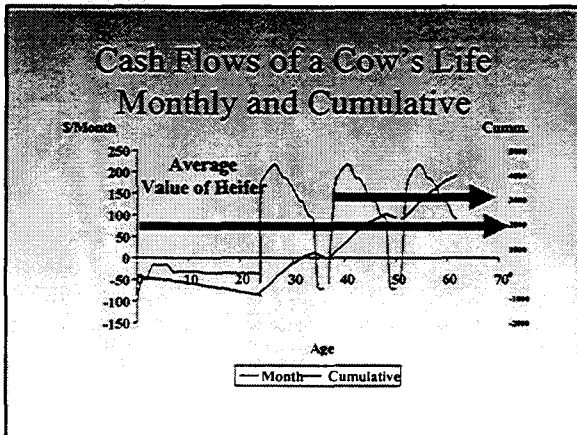
### Culling Models to Identify Inefficient Animals

Every cow is eventually culled - let's define the optimal time for it to occur!!!

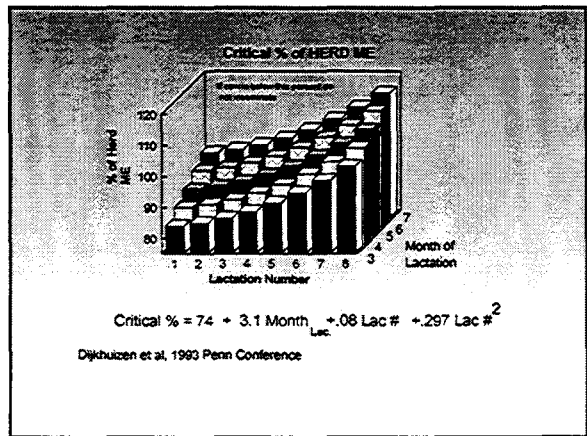
### Essence of Culling Decision

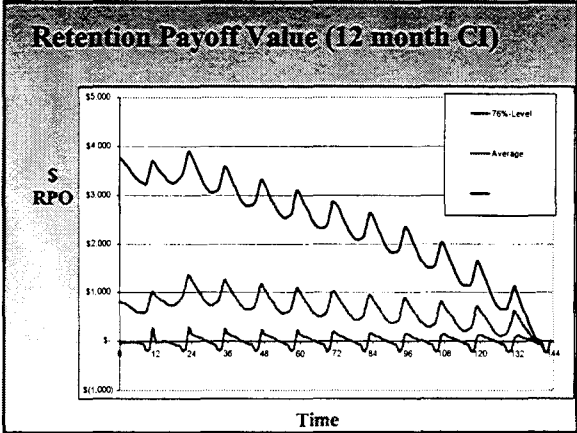
- Is the herd at Maximum Capacity?
- Can the herd buy replacements?
- Does the replacement animal dilute maintenance cost, better then the future production of the cow in question.
- Does the future value of a cow's production (marginal value) exceed the average value of the replacement animal

(note: average value of replacement animals, is it's future marginal value)



- ### Field Models
- Calculate the maximum average expected returns from a replacement heifer (ie her marginal value)
  - Calculate the projected returns from the cow in question (along with her future replacements)
  - Difference is call the Retention Payoff (RPO)





### Summary

- Reproductive Technology affects the economic viability of the operation by diluting maintenance cost.