Wood in Streams

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Outline

- Background of project
- Project objective
- Quartz Creek
- Probability of movement
- Accumulations
- OSU Streamwood
- Conclusion
- Acknowledgement

Wood is Dynamic

- Especially in higher order streams
- Those that experience high flows

Two Questions

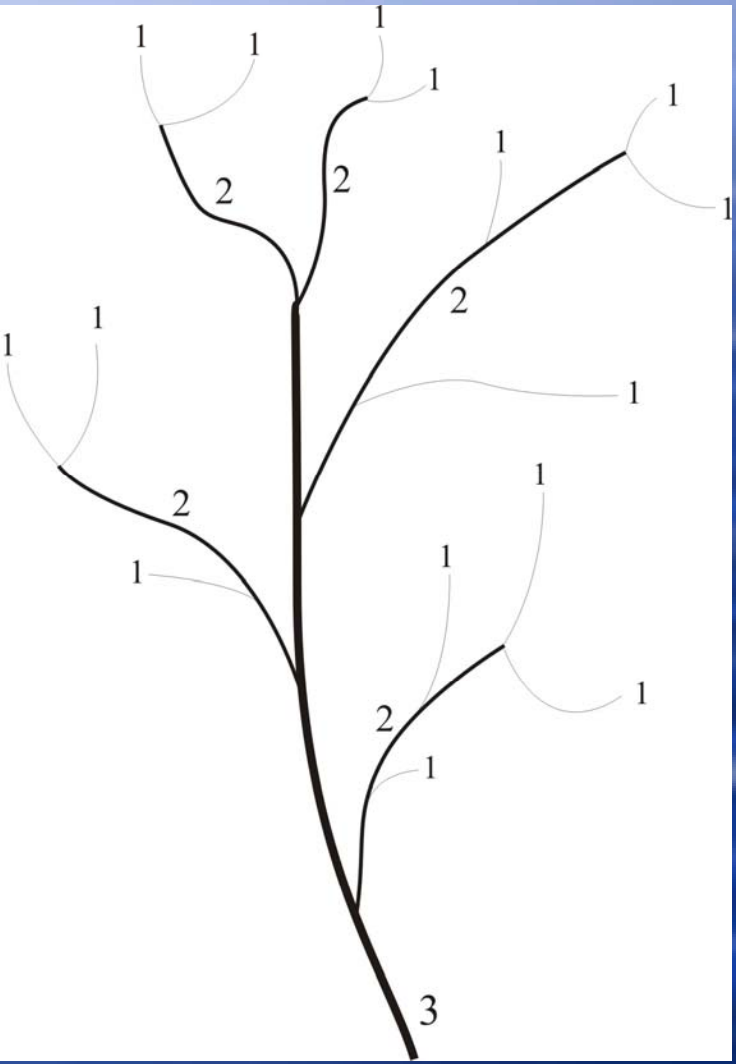
- In the literature on wood in streams, we find two foci of interest:
  - Prediction of wood volumes at the network scale due to various land management schemes
  - Accelerated habitat recovery through LWD placement in streams

Wood: Network Scale

- At network scale, wood volume per section of stream is useful measure of healthy stream functioning
- Prediction of wood volumes throughout network takes into account large floods, landslides, forest cutting practices, roads, stream order, etc.
- Has resulted in a lot of positive changes in land management policy:
  - 40m buffer zone
  - Road removal
  - Bridge alteration/removal

Wood: Network Scale

- If low wood volumes persistent in a section of a network, we may choose to increase those numbers quickly through stream restoration
- Why?
  - Response time of fish is shorter than that of forest
  - We may loose fish and other life from stream if low wood levels remain for too long



Wood: Restoration Reach Scale

- Restoration by LWD placement is done at a smaller scale
  - Isolated low wood volume section of a stream

Wood: Restoration Reach Scale

- Economic investment and liability demands that we impose stasis upon installed LWD wood

*This one got away

Wood: Restoration Reach Scale

- With addition of econ considerations, we know stable LWD's will accumulate more wood and complexify the stream habitat more than those that leave the reach (of course!!!)

- So now, within the restoration scale, we want to know under what conditions LWD's move the least and accumulate the most!
- We need to make some decisions about what we are interested in and how we are going to measure it

Scale Comparisons

- In reach restoration we consider some of same processes as in network scale
  - Floods, stream order, wood

*But in a different way

Scale Comparisons

Network prediction	Reach Restoration
Floods/landslides →	Annual peak flow
Stream order →	Channel width
Wood volume per stream length →	Each log: Length, diameter, volume, root wad, zonation, structure type

Wood: Restoration Reach Scale

- Environmental context reduced:
  - flow and channel width
- Wood characteristics greatly expanded upon:
  - Length
  - Width
  - Diameter
  - Root wad presence (roots attached or not)
  - Position in stream
    - Zonation
    - Structure type (more detailed measure

* Now we consider "movement" as important and need to quantify it.

Movement

- A log is considered to have “moved” if it changed its position by greater than 10m
- Why?
  - In QC report, structures that moved 10m or less are cited as still serving their intended function

Remember the Goal: Habitat Functioning

- All this work is done within the context of habitat restoration
- We assume that LWD's that don't move and accumulate the most contribute best to habitat functioning
- This is the reason for placing LWDs but we do not study this in our analysis

Project Objectives

1.) Predict probability of movement of logs and ask how well we are able to make these predictions given our parameters.

- Do we need to consider other channel characteristics to predict annual movement and accumulation?
  - boulder type and size, rapid or calm stretch

2.) Determine which of the measured factors of the restoration reach scale most dictate likelihood of wood movement.

3.) Investigate correlation between number of key pieces (length >= chan width) and accumulation.

4.) See whether the Streamwood model can accurately predict probability of wood movement in Quartz Creek.

Quartz Creek Restoration

- Reestablish natural volumes of wood
- Provide complex woody debris accum for salmonid habitat
- Reestablish diverse stepped channel profile
- Increase fish habitat diversity

Quartz Creek Restoration

- Overall idea:
  - Install an LWD “backbone” to catch smaller wood and retain sediment

Probability of Movement

- Objectives:
  - Model probability of movement to predict whether particular logs will move
  - Understand which factors are most significant in causing movement
- 3 Models
  - Linear Regression
  - Logistic Regression
  - Bayesian Belief Network

Quartz Creek Data Set

- 4000 logs tracked between 1988 and 2007
  - We know the location along a 1 km reach at each year
  - Know attributes of each log, peak flow for each year
- Treat each log separately every year
  - End up with 33,000 (log,year) pairs
  - Predict probability of movement *per year*

Time scale

- Our models give probability p of movement in a year
- If we want to predict movement over a period of several years, to get the probability in year n, we can use a geometric distribution. $P(n) = (1-p)^n p$
- To predict movement over years 1 to n, use $P(1) + P(2) + \dots + P(n)$

Inputs and Outputs

- One output - does it move?
  - Define movement as having moved >10 meters in a year
  - Treat movement as a binary variable
- Let movement be a function of several parameters
  - Length, Diameter, Volume, Root Wad, Flow, Zonation

Zonation

- Zone 1 - In Active channel
- Zone 2 - In Bankfull channel
- Zone 3 - Above active channel
- Zone 4 - Outside active channel

Linear Equation

$$p = a_0 + a_1F + a_2Z + a_3L + a_4D + a_5V + a_6R$$

Symbol	Meaning
F	Flow
Z	Zonation
L	Length
D	Diameter
V	Volume
R	RootWad

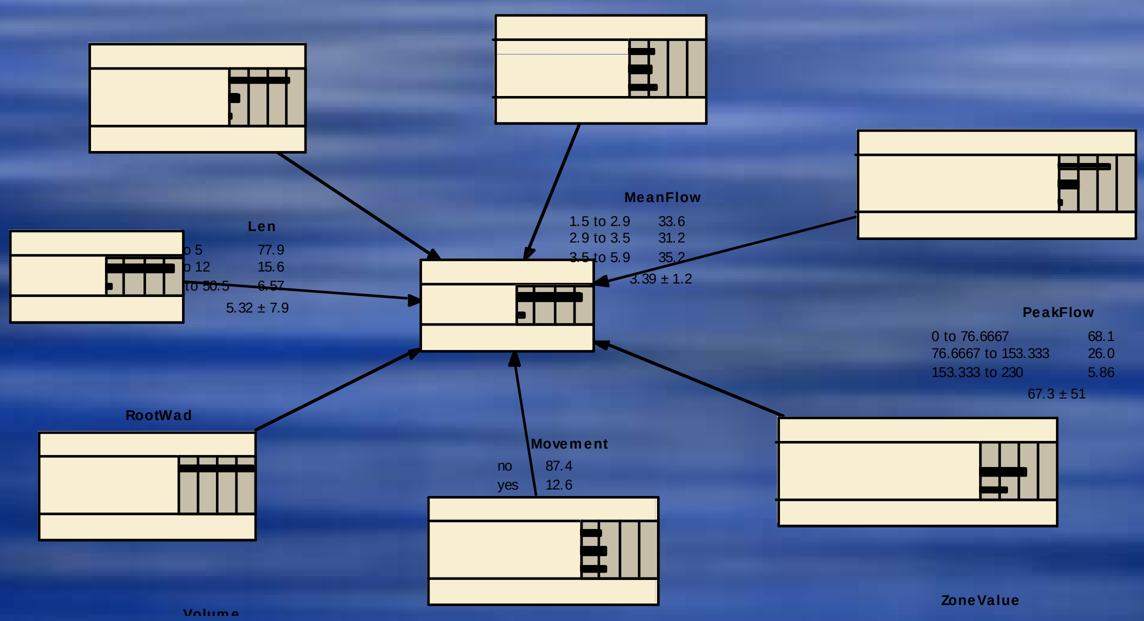
Logistic Equation

$$p = 1 / (1 + \exp(- (b_0 + b_1F + b_2Z + b_3L + b_4D + b_5V + b_6R))$$

Symbol	Meaning
F	Flow
Z	Zonation
L	Length
D	Diameter
V	Volume
R	RootWad

Bayesian Belief Net

- Outputs conditional probabilities of movement based on inputs
  - Parameters are discretized



Hypothesis Testing

- Test the ability of our models to predict movement
- Our models output a probability of movement, not a 'yes' or 'no'
- To predict whether a log will move, we choose a *threshold* k. If the model gives a probability p > k, we predict movement.

More Hypothesis Testing

- The probabilities of movement from the models are very low
  - Maximum from logistic model is 0.43
  - Maximum from linear model is 0.32
- We get the best accuracy by just predicting 0 for every log. There is no threshold that gives better accuracy.

Measures of Success

- Accuracy
  - fraction of correct predictions
- Precision
  - Of logs that we predicted to move, how many actually did move?
  - True Positives / (True Positives + False Positives)
- Recall
  - Of the logs that did move, how many did we predict?
  - True Positives / (True Positives + False Negatives)
- F-Score/F-Measure
  - Average of precision and recall. We weight them equally.
  - 2 * (precision * recall) / (precision + recall)

Test Results

Model	Precision	Recall	F-Score	Accuracy
Always Predict 0	undefined	0	Undefined	0.87
Random Guessing	0.13	0.47	0.20	0.50
Linear	0.16	0.83	0.27	0.41
Logistic	0.17	0.74	0.28	0.48

Moving Forward

- Our models cannot predict probability of movement very well on a yearly basis.
  - Better than random guessing, but not very good
- Do we need to consider other parameters to create *any model* that predicts well on a yearly basis?
  - We think so!
- Can we predict probability of movement accurately over a longer time scale with our model?
  - We think so!
  - Geometric distribution
  - If our model gives probability of movement of 0.15 for one year, probability of movement within 10 years would be about 0.65

Relative Significance of Inputs

Parameter	Diameter	PeakFlow	Length	Zonation	Volume	RootWad
t-Value	-13.092	12.238	-9.936	-9.243	7.037	-0.400
P(>|t|)	< 2e-16	< 2e-16	< 2e-16	< 2e-16	2.02e-12	0.689

Table 5: t-Values for Linear Model

Parameter	Diameter	PeakFlow	Zonation	Length	Volume	RootWad
t-Value	-11.971	11.913	-9.052	-8.707	3.365	-0.607
P(>|t|)	< 2e-16	< 2e-16	< 2e-16	< 2e-16	7.66e-4	0.5436

Table 6: t-Values for Logistic Model

Parameter	PeakFlow	Volume	Zonation	Diameter	Length	RootWad
Variance Reduction	1288	322.2	62.09	50.62	6.201	0.2586
Variance of Beliefs	5.76e-3	1.44e-3	2.78e-4	2.27e-4	2.78e-5	1.2e-6

Table 7: Sensitivity Values for BBN model

Relative Significance of Inputs (In order of importance)

Linear	Logistic	BBN
Diameter	Diameter	Peak Flow
Peak Flow	Peak Flow	Volume
Length	Zonation	Zonation
Zonation	Length	Diameter
Volume	Volume	Length
Root Wad	Root Wad	Root Wad

Installed Structures

Sill Logs

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Lateral Deflectors

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Full Channel Jam

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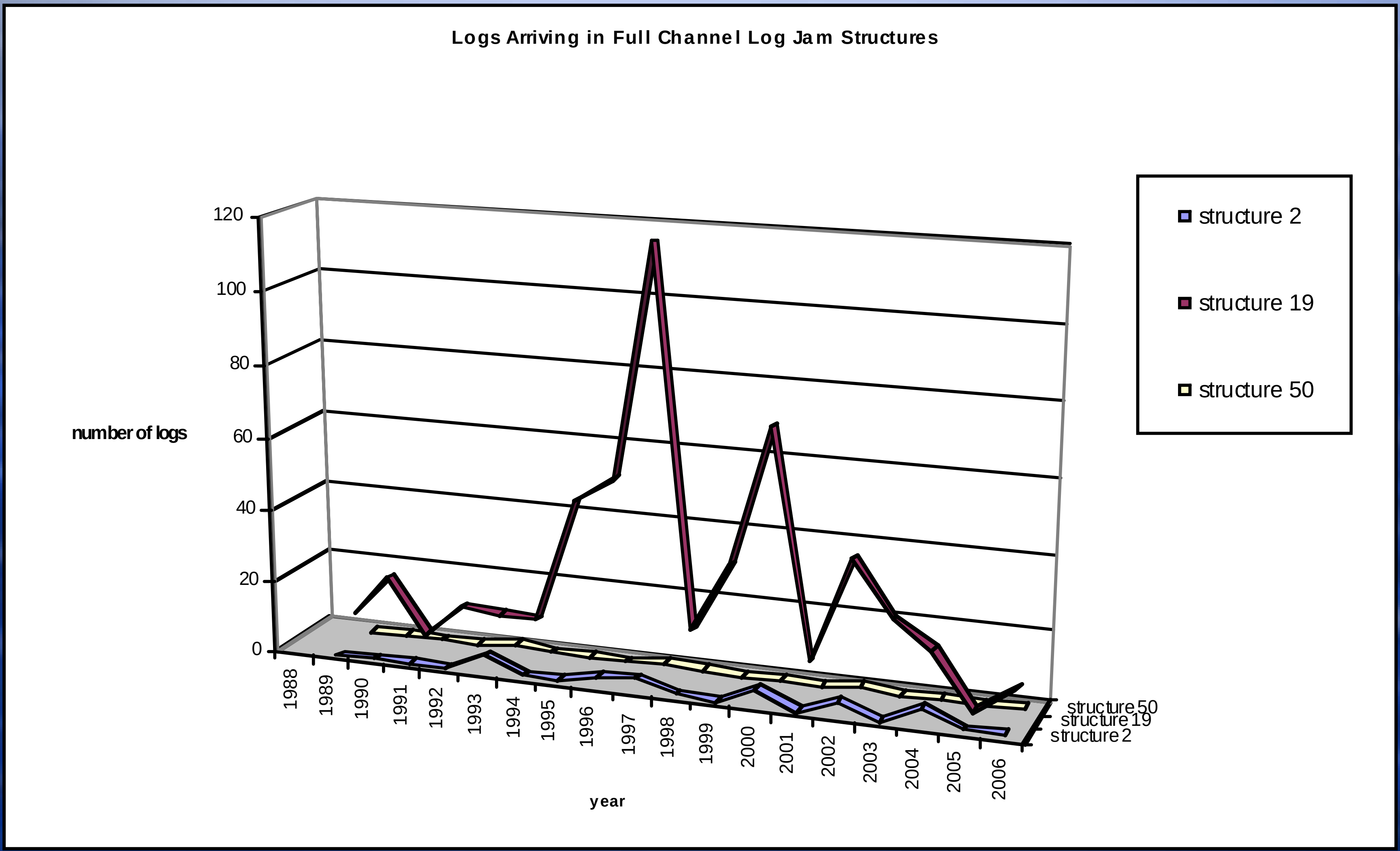
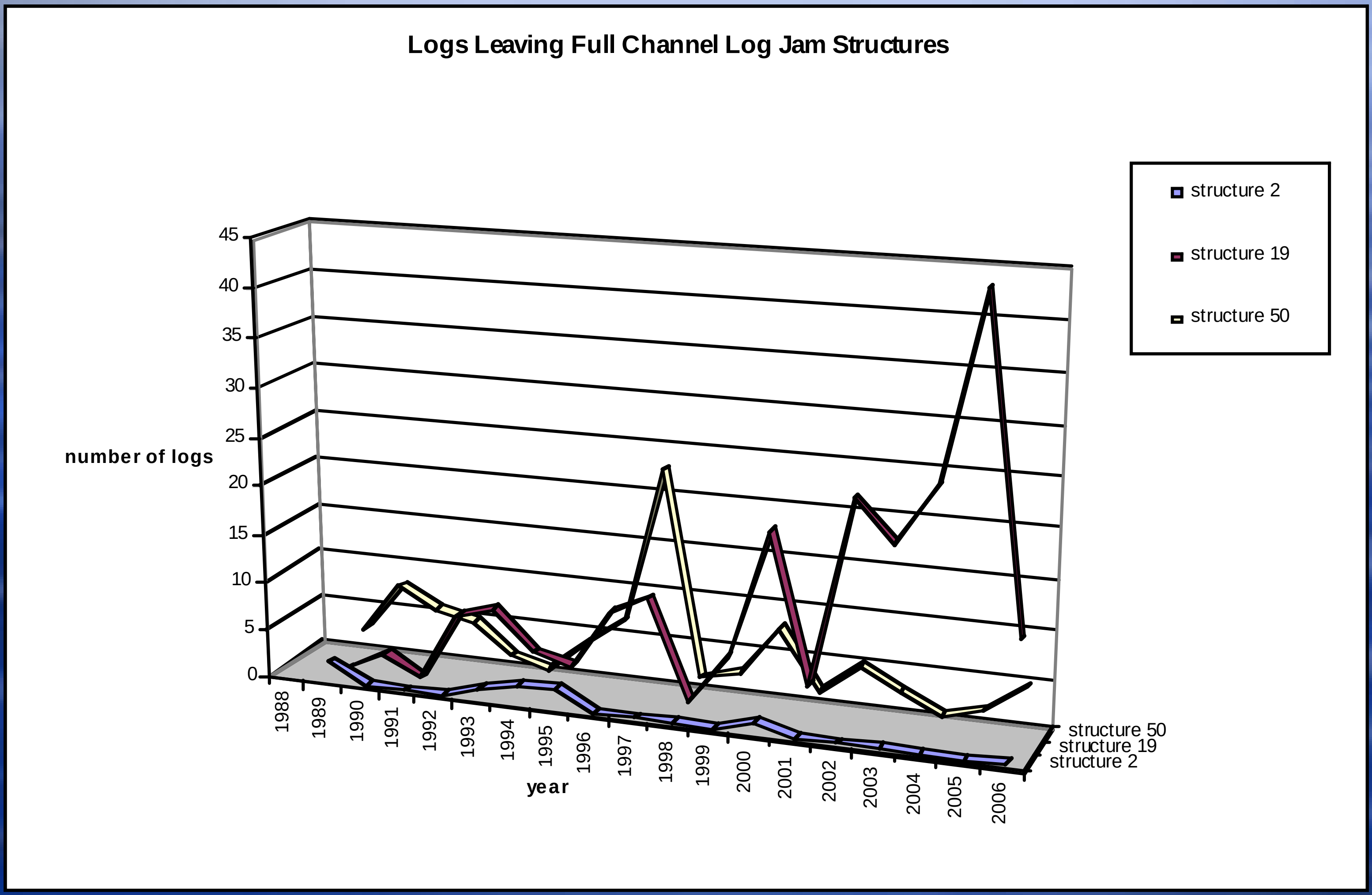
Success of Structures: Accumulation

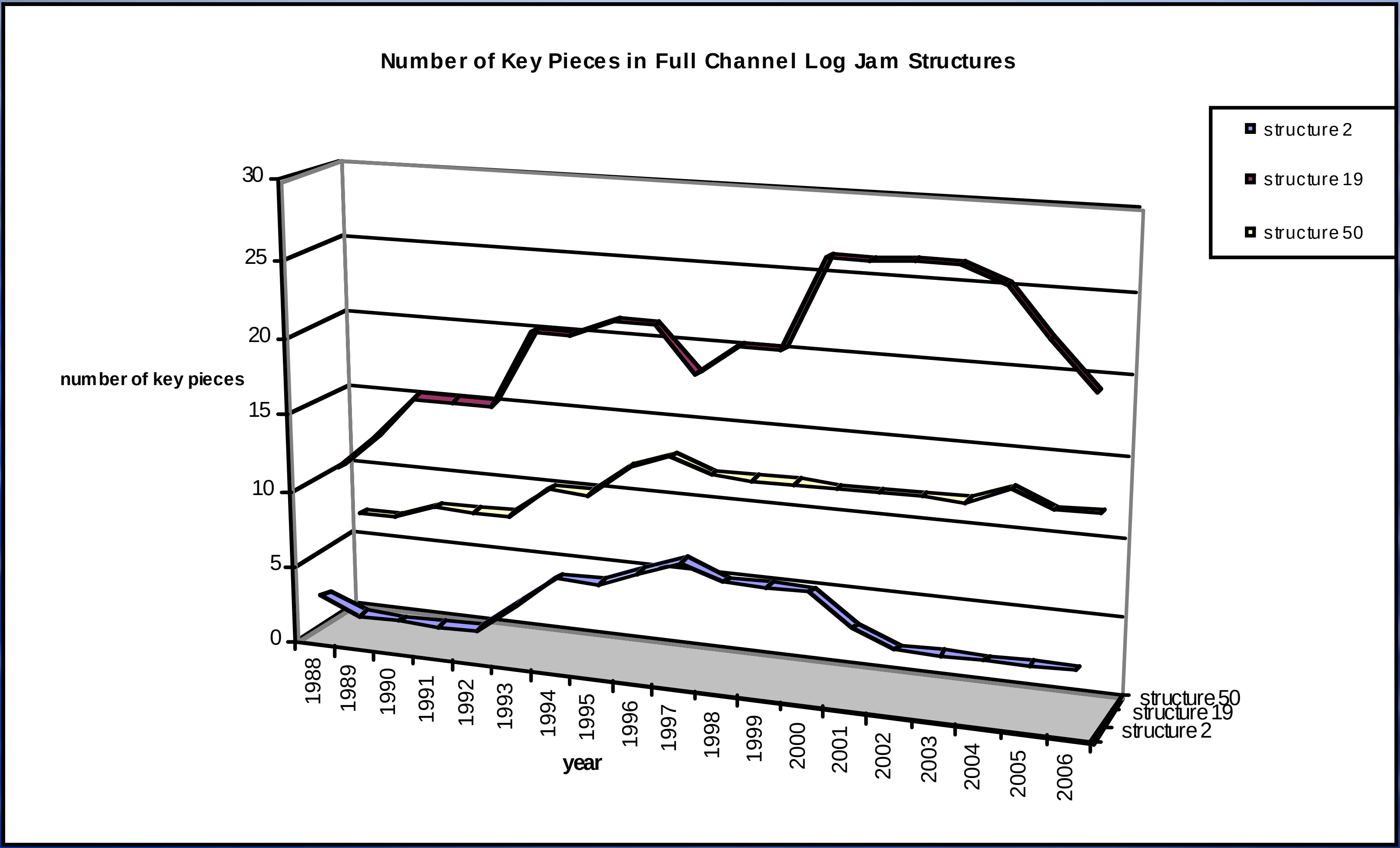
Full Channel Jam



Full Channel Jam



Full Channel Jam



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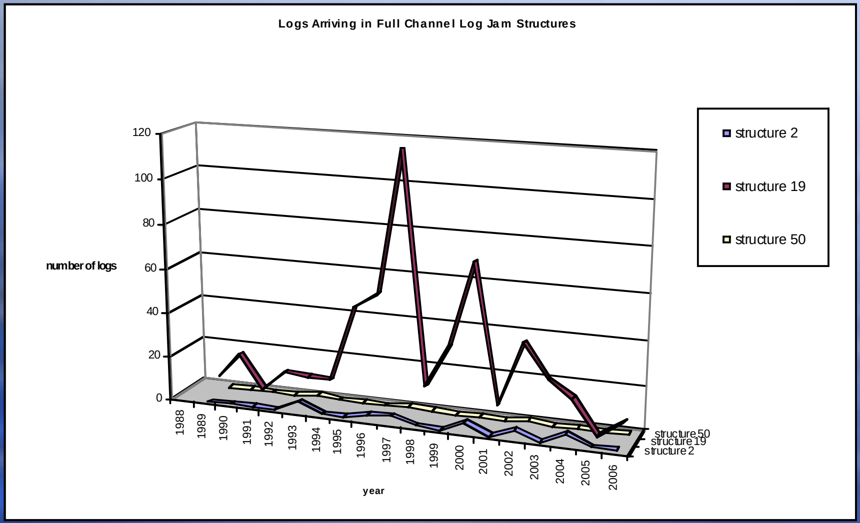
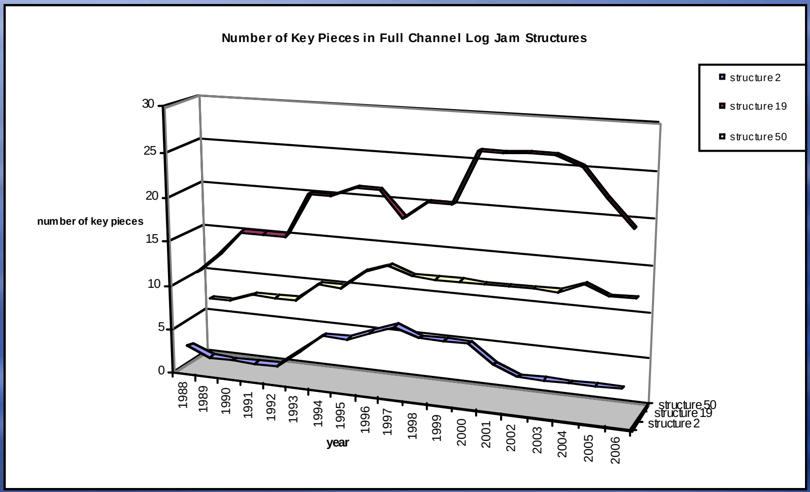
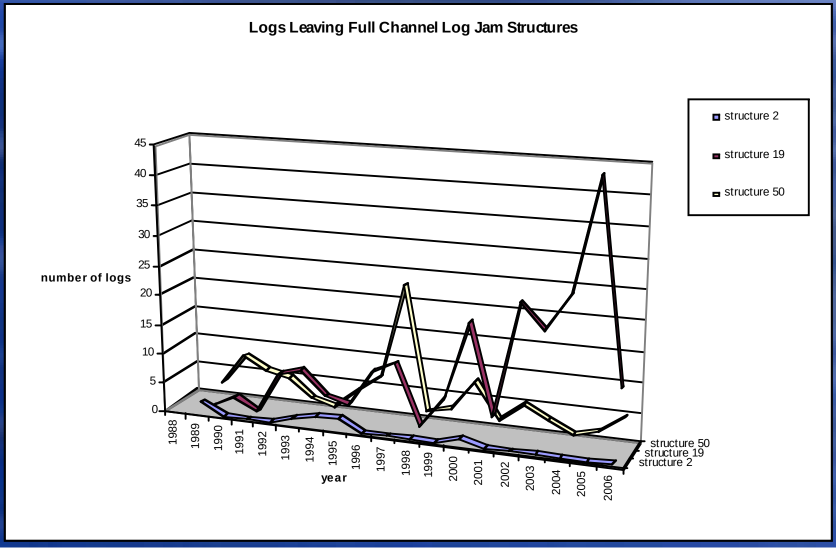
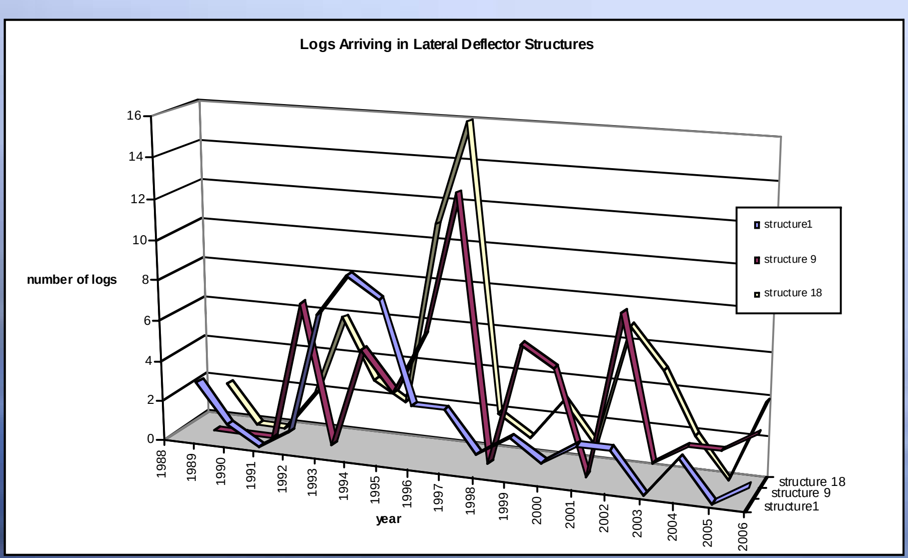
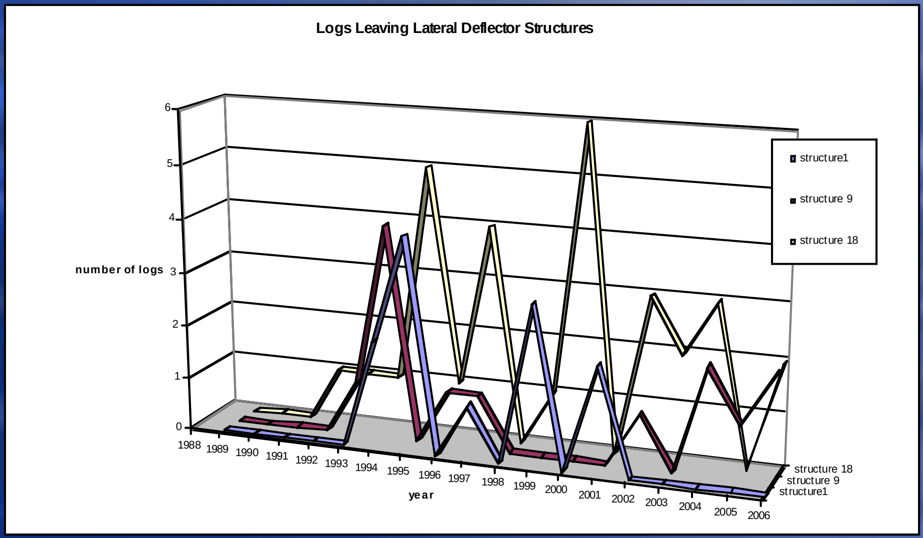


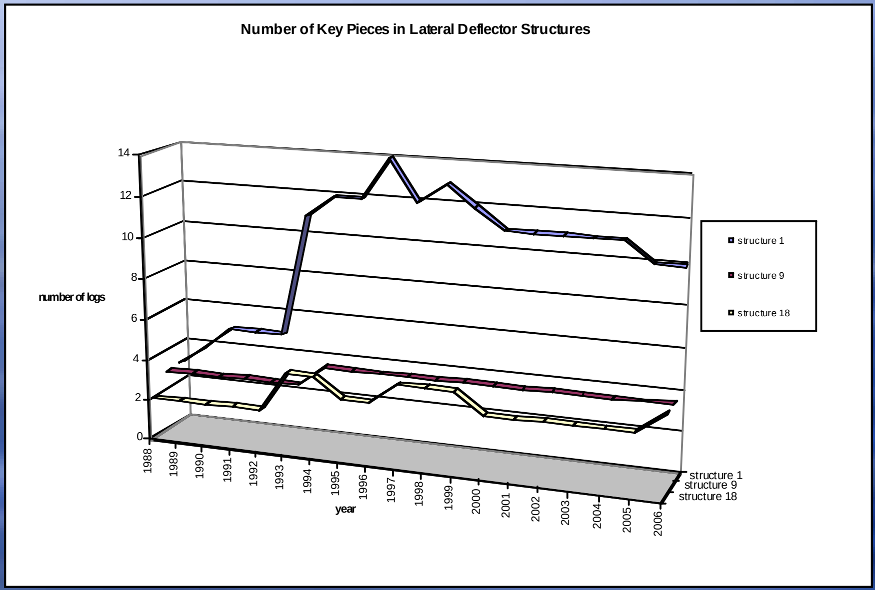




Lateral Deflector Structures



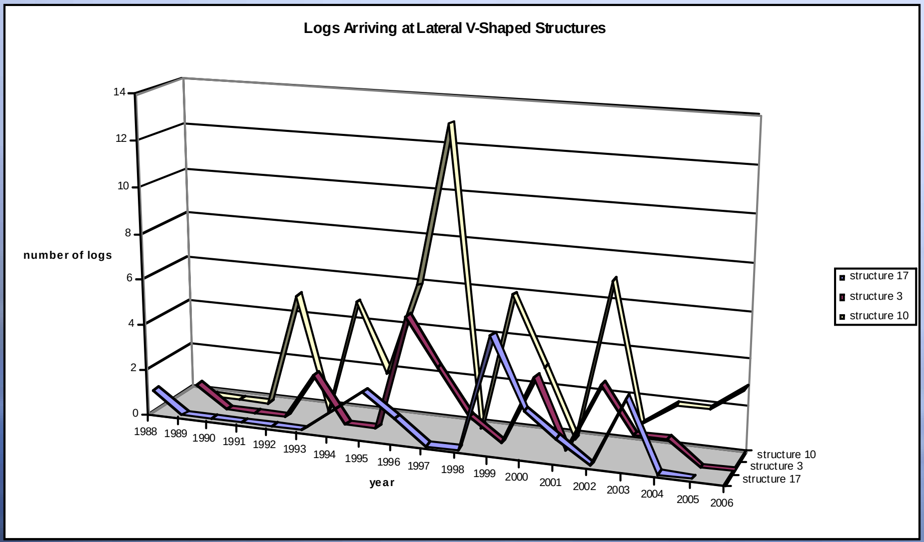


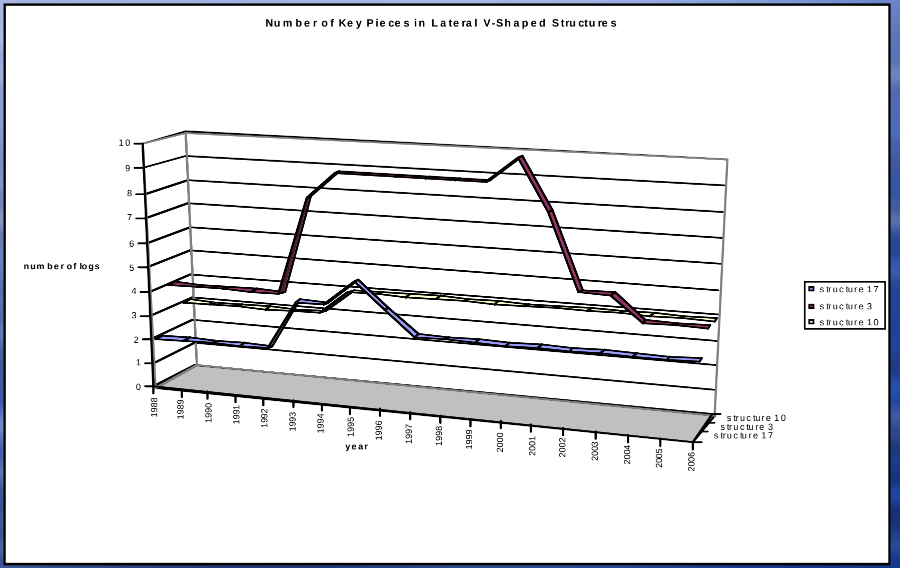


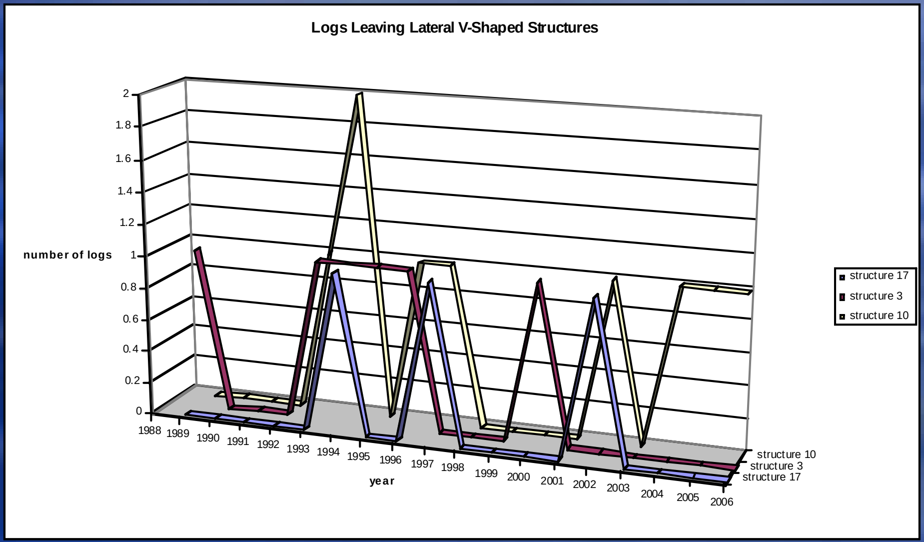
Correlation?

- No apparent correlation between number of key pieces and log accumulation

Lateral V-Deflector Structures





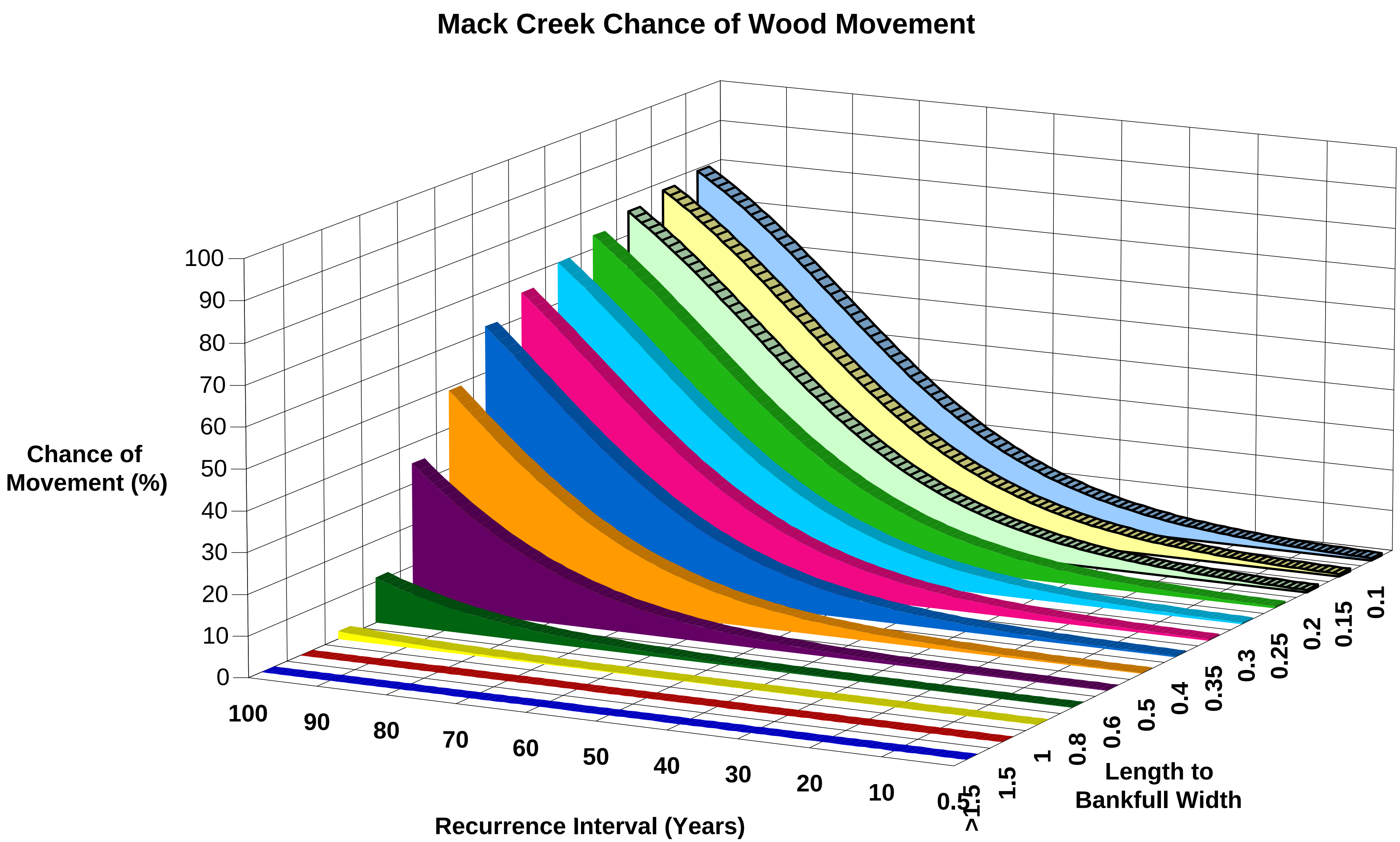


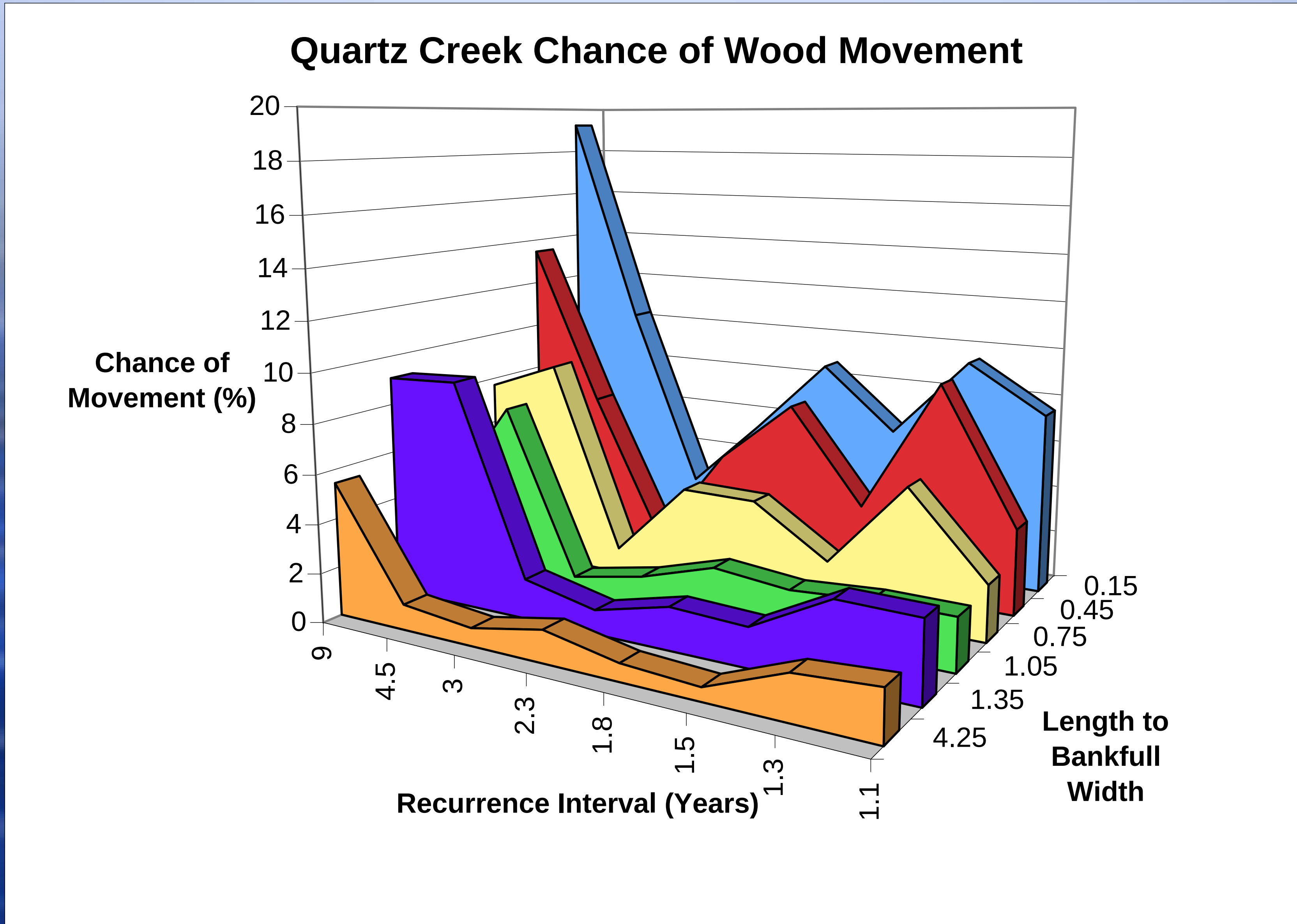
OSU StreamWood

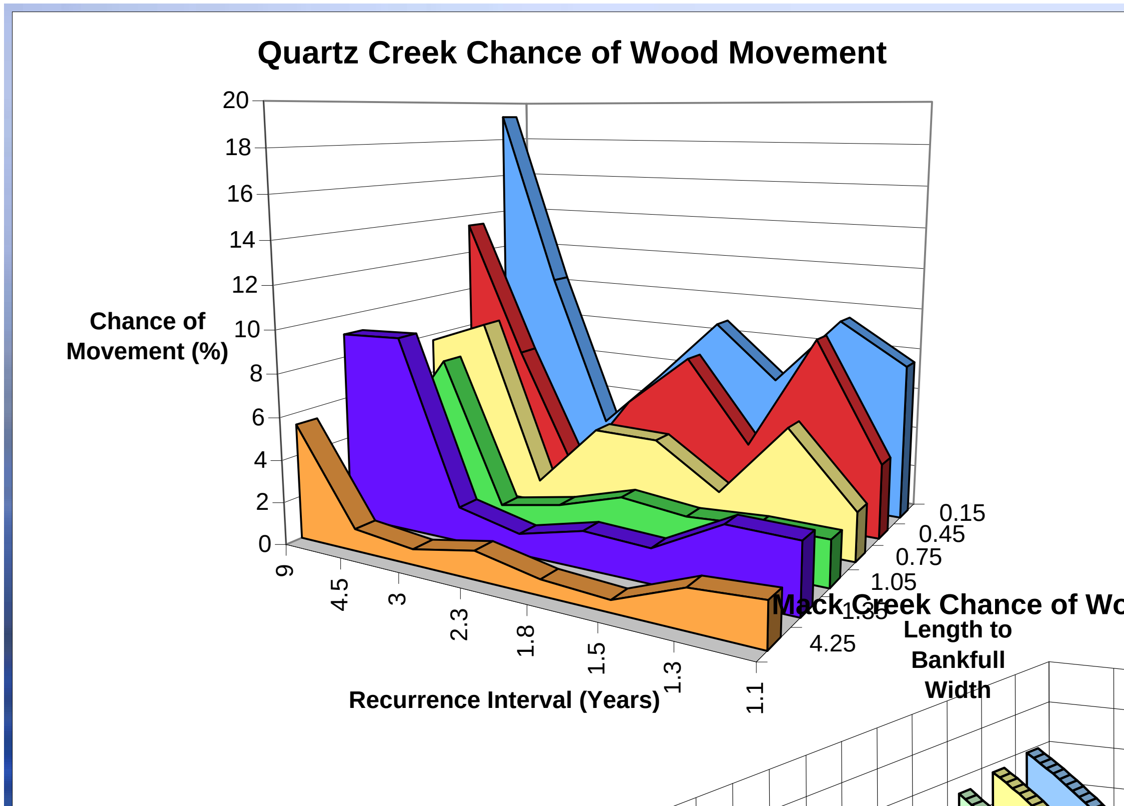
- Based on data from Mack Creek
- Individual based, stochastic
- Composed of two models
  - Forest model
    - Tree recruitment, growth, mortality, harvest
  - Stream model
    - Log recruitment, breakage, movement, decomposition

Theoretical Model for Chance of Wood Movement

- Chance of movement is a function of:
  - Flow (recurrence interval in years)
  - Piece length to bankfull width ratio
  - Proportion of piece outside channel
  - Number of key pieces


Mack Creek Chance of Wood Movement
Chance of Movement (%)
100
90
80
70
60
50
40
30
20
10
0
Recurrence Interval (Years)
100
90
80
70
60
50
40
30
20
10
0.5
Length to Bankfull Width
>1.5
1.5
1
0.8
0.6
0.5
0.4
0.35
0.3
0.25
0.2
0.15
0.1


Quartz Creek Chance of Wood Movement
Chance of Movement (%)
20
18
16
14
12
10
8
6
4
2
0
9
4.5
3
2.3
1.8
1.5
1.3
1.1
Recurrence Interval (Years)
0.15
0.45
0.75
1.05
1.35
4.25
Length to Bankfull Width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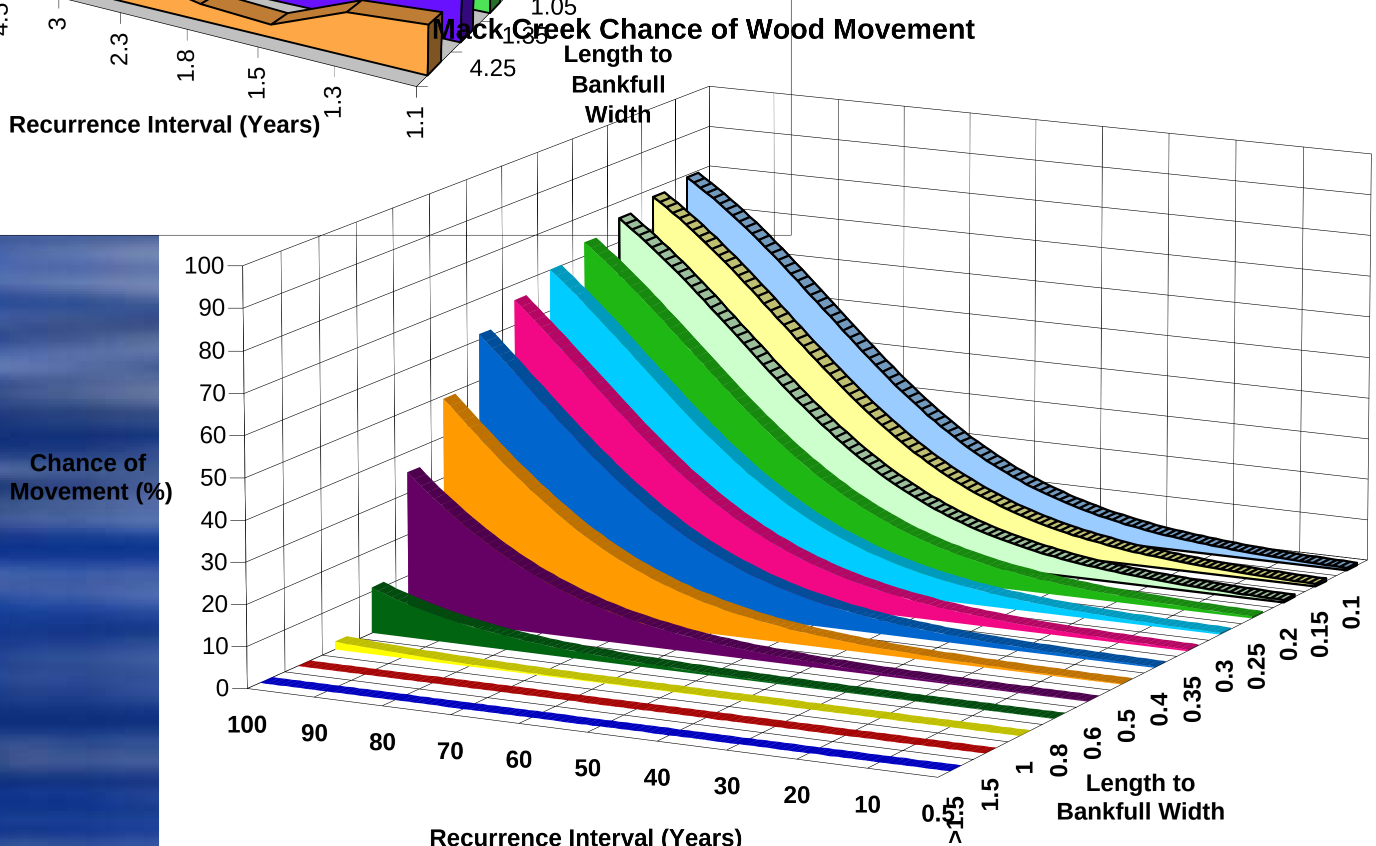
18
16
14
12
10
8
6
4
2
0
9
4.5
3
2.3
1.8
1.5
1.3
1.1
Recurrence Interval (Years)
0.15
0.45
0.75
1.05
1.35
4.25
Length to Bankfull Width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Chance of Movement (%)
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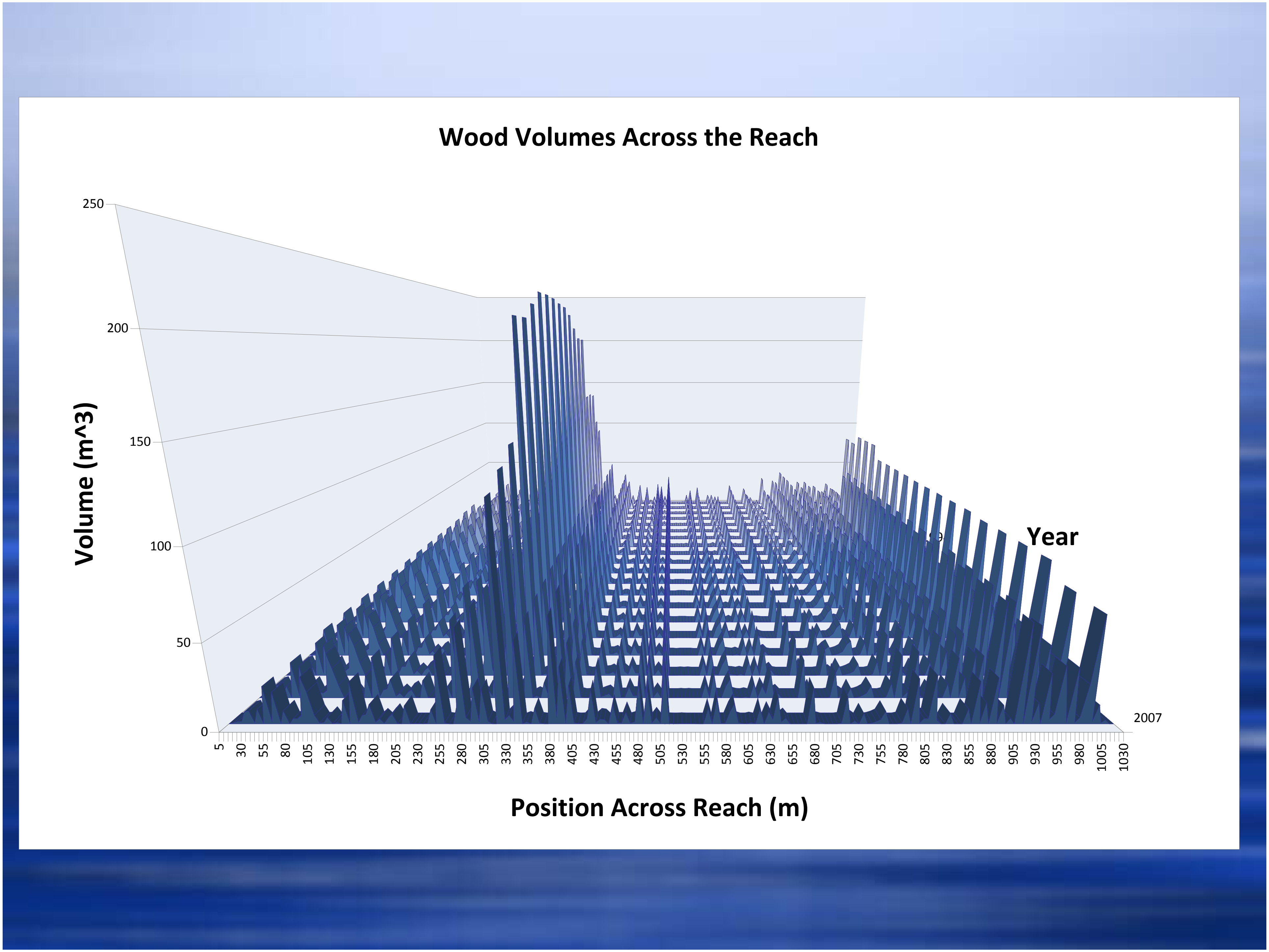
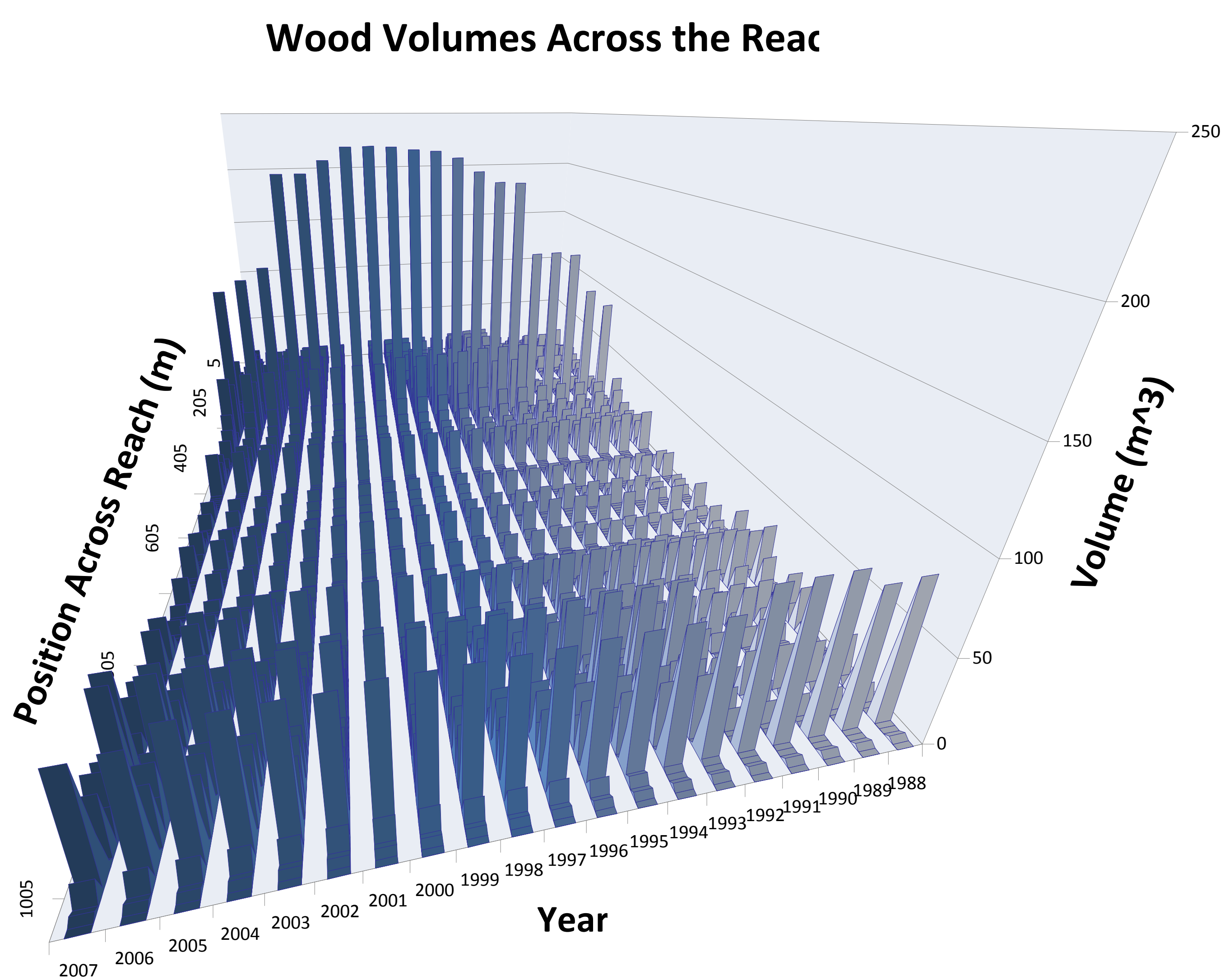
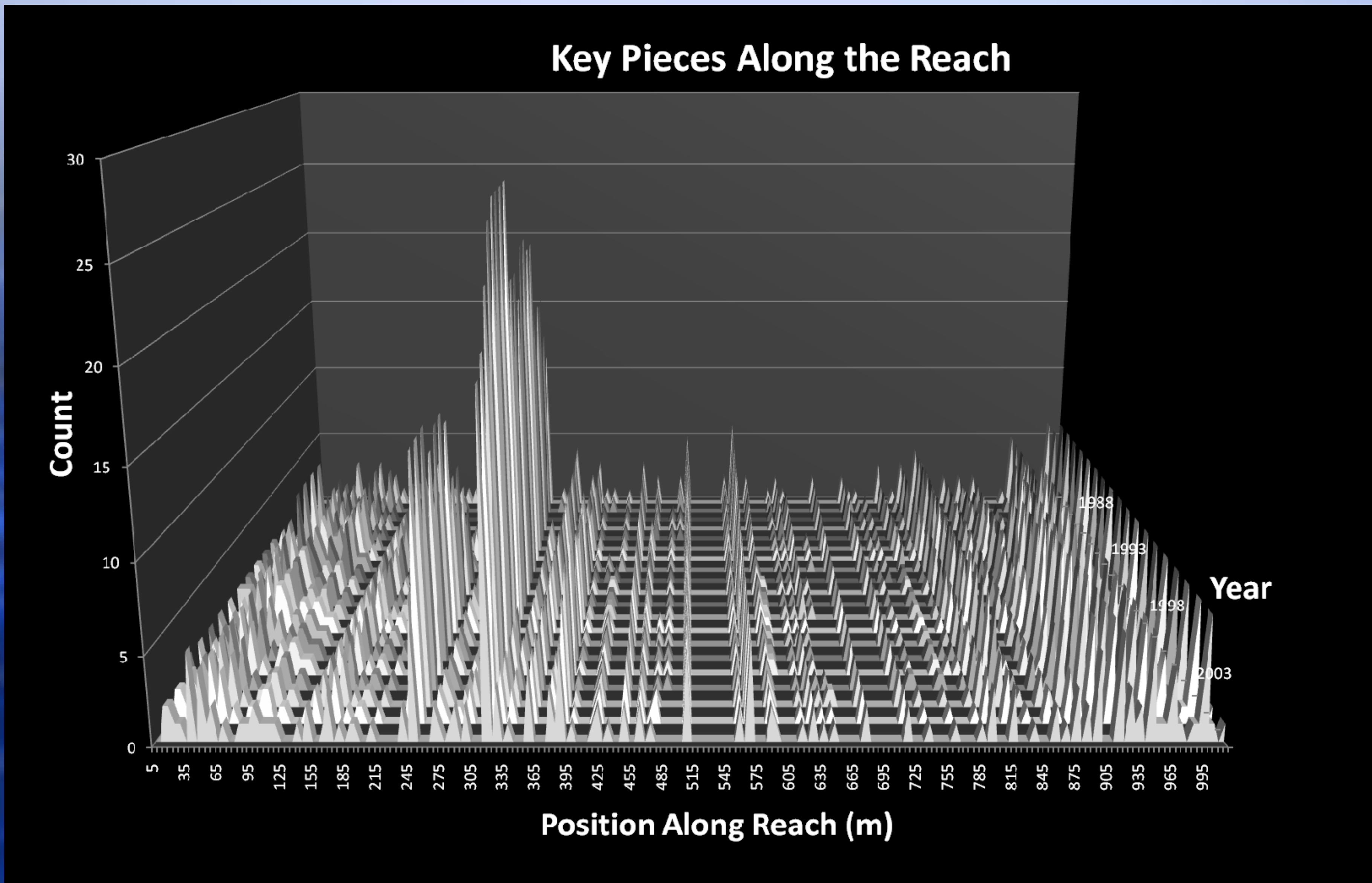
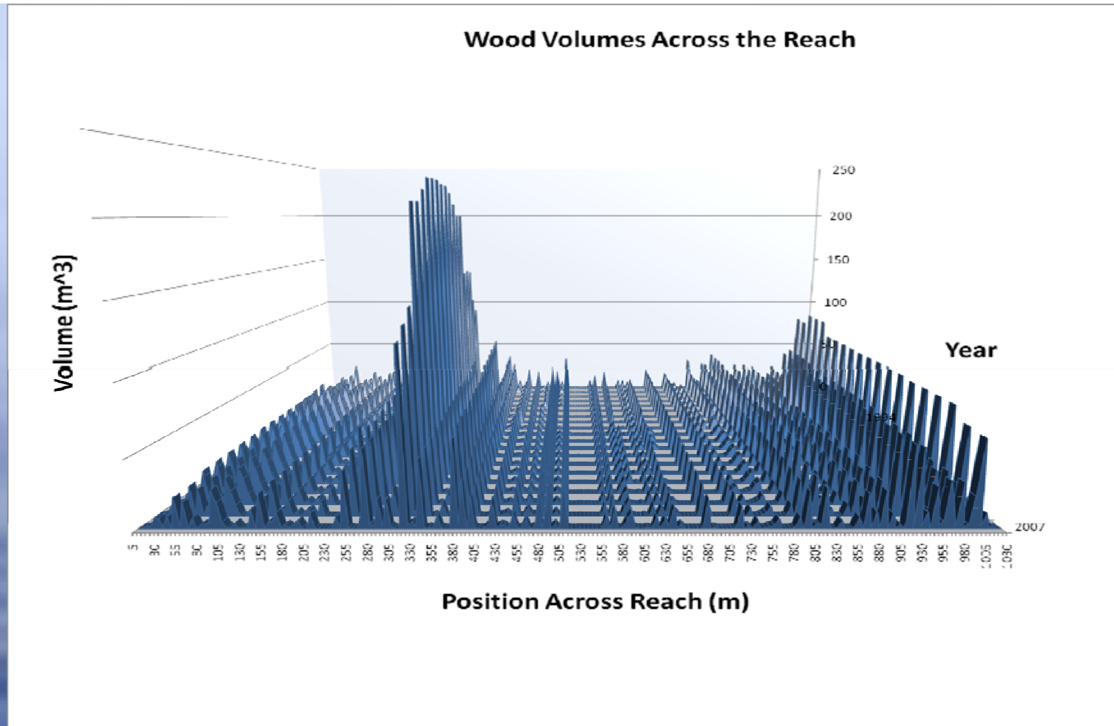
90
80
70
60
50
40
30
20
10
0
100
90
80
70
60
50
40
30
20
10
0.5
Recurrence Interval (Years)
>1.5
1.5
1
0.8
0.6
0.5
0.4
0.35
0.3
0.25
0.2
0.15
0.1
Length to Bankfull Width


Wood Volumes Across the Reach
Volume (m^3)
250
200
150
100
50
0
Year
2007
5
30
55
80
105
130
155
180
205
230
255
280
305
330
355
380
405
430
455
480
505
530
555
580
605
630
655
680
705
730
755
780
805
830
855
880
905
930
955
980
1005
1030
Position Across Reach (m)



Wood Volumes Across the Reac
Position Across Reach (m)
5
205
405
605
05
1005
Volume (m^3)
250
200
150
100
50
0
Year
2007
2006
2005
2004
2003
2002
2001
2000
1999
1998
1997
1996
1995
1994
1993
1992
1991
1990
1989
1988


Key Pieces Along the Reach
Count
0
5
10
15
20
25
30
Position Along Reach (m)
5
35
65
95
125
155
185
215
245
275
305
335
365
395
425
455
485
515
545
575
605
635
665
695
725
755
785
815
845
875
905
935
965
995
Year
1988
1993
1998
2003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Volume (m^3)
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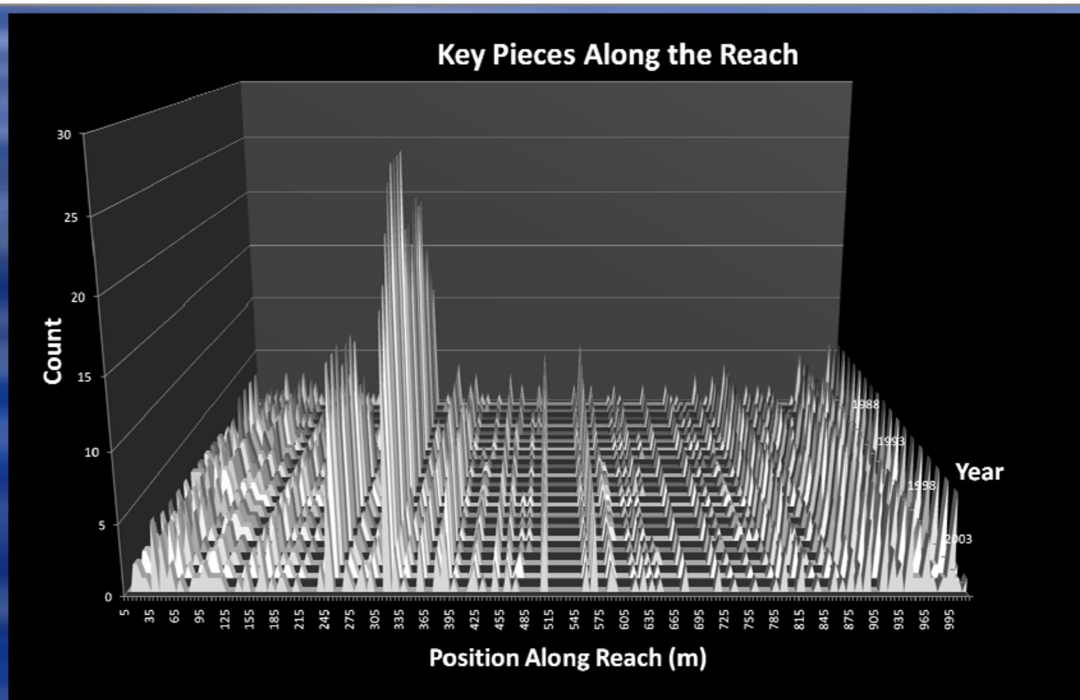
150
100
Year
2007
Position Across Reach (m)


Key Pieces Along the Reach
Count
30
25
20
15
10
5
0
1988
1993
1998
2003
Year
5
35
65
95
125
155
185
215
245
275
305
335
365
395
425
455
485
515
545
575
605
635
665
695
725
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785
815
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875
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935
965
995
Position Along Reach (m)

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1.) Predict probability of movement of logs and ask how well we are able to make these predictions given our parameters.

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Other Stuff We Did

- Cold Creek Mapping with John Faustini
- Got REALLY good at Ping Pong
- Took nice long walks

- Learned TONS of stuff!!!!

Acknowledgements

- NSF REU
- Mark Meleason
- Desiree Tullos
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- John Faustini
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- Gran Stegory
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- HJ Andrews staff
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- EISI 2009
  - Vu, Greg, Jon, Kevin, Andrew Z, Eli, Meridith, Ben, Michelle, Ed, Brian, Dylan, Alex, Harry, Julie Lapidus, Raymundo, Amanda, Jose, Gelseigh, Andrew N
- Beard guy
- Coffee and cigarette guy
- The deer, especially the fauns

Thank you all!


Questions?