Potentially available LWD metrics for assessing riparian forest function

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Introduction

- Contexts for LWD models and metrics
  - Ecological *vs.* management and regulatory
- Potentially available functional LWD (AFLWD)
  - Assumptions and computational methods
- Reference condition definition
- Management scenarios and assessments
- Equivalence of AFLWD and an ecological model
- Closing remarks

Ecological context

- Understanding or knowledge oriented
  - How did we get here?
  - How does this work?
- Past looking
  - What processes caused the observed conditions?
- Accumulative or integrative processes
  - Inputs, outputs, changes integrated over time

Regulatory/management context

- Control and compliance oriented
  - Are we where we are supposed to be?
  - How can we achieve our objective?
- Instantaneous (present) and future looking
  - Are we currently in compliance?
  - How can we stay in compliance?
- Measurement and comparative processes
  - What's on the ground now?
  - Is it what we want? How do we get/keep what we want?

Conflicting contexts

- Potential for conflict exists between the past looking, knowledge oriented ecological context and the present and future looking, control and compliance oriented regulatory and management context
  - Requires negotiation and compromise
  - Can lead to unwanted complexity
  - Can lead to oversimplification

Resolving the conflict

- Simplify, don't oversimplify
  - The underlying issues **are** ecological
  - Regulatory and management tools should be consistent with the ecology but easier to use and understand than knowledge oriented ecological tools
- Choose appropriate attributes
  - Develop regulatory and management tools using ecologically relevant attributes whenever possible
  - The attributes may not be the same as those used in the ecological, knowledge oriented tools

Relevant simplification

- Potentially available functional LWD (AFLWD) is used as an example of relevant ecological simplification
  - Source (forest) based, not stream based, LWD hence *available*
  - Larger streams need larger LWD logs to support functions, e.g., pool formation
  - Uses a bootstrap simulation framework to approximate distributions of LWD values

AFLWD assumptions: Part 1

- LWD recruited to a stream must come from adjacent forests within its watershed
- Standing trees are, therefore, the source for future LWD logs
- Live trees were chosen for AFLWD
  - Ease of use with growth models
  - Ease of identification and measurement by landowners
- Trees are assumed to have a single bole

AFLWD assumptions: Part 2

- Don’t model in stream LWD
  - Too complicated, too much model uncertainty
  - Recall: interested in regulatory/management context
- Model instead the potential for instream LWD from the pool of available (standing live) trees in the adjacent forest, i.e., the supply of LWD
- Use the individual trees and their volumes rather than volume or biomass alone
  - This includes the discrete nature of the trees and their mass or volume, both of which are relevant

AFLWD assumptions: Part 3

- Trees fall randomly relative to a stream
  - Should be a good enough approximation to make relative comparisons among alternative management scenarios or for assessing regulatory compliance relative to a standard
- Trees fall independently of one another
  - Not realistic: overestimates for distant trees
  - Weight by probability of stream intersection to reduce potential overestimation of LWD

AFLWD assumptions: Part 4

- Don’t include LWD log breakage
  - Piece counts may be low
- Compute estimates of both volume and number of pieces
- Functional LWD log dimensions vary by stream size
  - Larger streams require larger LWD logs to achieve functions, e.g., pool formation
  - Think of this as log “stickiness”

AFLWD assumption: Part 5

- Define potential LWD logs relative to the point of intersection with the nearest stream bank
- Do not count any portion of the log on the near bank
  - This will underestimate LWD log volumes and dimensions
- LWD logs are measured from the point of near bank stream intersection to a specified minimum upper stem diameter

What about snags?

- Snags and fallen trees were standing live trees at some point, and would be considered when they were living trees
- Snags make up a small percentage of the standing wood (Ohmann and Wadell, 2002)
- Older snags contribute less to functional LWD because they are partially decomposed when they eventually fall
- Snags already play an ecological role as wildlife trees

AFLWD Computation Inputs

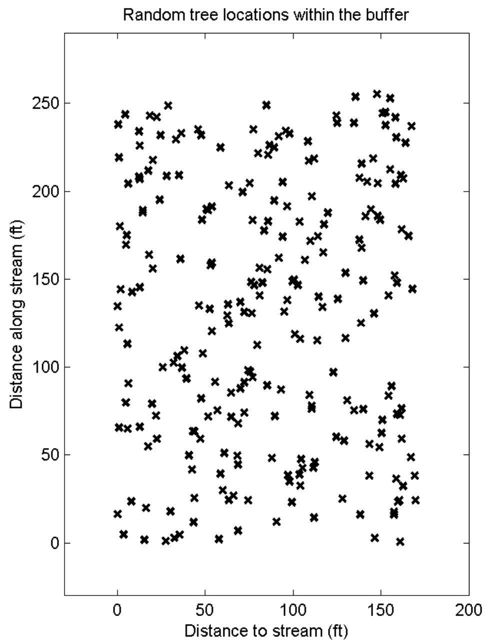
- A tree list: DBH, height, TPA and species.
  - Forest model output or actual data
  - A taper equation for Douglas fir (Kozak, 1988) was used to compute volumes for all trees
- The modeled area
  - A one acre area, 170 ft wide on one side of a stream with a reach of 256.2 ft
- Minimum diameters, lengths for functional LWD log sizes
- Specify number of simulation trials

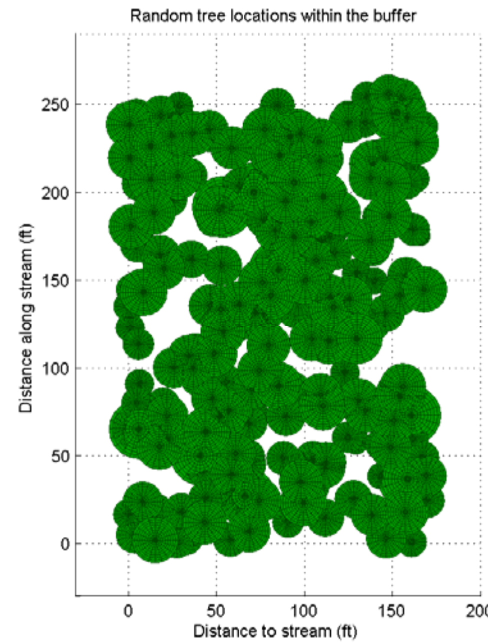
AFLWD stream/log size classes

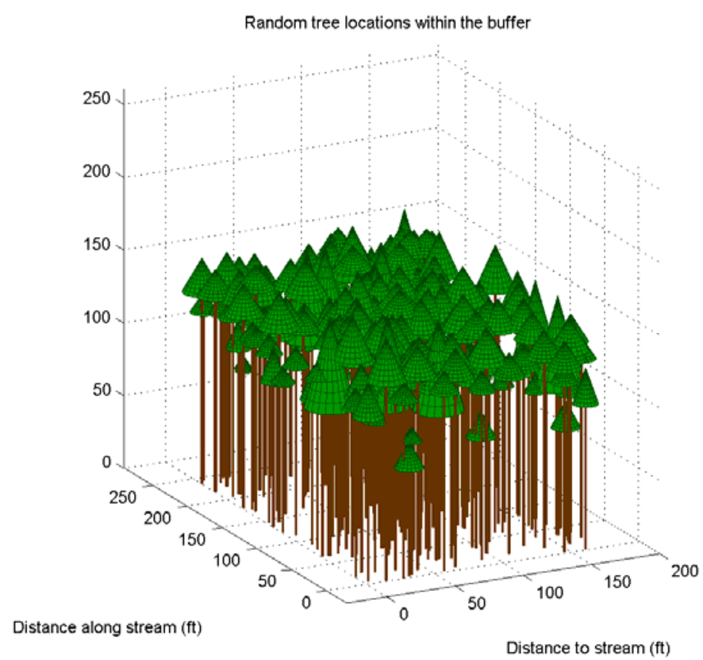
Stream/log size class	Bank full width (ft)	Minimum diameter (in)	Minimum length (ft)
A	75.0	25.6	44.0
B	30.0	10.3	24.5
C	15.0	5.3	15
D	7.5	4.0	7.5
E	5.0	4.0	6.6

Tree list expansion and placement

- Step 1: Expand the tree list into individual trees having TPA values ≤ 1
  - Replicate each tree having a TPA value > 1
    - Obtain whole trees having TPA values of 1
    - If there is a fractional remainder, include this too using a fractional TPA value (TPA < 1)
- Step 2: Randomly (uniformly) assign trees within the modeled area or buffer zone
  - Only need distance from stream for AFLWD
  - Location along the stream was also assumed to be random, needed for shade/blocking post processor

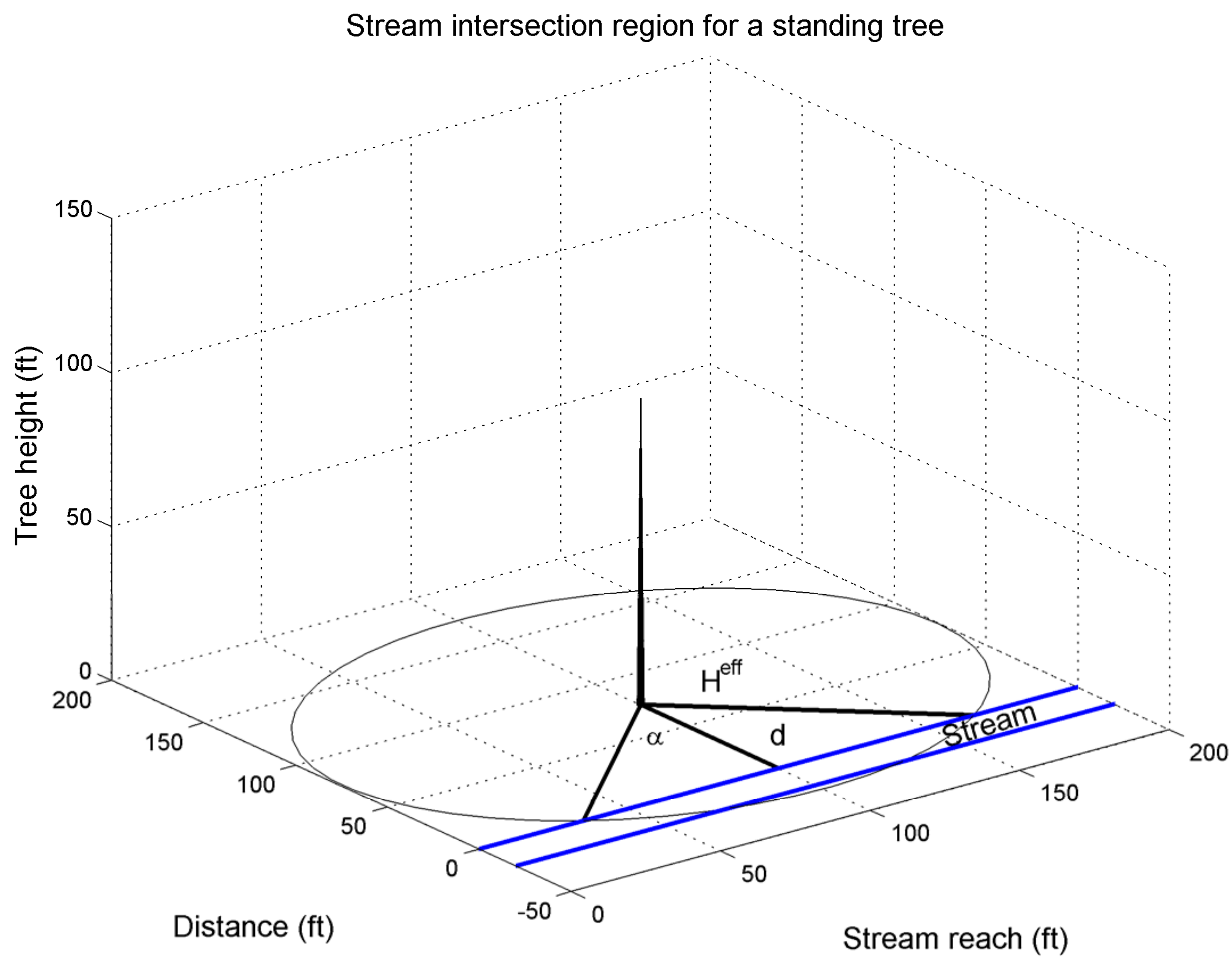

Random tree locations within the buffer
Distance along stream (ft)
Distance to stream (ft)
250
200
150
100
50
0
0
50
100
150
200


Random tree locations within the buffer
Distance along stream (ft)
Distance to stream (ft)
250
200
150
100
50
0
0
50
100
150
200


Random tree locations within the buffer
250
200
150
100
50
0
Distance along stream (ft)
Distance to stream (ft)

Stream intersection

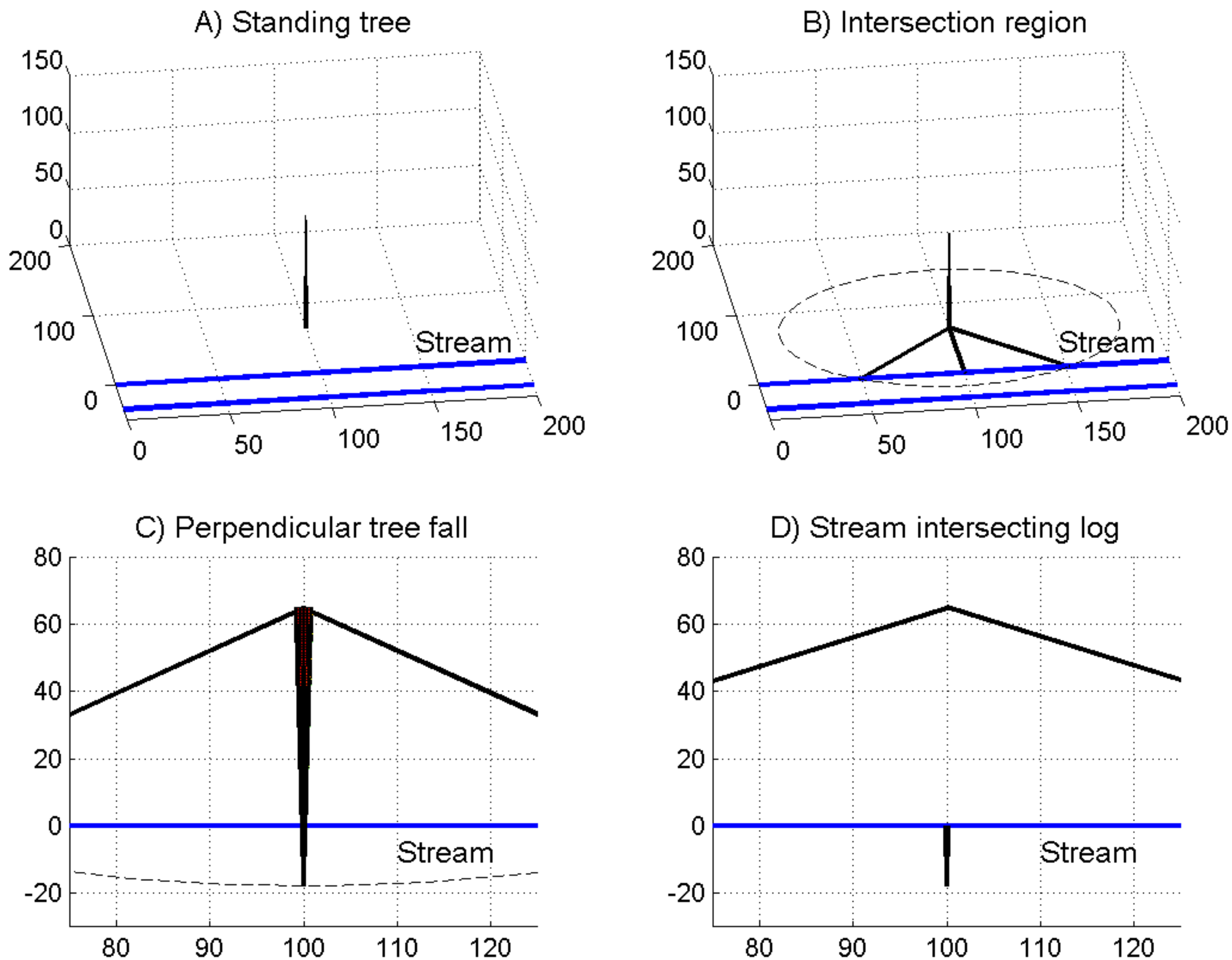
- Step 3: Compute the effective tree height and the limiting stream intersection angle α for each tree
  - Effective height was the height to a 4 inch upper stem diameter
- Step 4: Compute the probability of stream intersection for each tree
  - A uniform fall direction distribution was assumed
  - The probability of stream intersection is then α/180 for angles measured in degrees



Stream intersection region for a standing tree
Tree height (ft)
150
100
50
0
200
150
100
50
0
-50
Distance (ft)
0
50
100
150
200
Stream reach (ft)
H^eff
d
α
Stream

Tree fall and AFLWD logs

- Step 5: Assign a stream intersecting fall direction to each tree
  - Random (uniform) within (-α, α)
  - Perpendicular to stream for maximums
- Step 6: Compute the dimensions and volume of the stream intersecting logs
  - Point of near bank intersection is the log base
  - Top of the log is the effective height location



A) Standing tree
B) Intersection region
C) Perpendicular tree fall
D) Stream intersecting log
Stream
Stream
Stream
Stream
150
100
50
0
200
100
0
0
50
100
150
200
80
60
40
20
0
-20
80
90
100
110
120

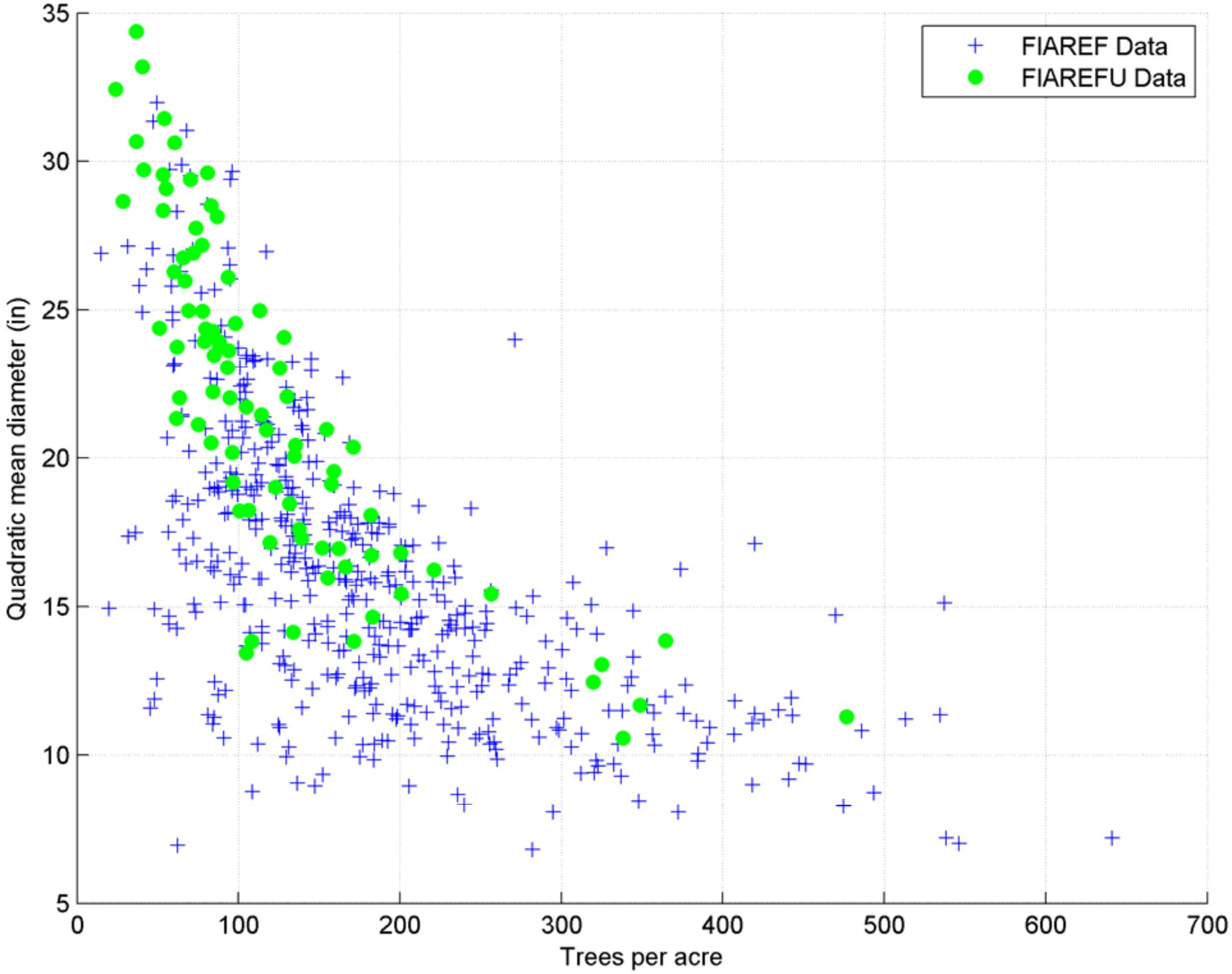
Expected AFLWD values

- Step 7: Compute the expected AFLWD contribution for each tree using the probability of stream intersection
- Step 8: Sum the expected values filtering by the minimum dimensions specified for each stream or log size class
  - This gives frequency/volume by size class
- Step 9: Repeat steps 1-8 the desired number of times and compute the desired statistics or distributions

Reference condition

- 553 sample plots from FIA IDB v2.0
- Age range from 100 to 180 years
- Douglas-fir dominated stands
  - At least 50% of basal area Douglas-fir and FIA stand type of Douglas-fir
- Not specifically riparian
  - For gross characteristics likely not an issue
- All plots are not untreated
  - Given natural variability, likely not an issue

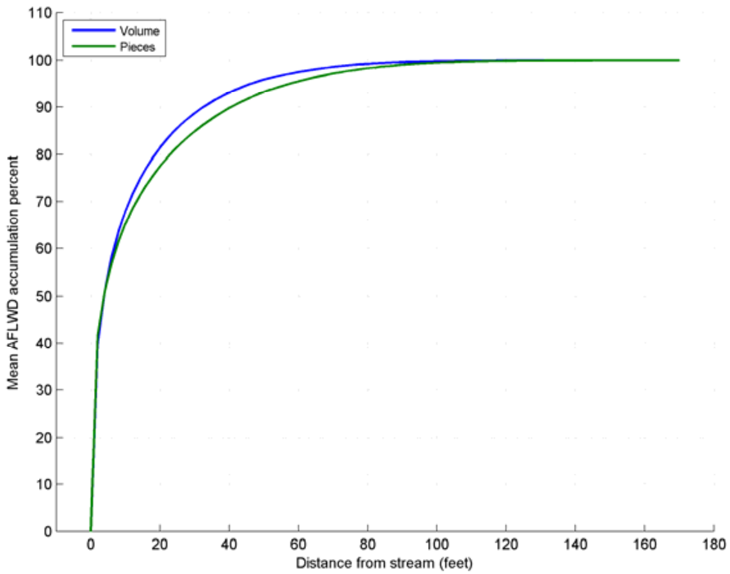
FIAREF QMD *vs.* TPA



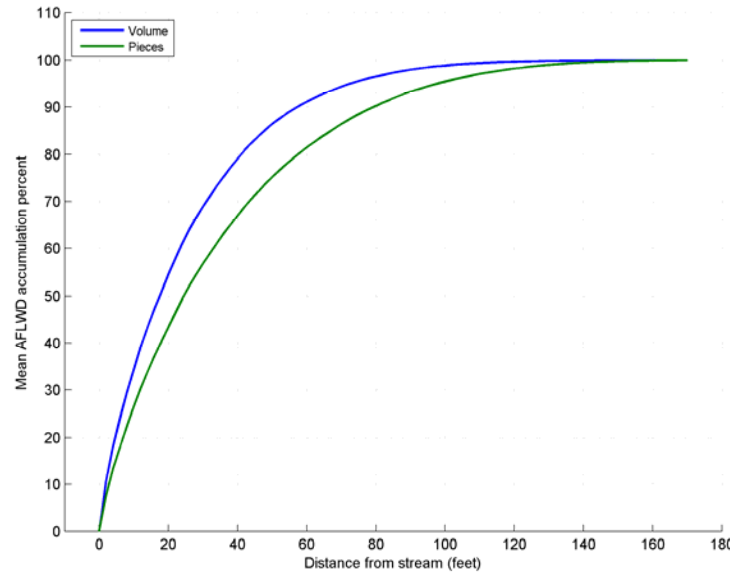
AFLWD results

- Computed source distance profiles for AFLWD volume and frequency
  - Stream/log size classes A and E
- Scatter plots of AFLWD volume and frequency
  - Stream/log size classes A and E

AFLWD source distances



Stream/log size class A



Stream/log size class E

AFLWD mean source distances

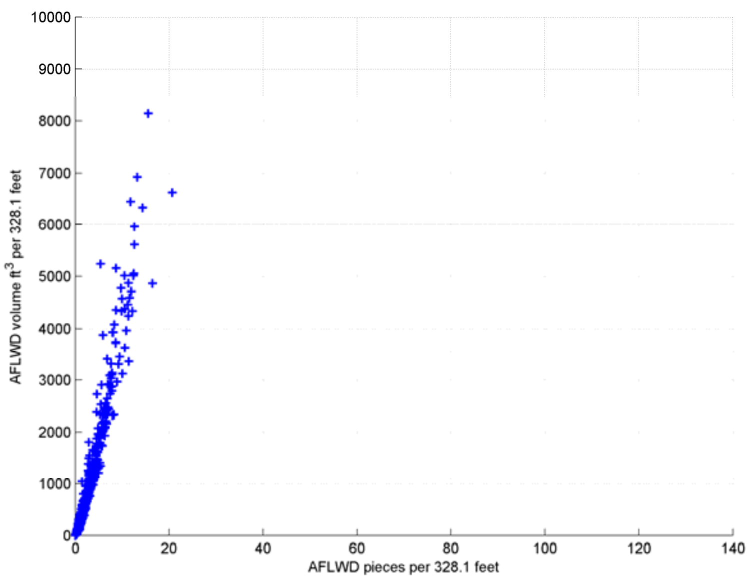
Stream/log size class A

Percent	Pieces	Volume
99%	89 ft	76 ft
95%	57 ft	46 ft
90%	41 ft	32 ft
80%	23 ft	19 ft
50%	4 ft	4 ft

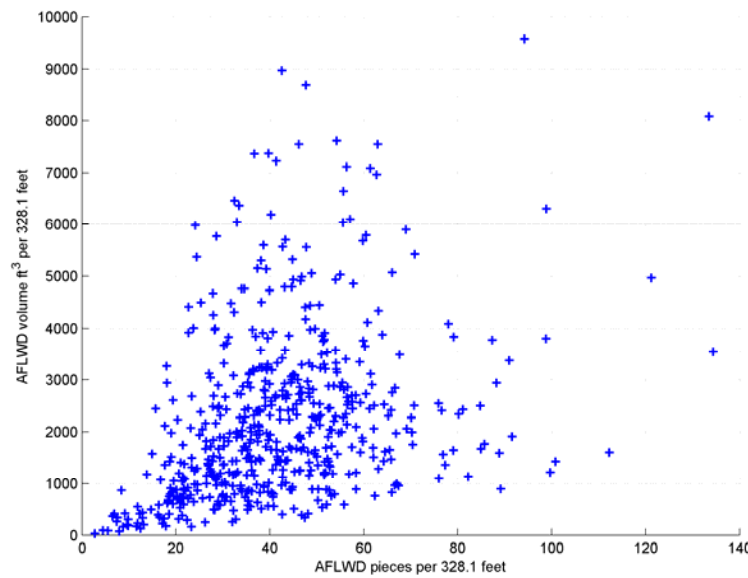
Stream/log size class E

Percent	Pieces	Volume
99%	130 ft	102 ft
95%	98 ft	72 ft
90%	79 ft	57 ft
80%	57 ft	41 ft
50%	24 ft	17 ft

AFLWD per 328.1 feet



Stream/log size class A

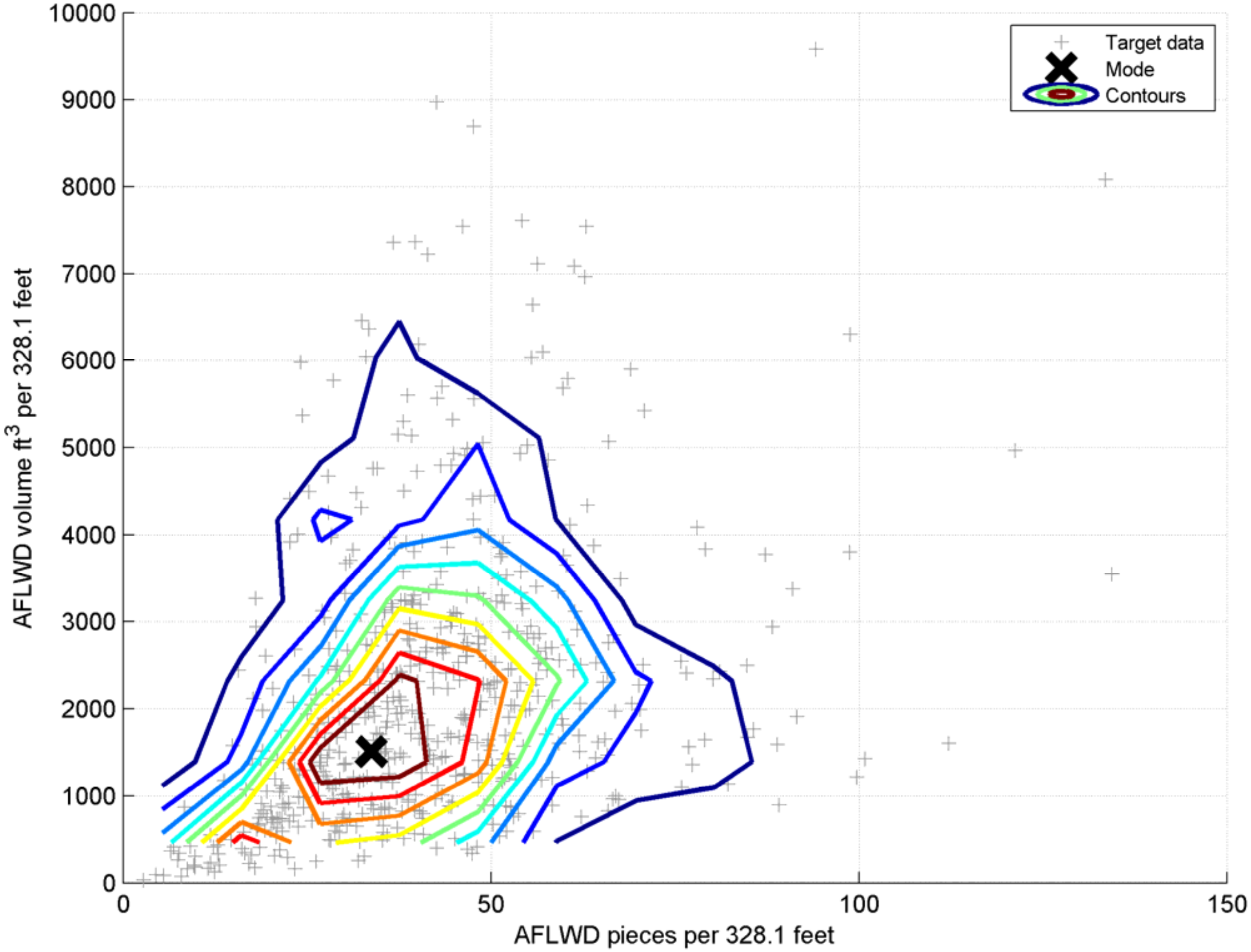


Stream/log size class E

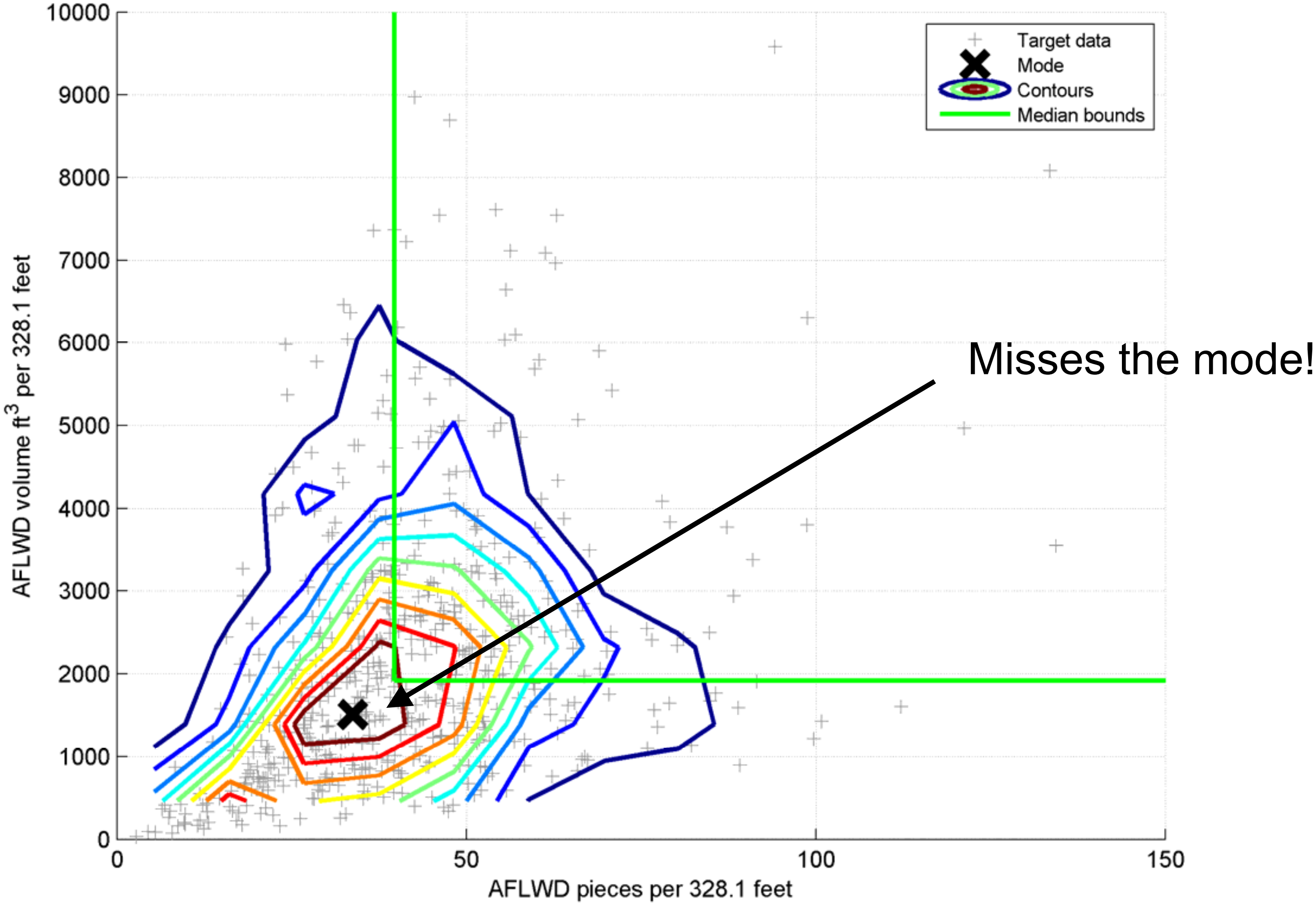
Assessment

- Simple assessment based on approximate likelihood contours of the AFLWD frequency and volume joint distribution for stream/log size class E
- A 90% acceptance region about the mode is used as the target
  - Simple lower bounds, e.g., median values, may be a poor choice

AFLWD joint distribution



Median based lower bounds



Management scenarios

- Douglas-fir dominant/pure stands
- Site Class II: 119-137 feet at 50 years
- Scenarios
  - 50 foot no harvest with 50 year rotation
  - Bio-Pathway (produces multistory canopy)
  - Forest and Fish Option 2 ≥ 10 feet
  - Forest and Fish Option 2 < 10 feet
  - No action

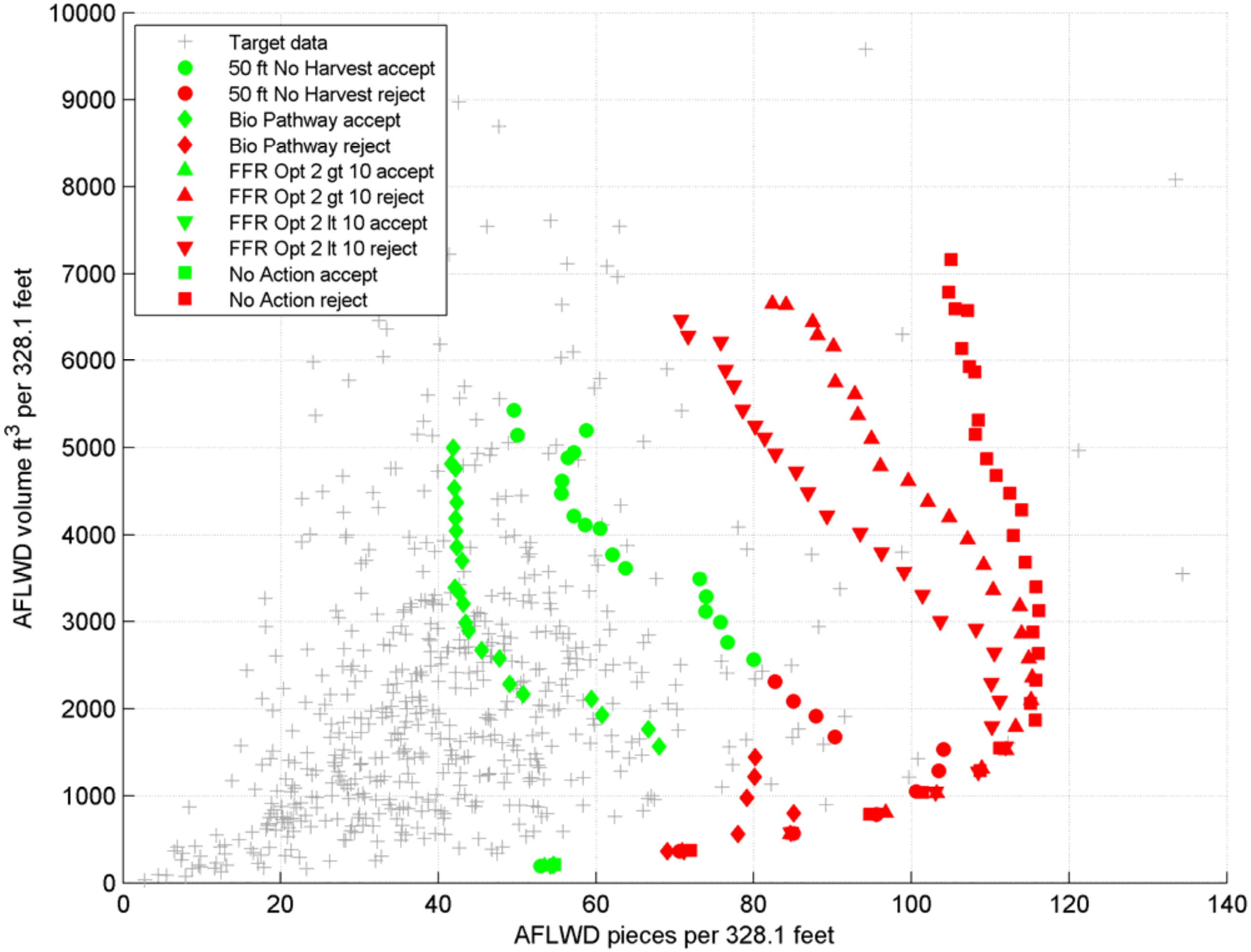
Initial conditions/Treatments

- 471 TPA planted Douglas-fir stand
- 20 years old
- Site index 120 feet at 50 years
- Located in southwest Washington
- Treatments
  - Do nothing
  - 50 year rotation with multiple thinnings
  - Multiple thinnings with underplanting
  - 10 and 20 TPA leave tree 50 year rotations

Simulated RMZ

- A one acre plot on one side of a stream
- 170 feet wide
- 256.2 feet of stream reach
- Interested in relatively dense riparian forest stands
  - WA state widened no harvest buffers with recent changes to its forest practices rules
  - This removed portions of planted stands adjacent to streams from management

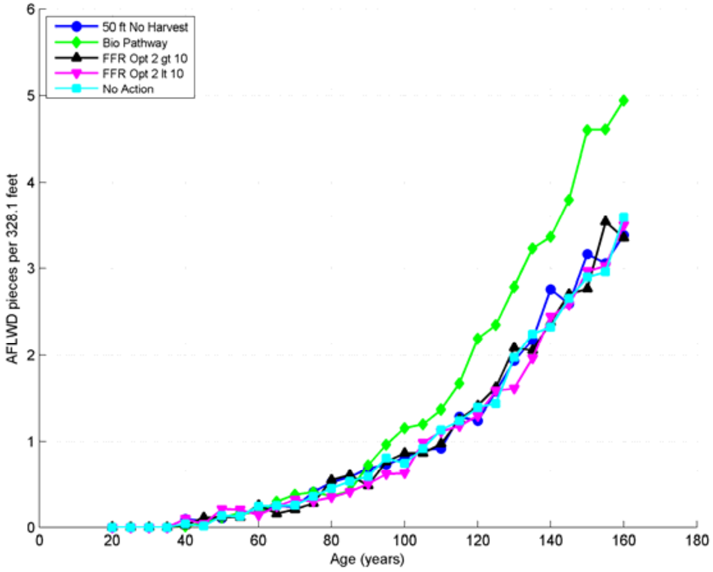
Assessment results



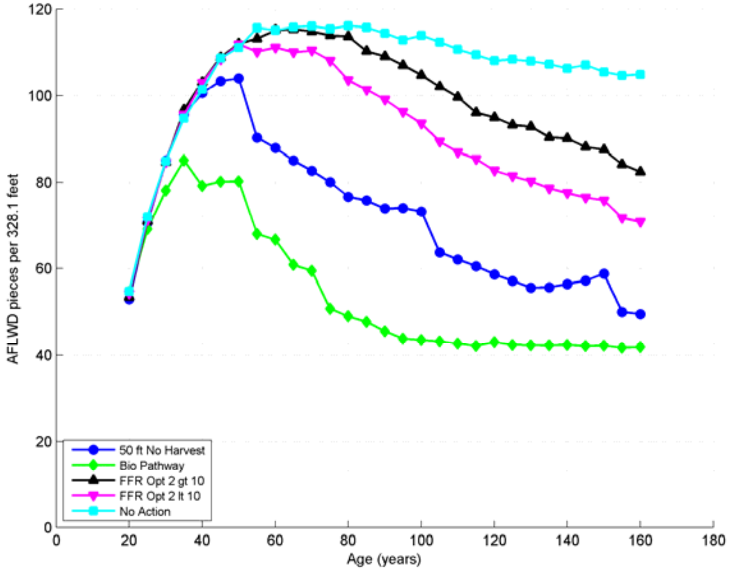
Assessment results

Management scenario	Percent accepted
50 ft no harvest	66%
Bio-pathway	79%
Forests and Fish ≥ 10 ft	3%
Forests and Fish < 10 ft	3%
No action	3%

Scenario AFLWD pieces

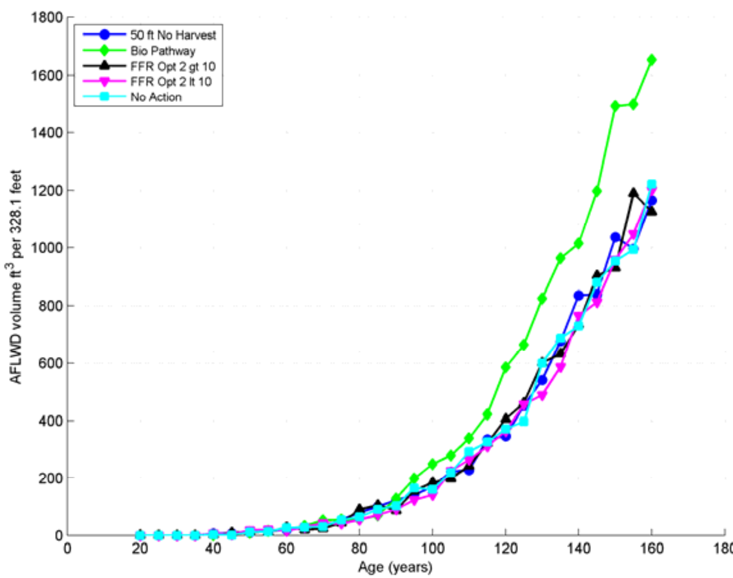


Stream/log size class A

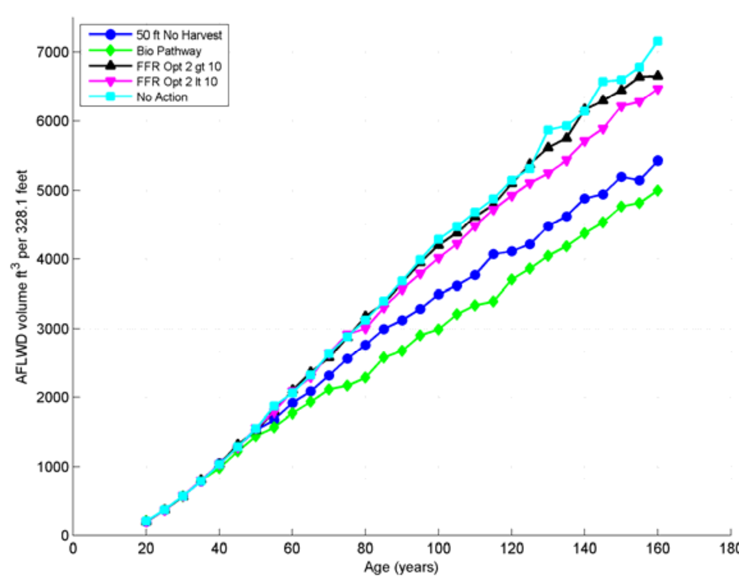


Stream/log size class E

Scenario AFLWD volume



Stream/log size class A



Stream/log size class E

Ecological model comparison

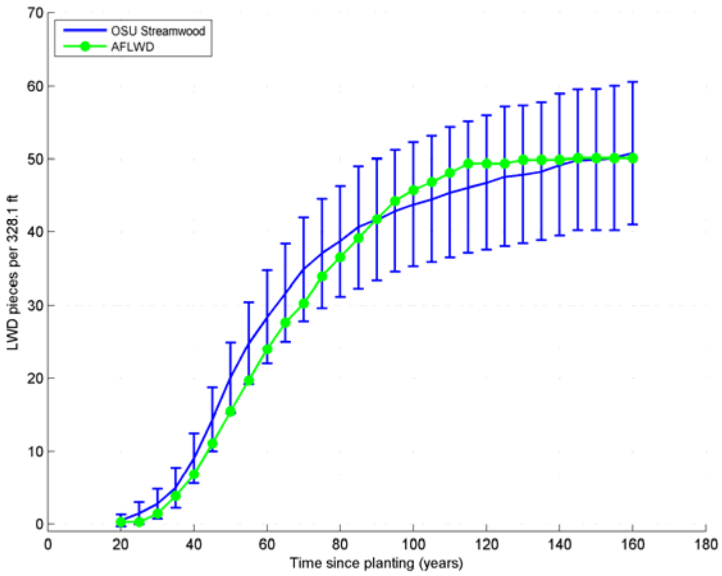
- OSU Streamwood (release 12/21/2001)
  - Latest version I'm aware of
- Essentially identical assumptions except:
  - OSU Streamwood simulates in stream LWD
  - OSU Streamwood assumes only mortality trees contribute to LWD
  - OSU Streamwood includes transport, breakage, decay, …
  - OSU Streamwood uses a forest gap growth model

Converting AFLWD to in stream

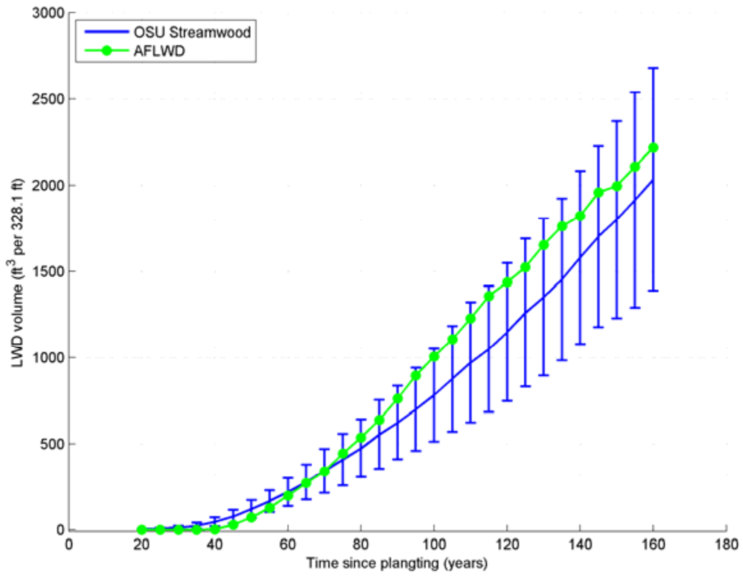
- Consider no action management scenario
- Compute mortality percentages
- Convert AFLWD values to mortality basis
- Account for dynamic losses:1.5% of mean in stream values from OSU Streamwood
  - 60 cubic feet of volume every 5 years
  - 3 pieces every 5 years
- Set negative values to zero
- Perform cumulative summation/integration

AFLWD *vs.* OSU Streamwood

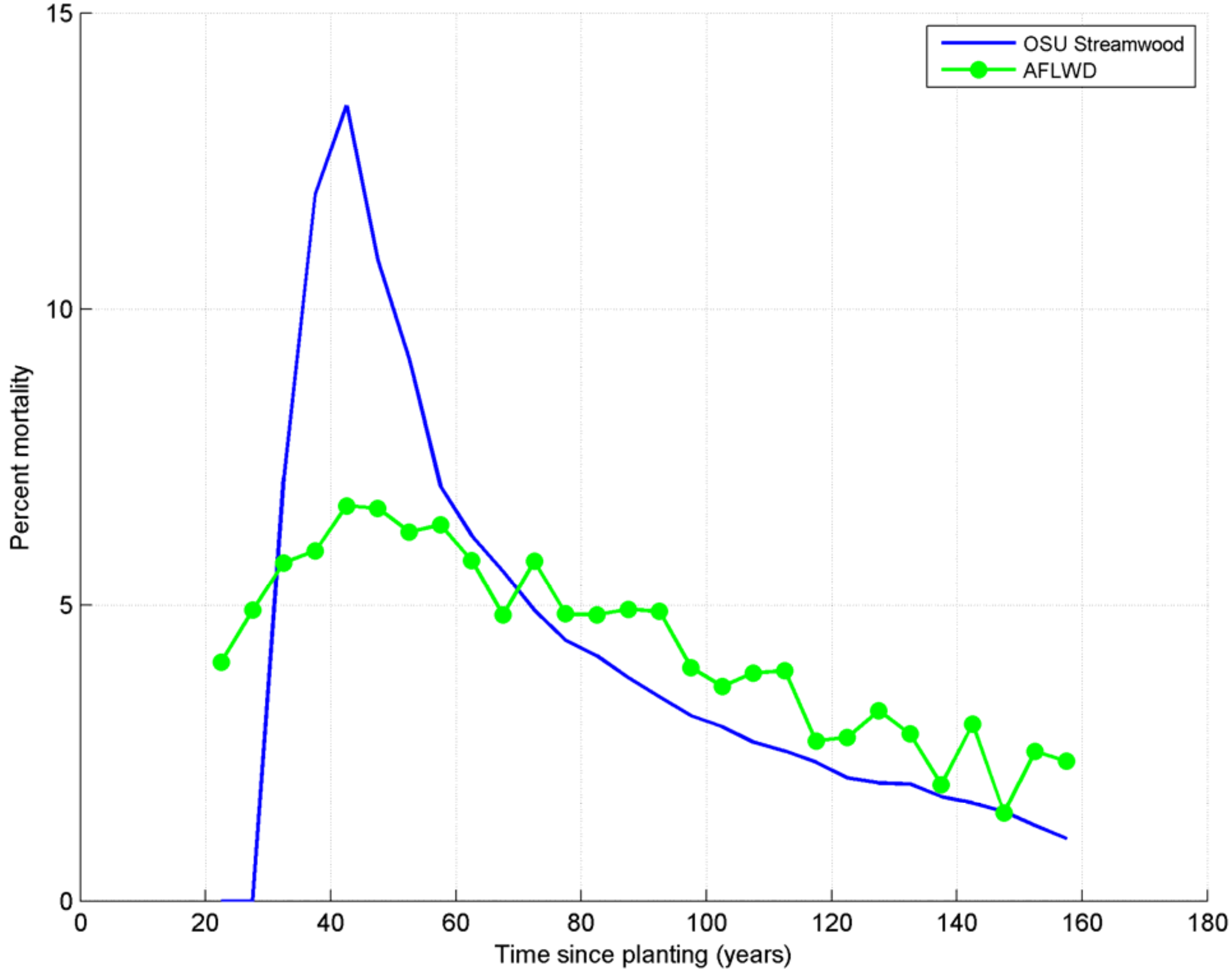
Pieces per 328.1 feet



Volume ft^3 per 328.1 feet

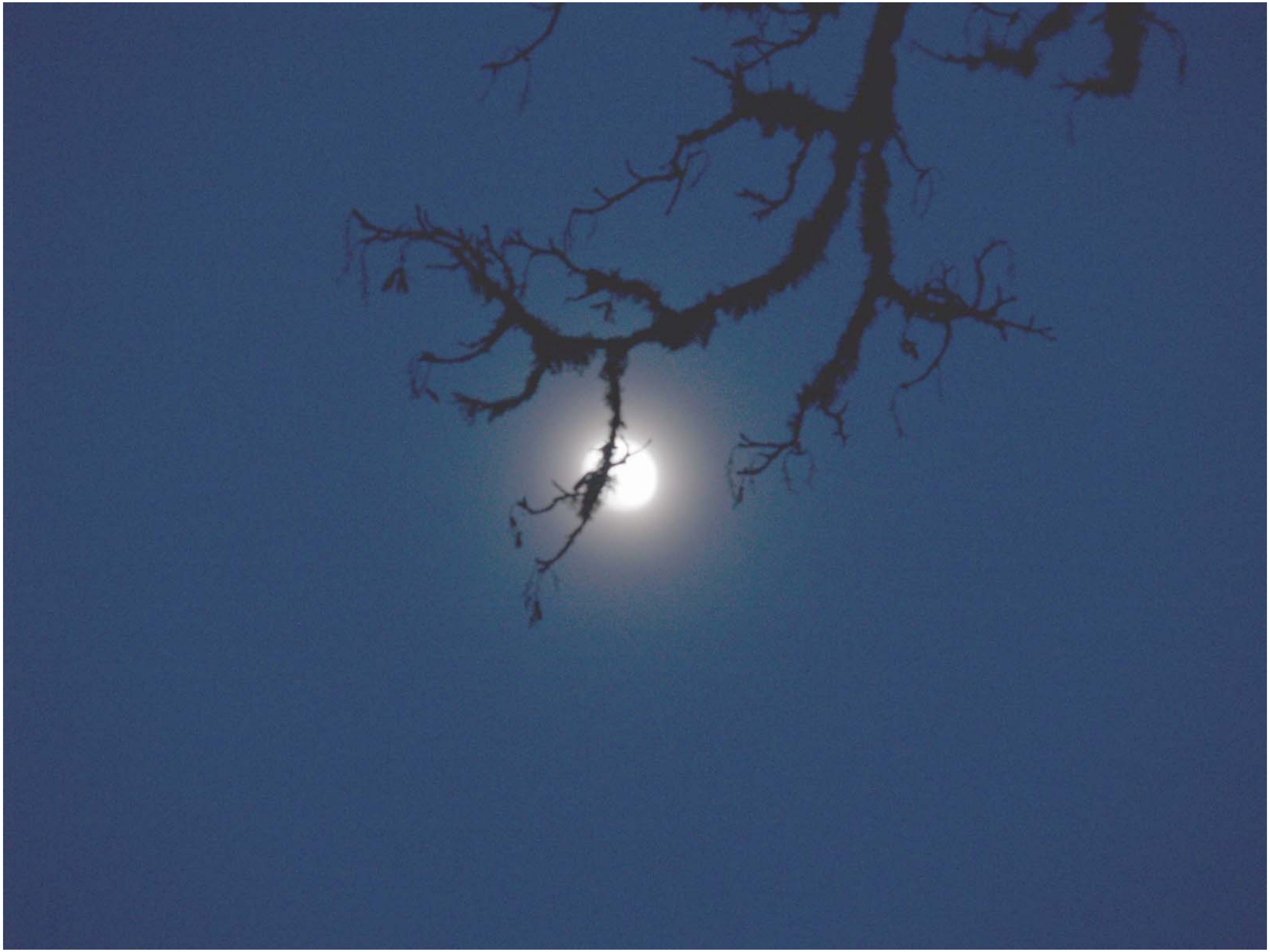


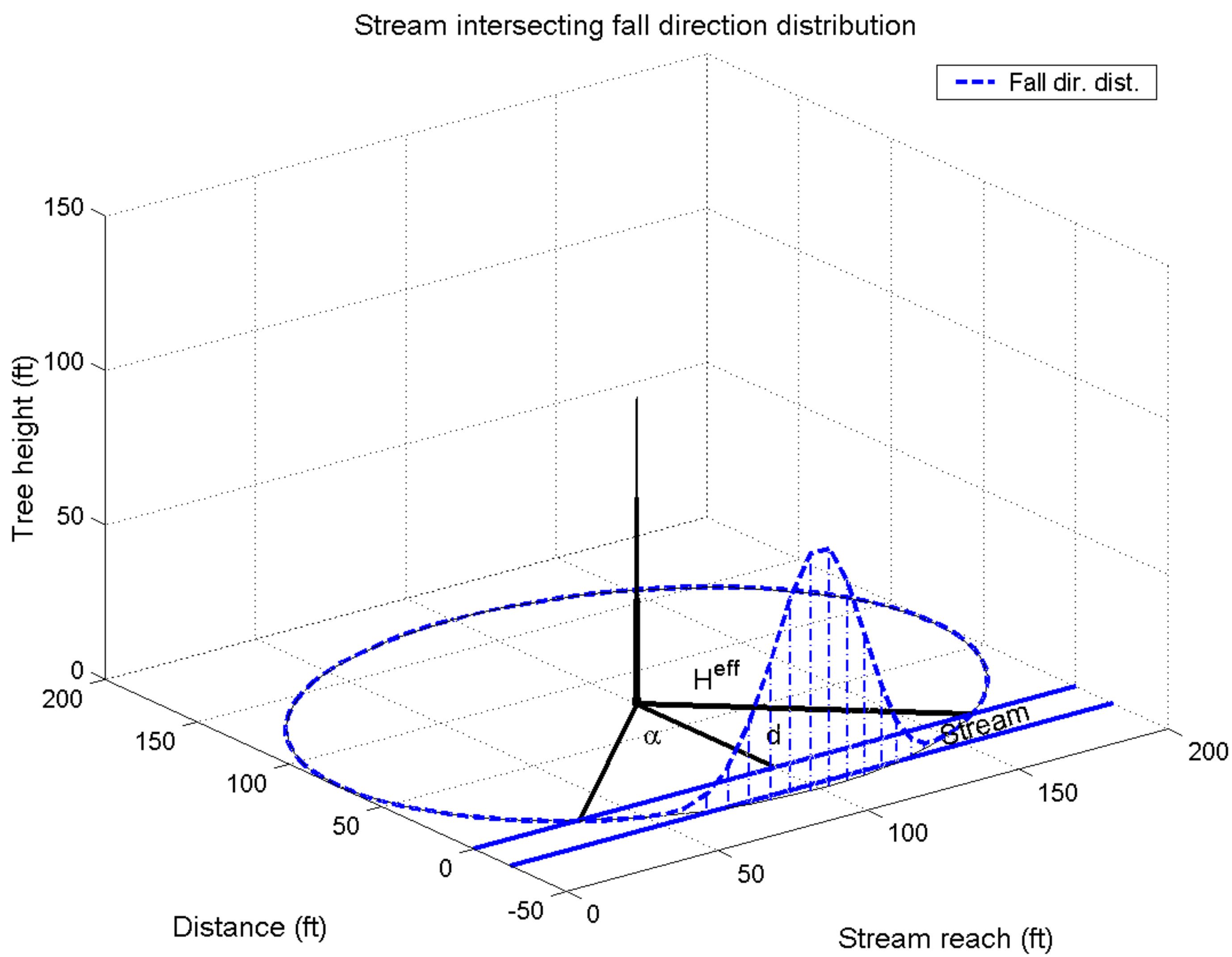
Mortality percent



Final remarks

- AFLWD metrics are easier to compute than in stream LWD metrics
- AFLWD metrics meet the present and future oriented needs of regulatory and management contexts
- AFLWD metrics may be effectively combined with assessment procedures
- AFLWD metrics are equivalent to a class of individual tree ecological models for in stream LWD





Stream intersecting fall direction distribution
Fall dir. dist.
Tree height (ft)
150
100
50
0
200
150
100
50
0
-50
Distance (ft)
0
50
100
150
200
Stream reach (ft)
H^eff
α
d
Stream

AFLWD rationale: Part 1

- We don’t know which trees will fall and enter a stream or when they will fall
- We know that regular mortality is **not** the only source of LWD that could enter a stream
- We know that the trees located closer to a stream are more likely to fall and enter it than are trees further away
- We know that trees adjacent to a stream are the source of LWD within a watershed
- We know that trees closer to a stream produce larger pieces of LWD

AFLWD rationale: Part 2

- Amounts of instream LWD are highly variable both temporally and spatially
  - A myriad of input processes (wind, landslides, erosion) and transport, breakage, decay, etc.
- Mass or volume balance approaches to instream LWD are extremely complex
  - Very general and difficult to validate
  - Individual trees are not directly represented, but they **are** the relevant entities
  - Need a log size distribution to be useful

AFLWD rationale: Part 3

- Tree fall directions may be preferential toward a stream
  - Particularly for wider streams
  - Smaller streams may have a more random pattern of tree fall
- Both fall patterns are relevant
  - Perpendicular fall directions provide estimates of upper bounds on LWD values
  - Random fall directions provide estimates of lower bounds on LWD values

AFLWD rationale: Part 4

- There may be a size-piece count trade off, particularly for larger streams
  - Volume or piece size may be more important than number of pieces for “quality” LWD
  - Larger streams require larger logs to act as functional LWD, e.g., pool forming logs
- Similar forests produce similar quantities and qualities of total LWD
  - Functional LWD is stream size dependent

AFLWD rationale: Part 5

- Instream LWD logs must be defined using the stream bank as a point of reference
  - How much of the log on the bank should count? In the stream? On the far bank?
  - While some data have been collected they have typically not been published
  - Different LWD models and tools use different assumptions and methods, complicating comparisons