Uncertainty and Extended Rotations

(a)Symmetric Risk and Surprise

Hugh Scorah

UBC Forestry

Two Primary Objectives

1. Think about risk in terms of information and surprise
2. Using options, not discounted cash flow to think about forestry investments.

I was taught probability in terms of...

1. Frequency – proportion of outcomes
2. The Bayesian interpretation – degree of belief
   - "When I get new information I update my prior"

Another possibility is an information theoretic approach

- Suppose you have a message coming through a channel that you wish to compress

- 000111010100011001101…

- The compression algorithm predicts that the next bit will be a 1 with probability 0.9999

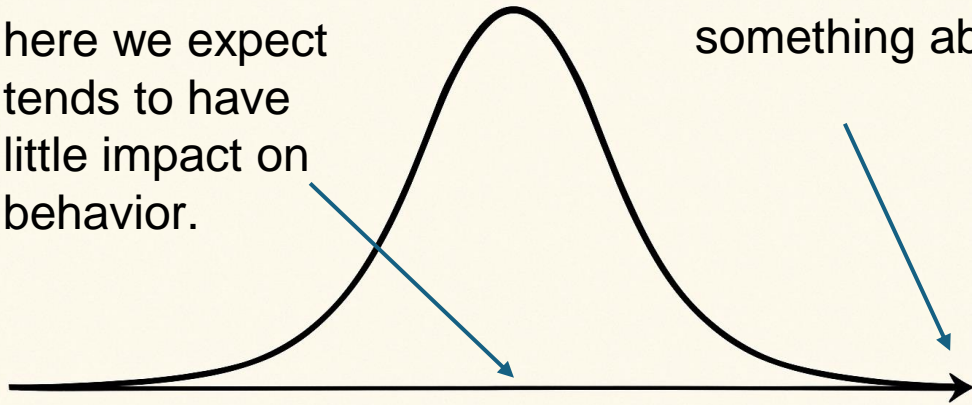- A 0 would be very surprising according to the model of the compression algorithm!

THE MATHEMATICAL THEORY OF COMMUNICATION

by Claude E. Shannon and Warren Weaver

Something carries information to the extent that it is surprising

An event in here we expect tends to have little impact on behavior.

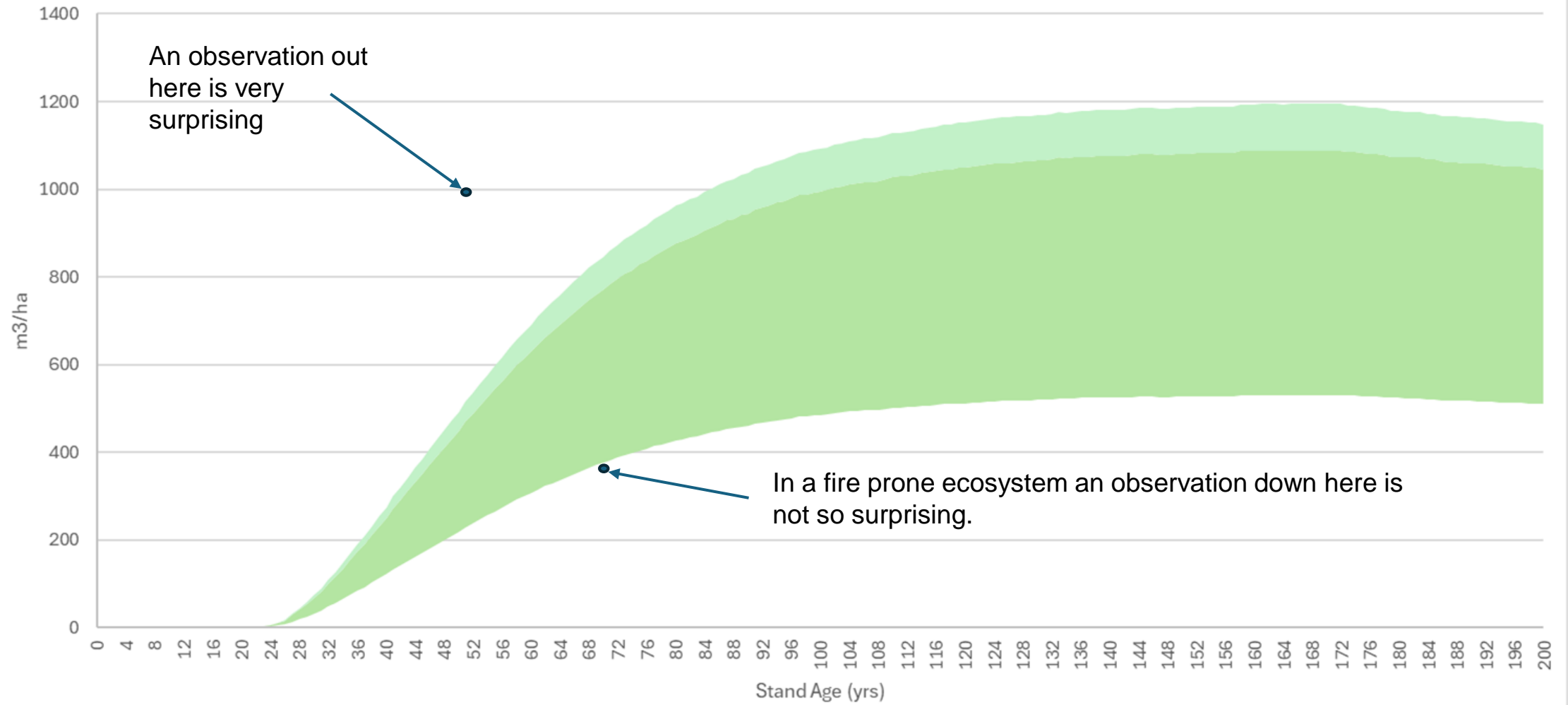An event out here we need to do something about
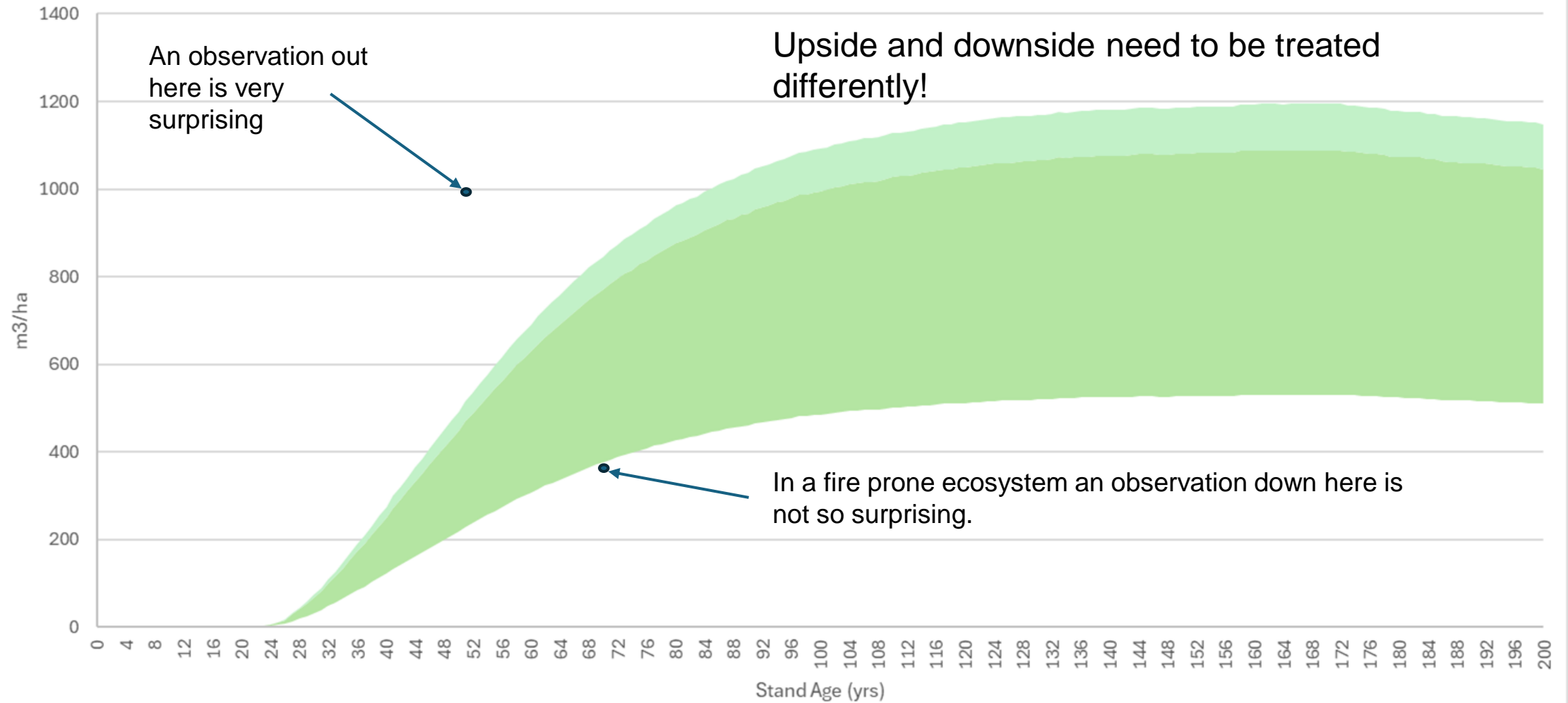
INFORMATION THEORY SECOND EDITION

THOMAS M. COVER
JOY A. THOMAS

Lodgepole Pine Stand Growth and Yield

An observation out here is very surprising

In a fire prone ecosystem an observation down here is not so surprising.

Lodgepole Pine Stand Growth and Yield

An observation out here is very surprising

Upside and downside need to be treated differently!

In a fire prone ecosystem an observation down here is not so surprising.

Treating upside and downside differently

- We like to treat uncertainty using symmetrical distributions in economics and finance because it makes the math easy
  - Both for the availability of analytical solutions and parameter fitting.

- We lose the characteristics of the underlying problem when we treat uncertainty this way
  - When something is surprising, and we should be changing behaviour and we tend to IGNORE it
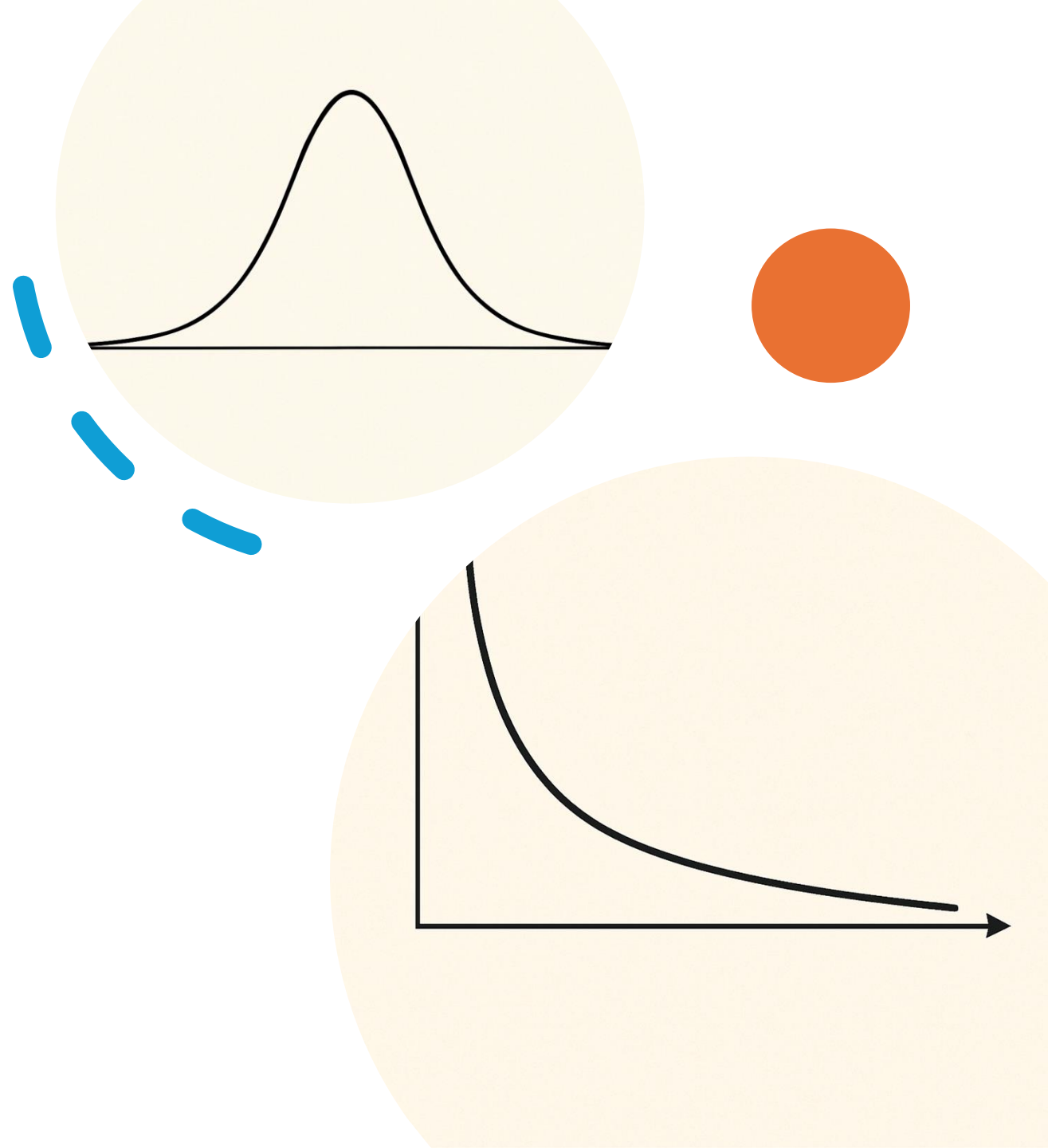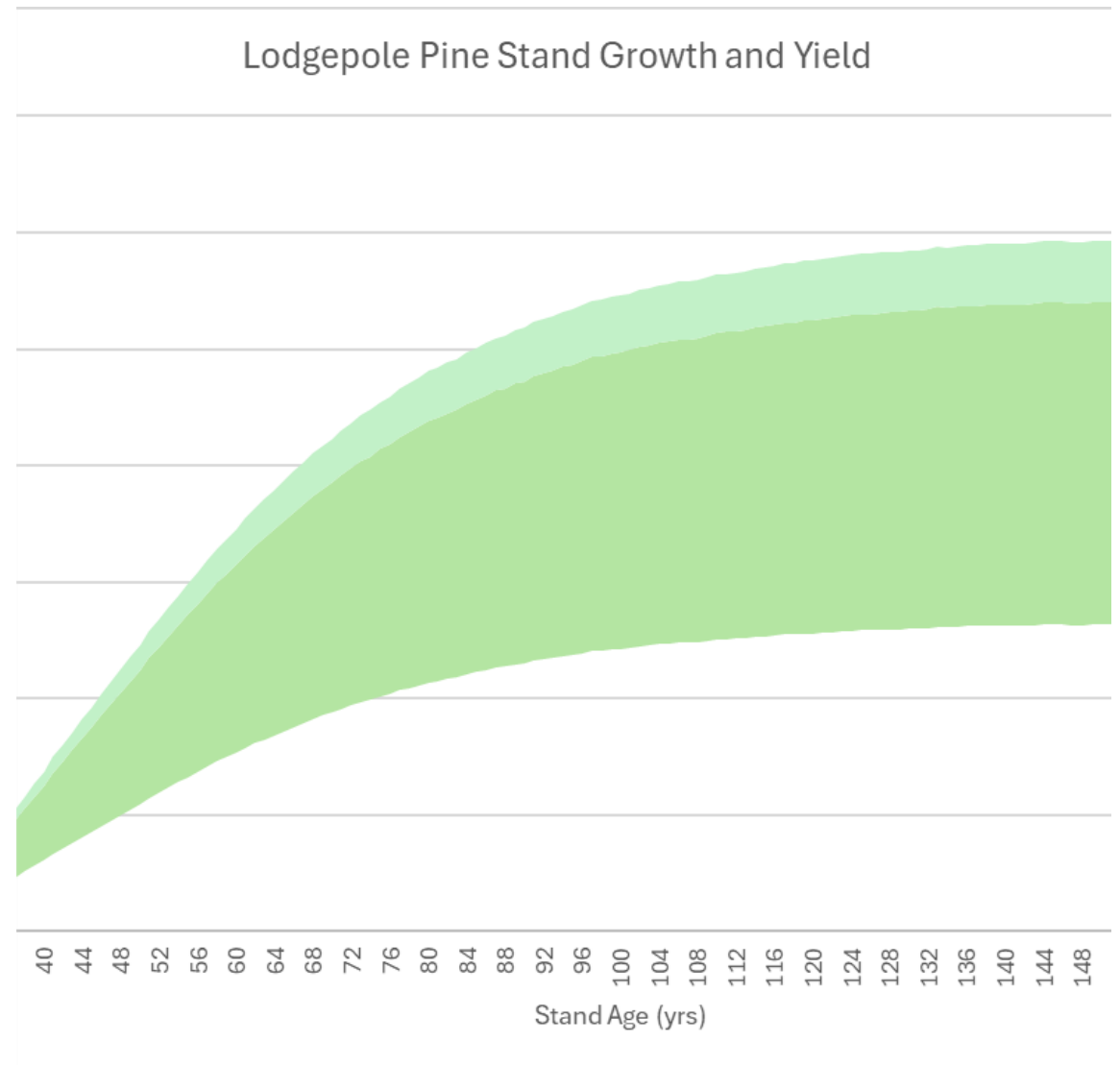
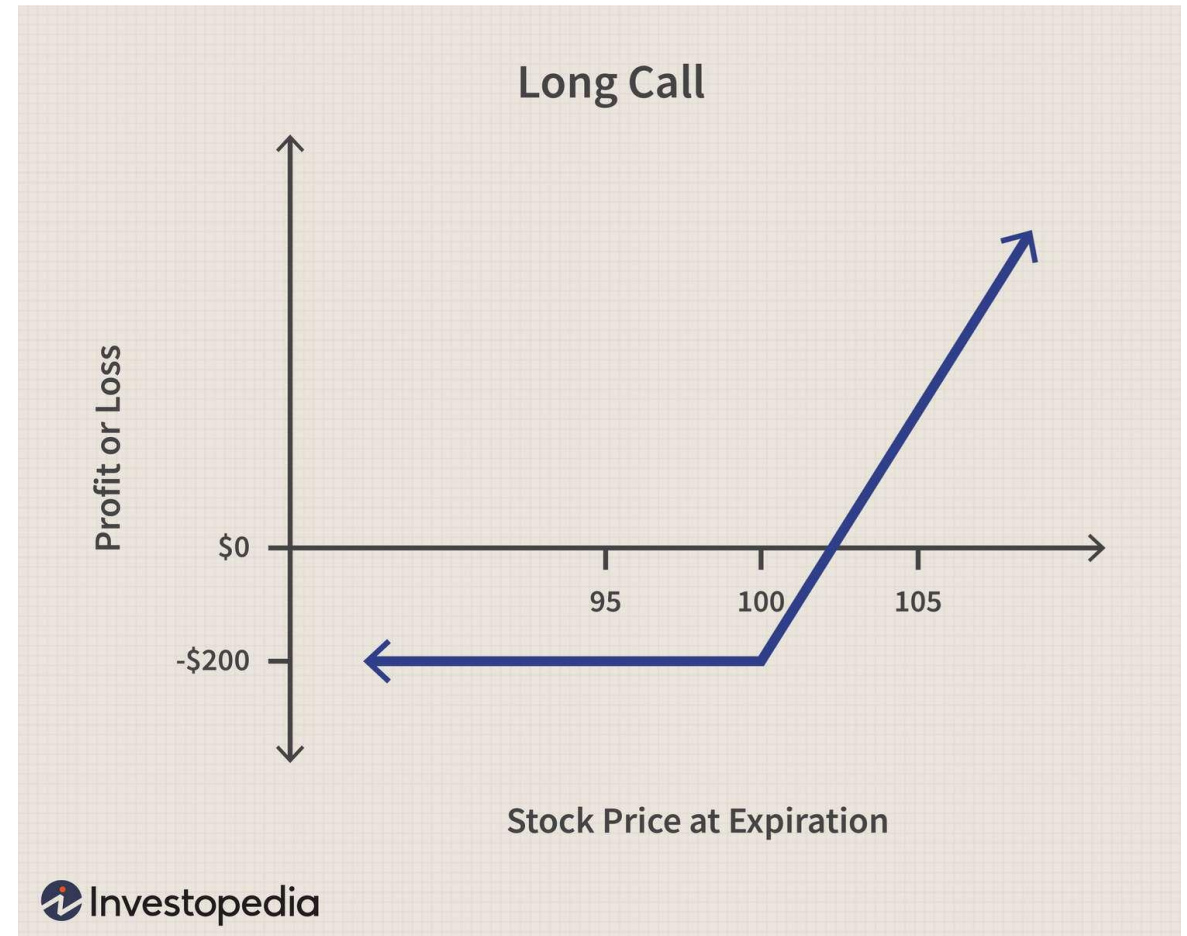# Consequences of ignoring surprises for stand/landscape option value

Components

- Growth and yield model

- Price model (mean-reverting)

- Cat-event model

DCF/Faustmann Approach

- Prices are fixed – choose to harvest when growth in stand value equals opportunity cost of starting subsequent rotations + investment of cash at the risk-free rate

Lodgepole Pine Stand Growth and Yield

Stand Age (yrs)

40 44 48 52 56 60 64 68 72 76 80 84 88 92 96 100 104 108 112 116 120 124 128 132 136 140 144 148
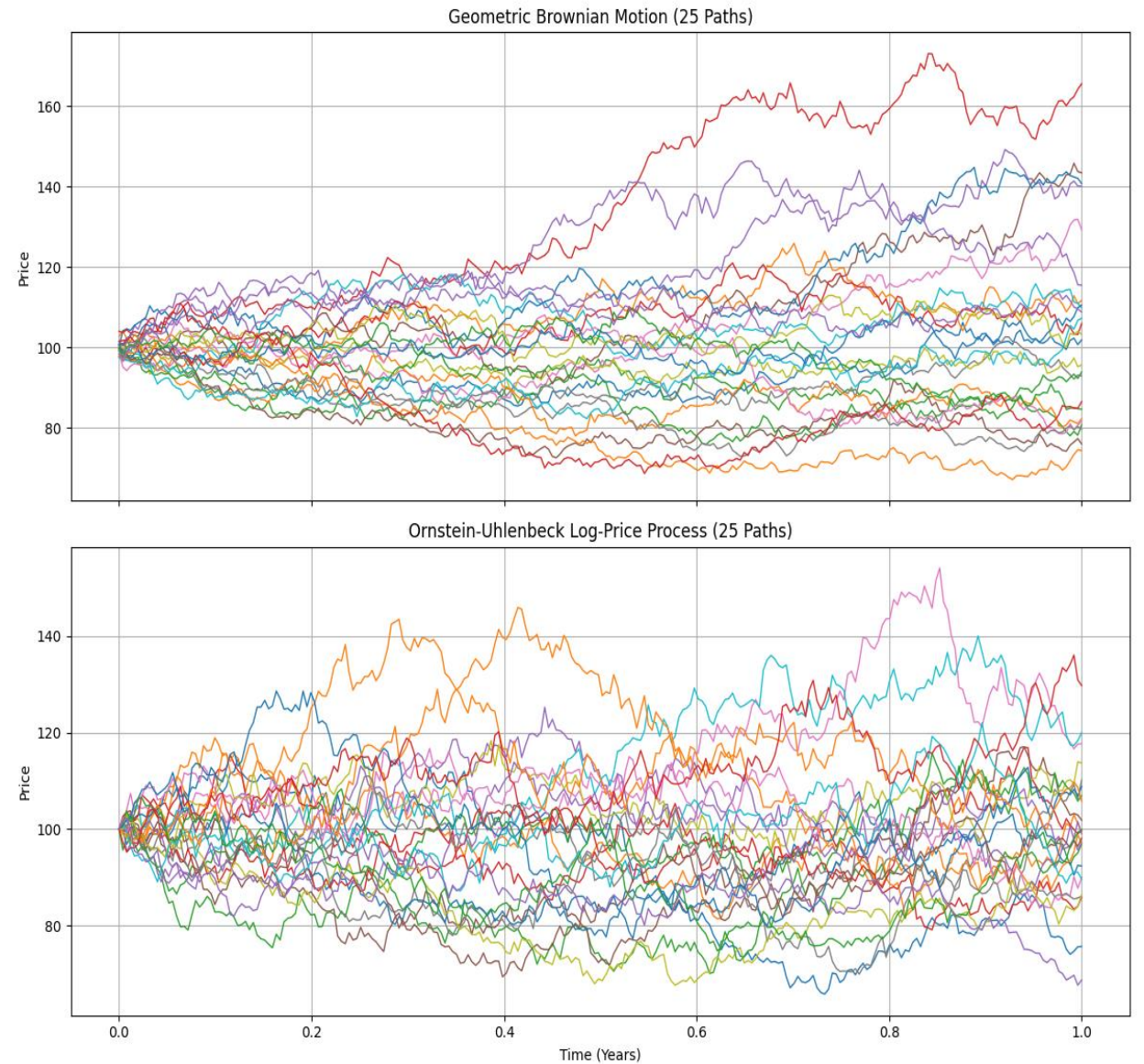
Pay-off of a call option

Price Model

$$GBM: dS_t = \mu S_t \, dt + \sigma S_t \, dW_t$$

$$OU: dS_t = \theta(\mu - S_t)dt + \sigma dW_t$$

Literature has settled on the OU-process for log prices.

Geometric Brownian Motion (25 Paths)

Ornstein-Uhlenbeck Log-Price Process (25 Paths)

Poisson process – fire return interval modeled using an exponential distribution

Catastrophic Event Arrival Process

Exponential Distribution ($\lambda = 1/10$)
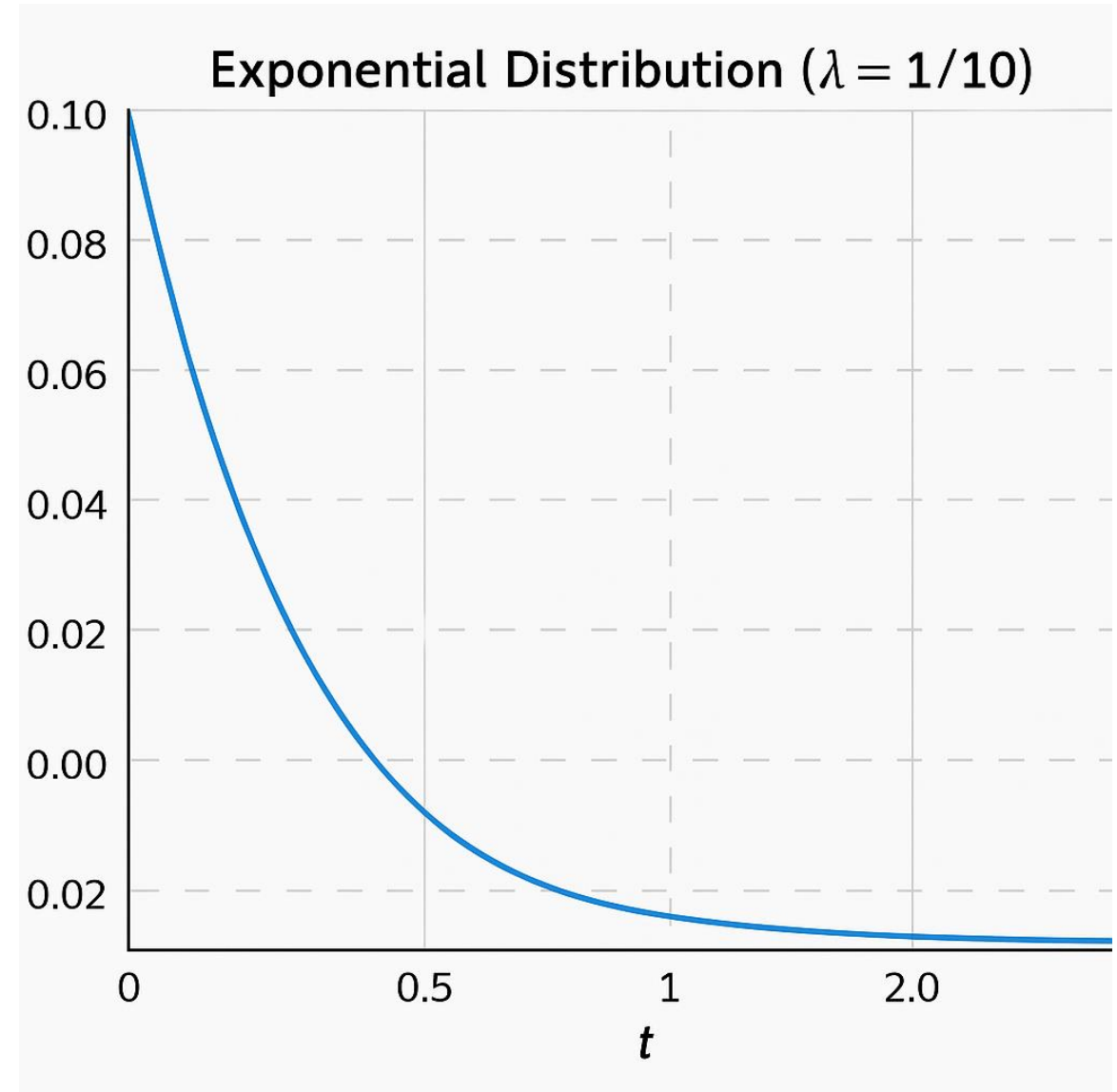
Assumptions for the Option Model

- Stand value is modeled as a call option with exercise of a European option being exercised at 50 years (base case), 60, 80 and 120 years extended rotations
- Log values modeled using an Ornstein-Uhnlenbeck process
- Cat fire which causes loss of 50% of the value of the stand arrives with mean return interval of 80 years.

The Cost of Surprise

Starting price: $100/m3
Strike (discounted cost of log): $80/m3
R = 3%

Wildfire with mean return interval of 80 years halves value of the stand.

Option Exercise Time (yrs)	Value Without Catastrophic Events ($/ha)	Value With Catastrophic Events ($/ha)	Stand Volume (m3/ha)
50	$1800	$1211	219
60	$1845	$1108	307
80	$1450	$740	428
120	$517.12	$195	512

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Surprise! Risk (a)symmetry matters. Big downside means that extended rotation isn't worth it.
This is only surprising because we use the wrong model that doesn't account for observed reality.
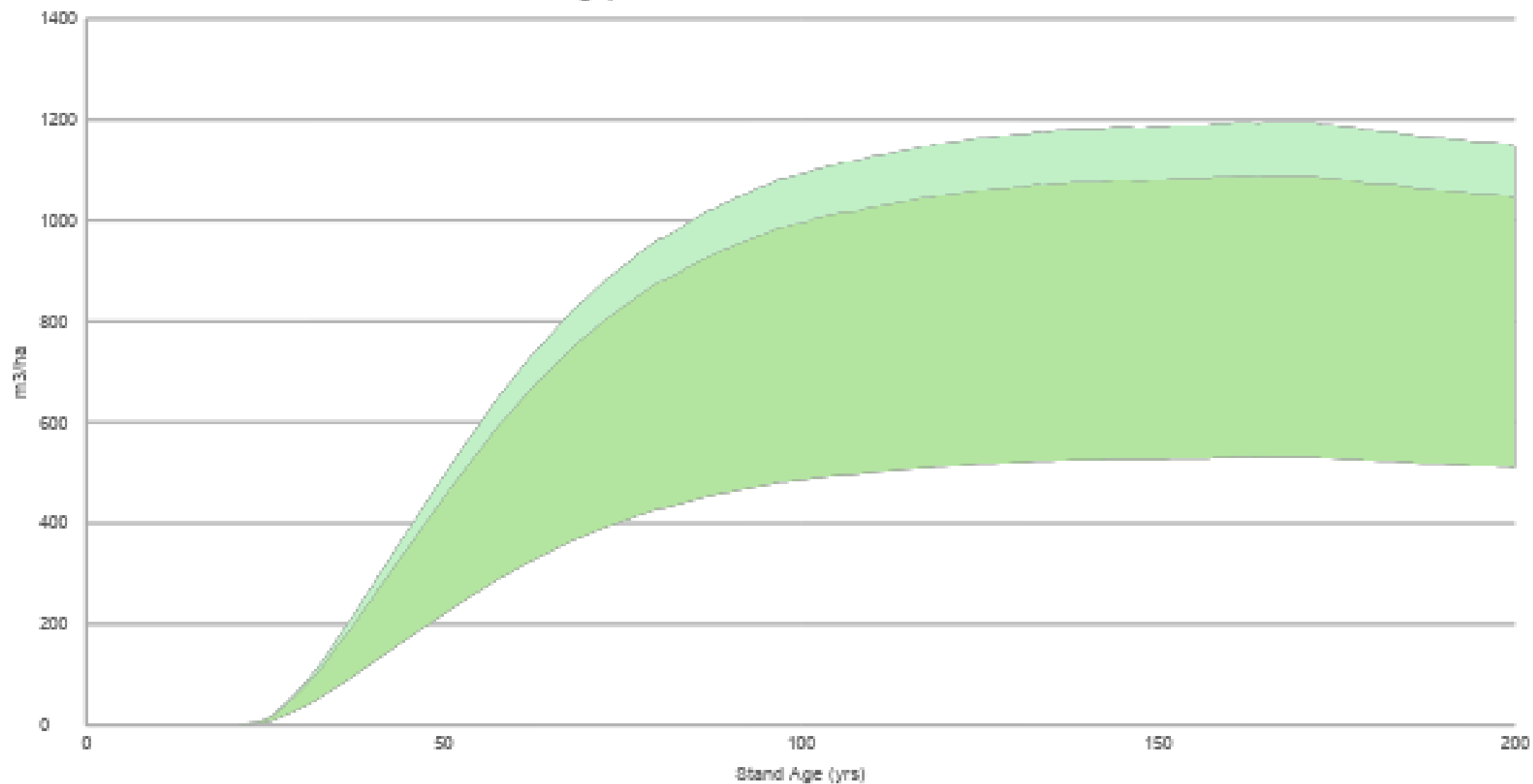
Perils besides wildfire where this matters

- Bugs
- Wind events
- Drought

Start with observed behaviour not the math

Lodgepole Pine Stand Growth and Yield

Questions?

hscorah@gmail.com

Hugh.Scorah@ubc.ca