Uncertainty and Extended Rotations

(a)Symmetric Risk and Surprise

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Two Primary Objectives

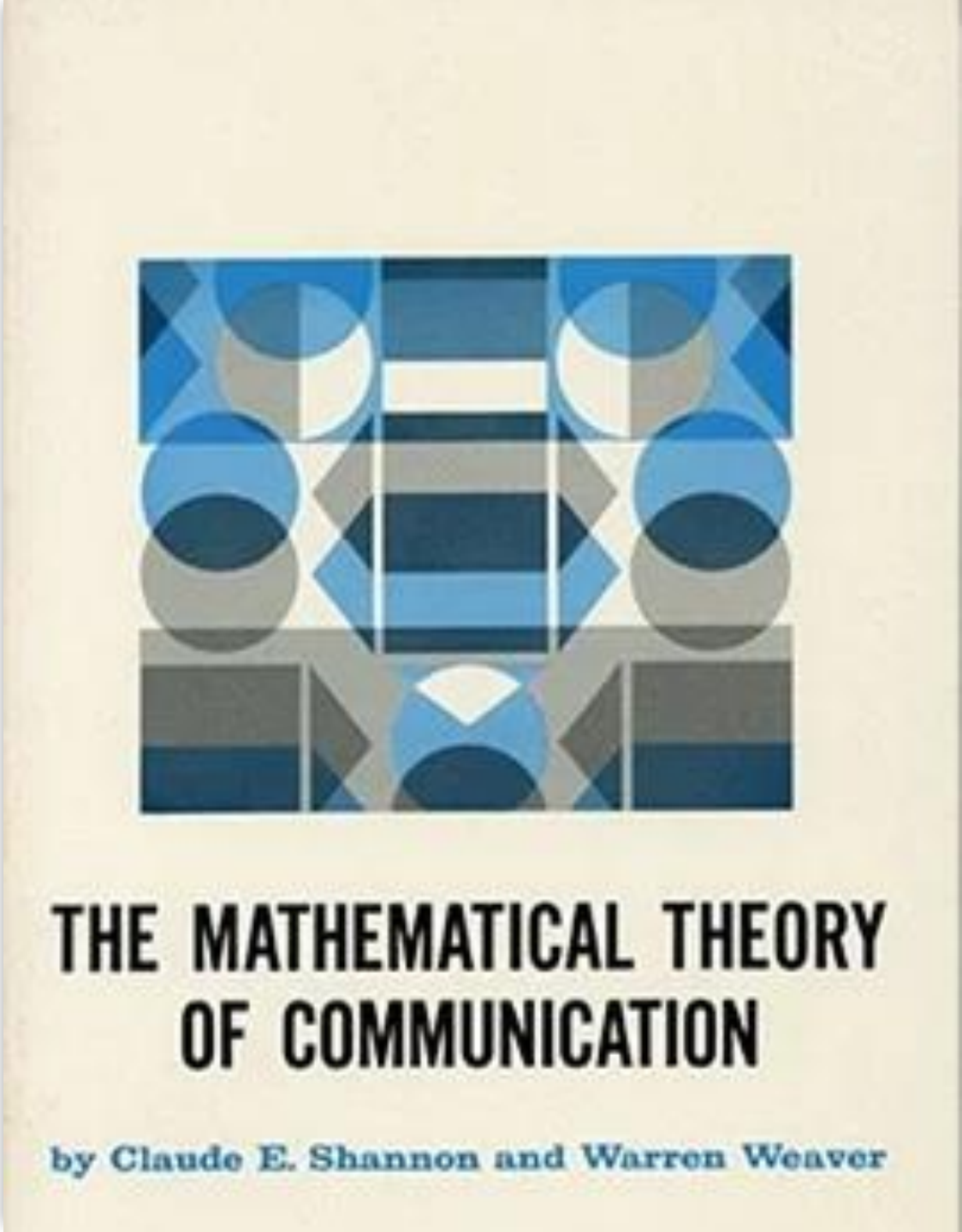
1. Think about risk in terms of information and surprise
2. Using options, not discounted cash flow to think about forestry investments.

I was taught probability in terms of…

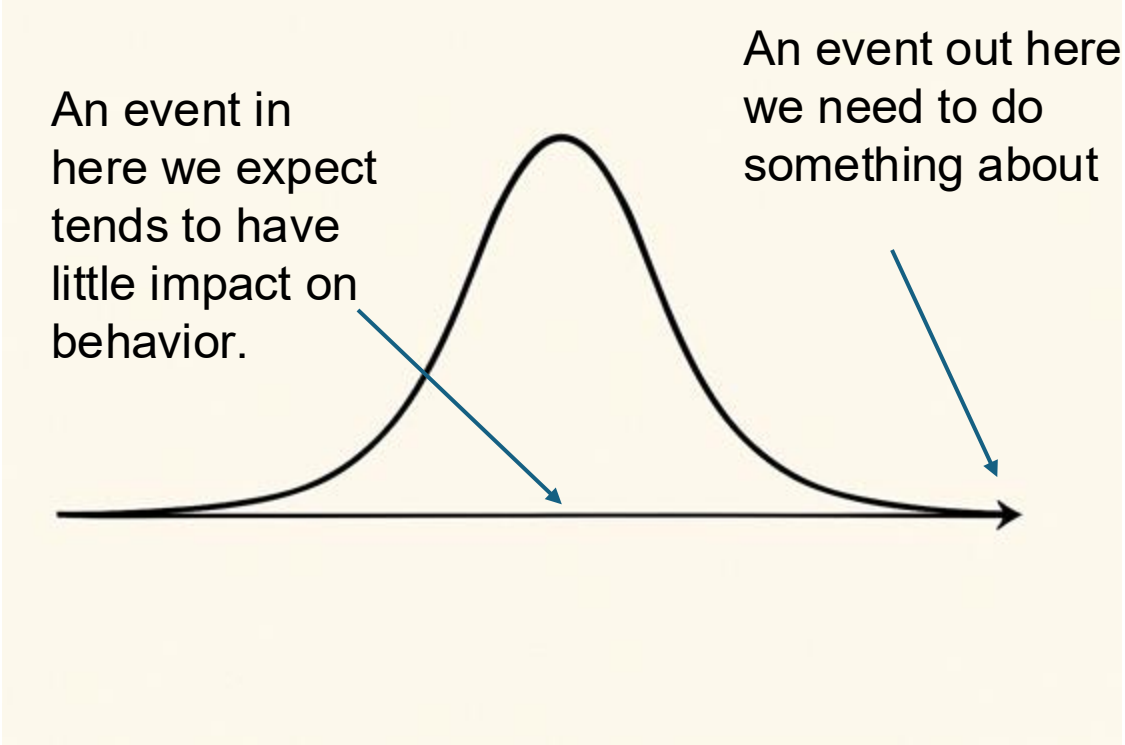
1. Frequency – proportion of outcomes
2. The Bayesian interpretation – degree of belief
   - “When I get new information I update my prior”

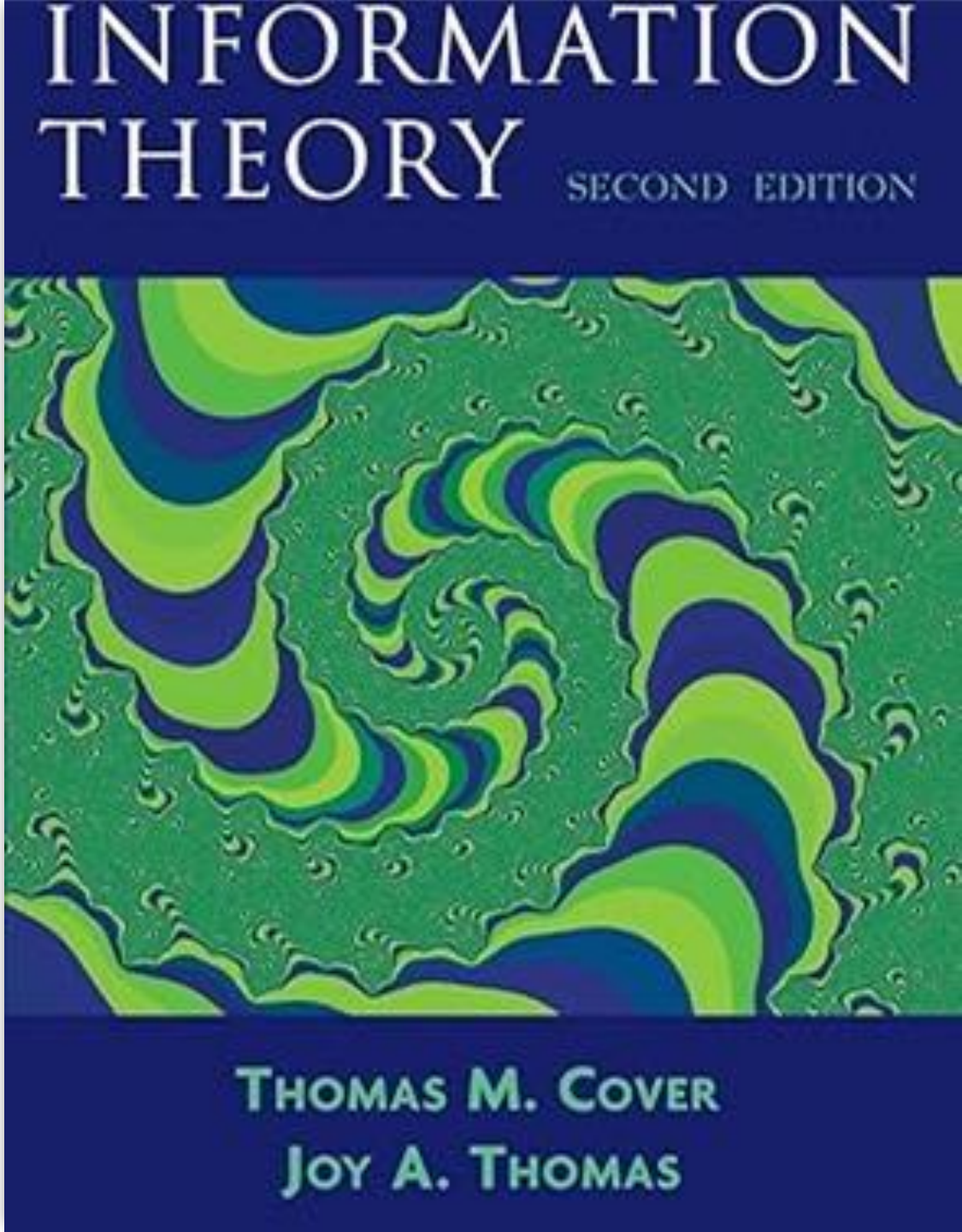
Another possibility is an information theoretic approach

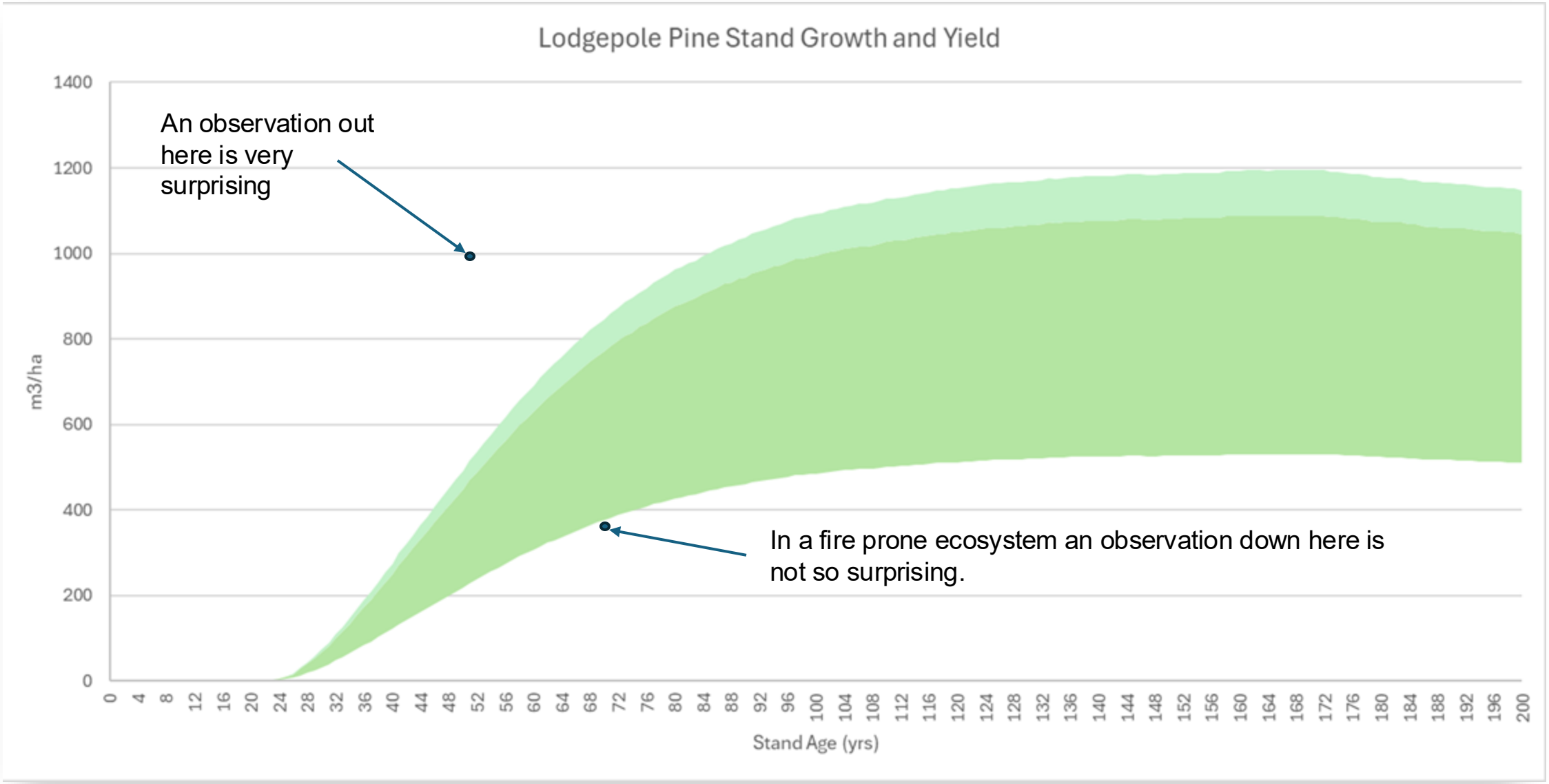
- Suppose you have a message coming through a channel that you wish to compress
- 000111010100011100110 1…
- The compression algorithm predicts that the next bit will be a 1 with probability 0.9999
- A 0 would be very surprising according to the model of the compression algorithm!

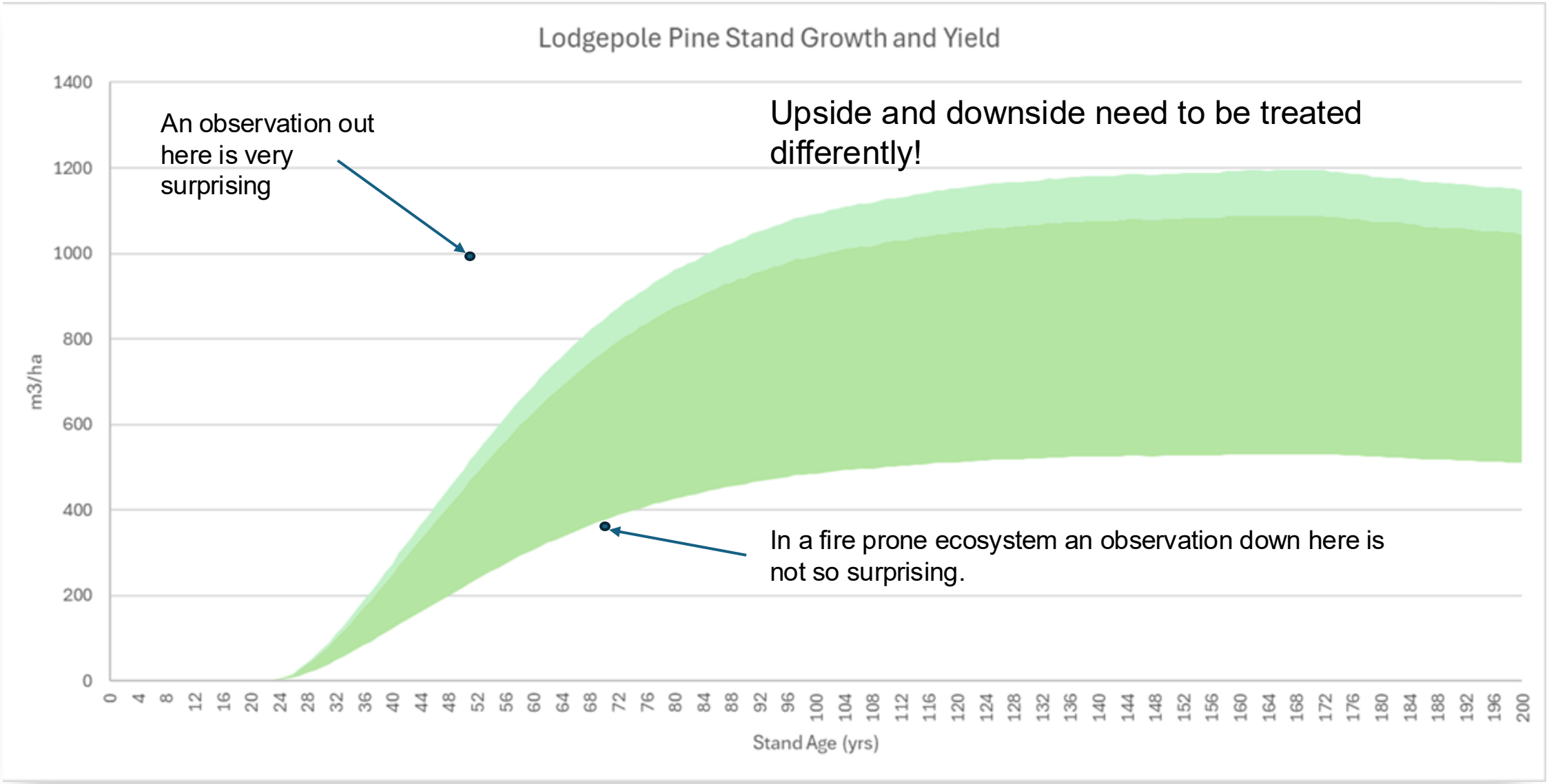


Something carries information to the extent that it is surprising






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.
m3/ha
Stand Age (yrs)
0
200
400
600
800
1000
1200
1400
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80 84 88 92 96 100 104 108 112 116 120 124 128 132 136 140 144 148 152 156 160 164 168 172 176 180 184 188 192 196 200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An observation out here is very surprising
Upside and downside need to be treated differently!
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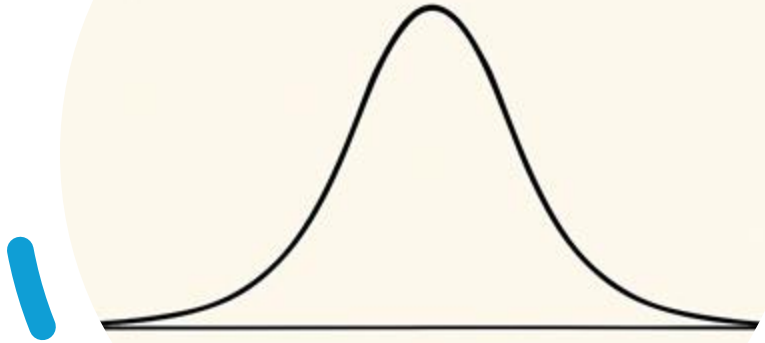
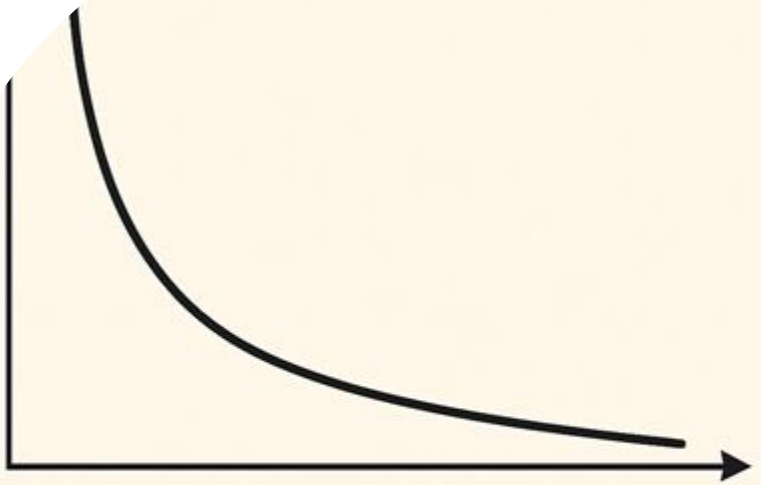
Treating updside and downside differently

- 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





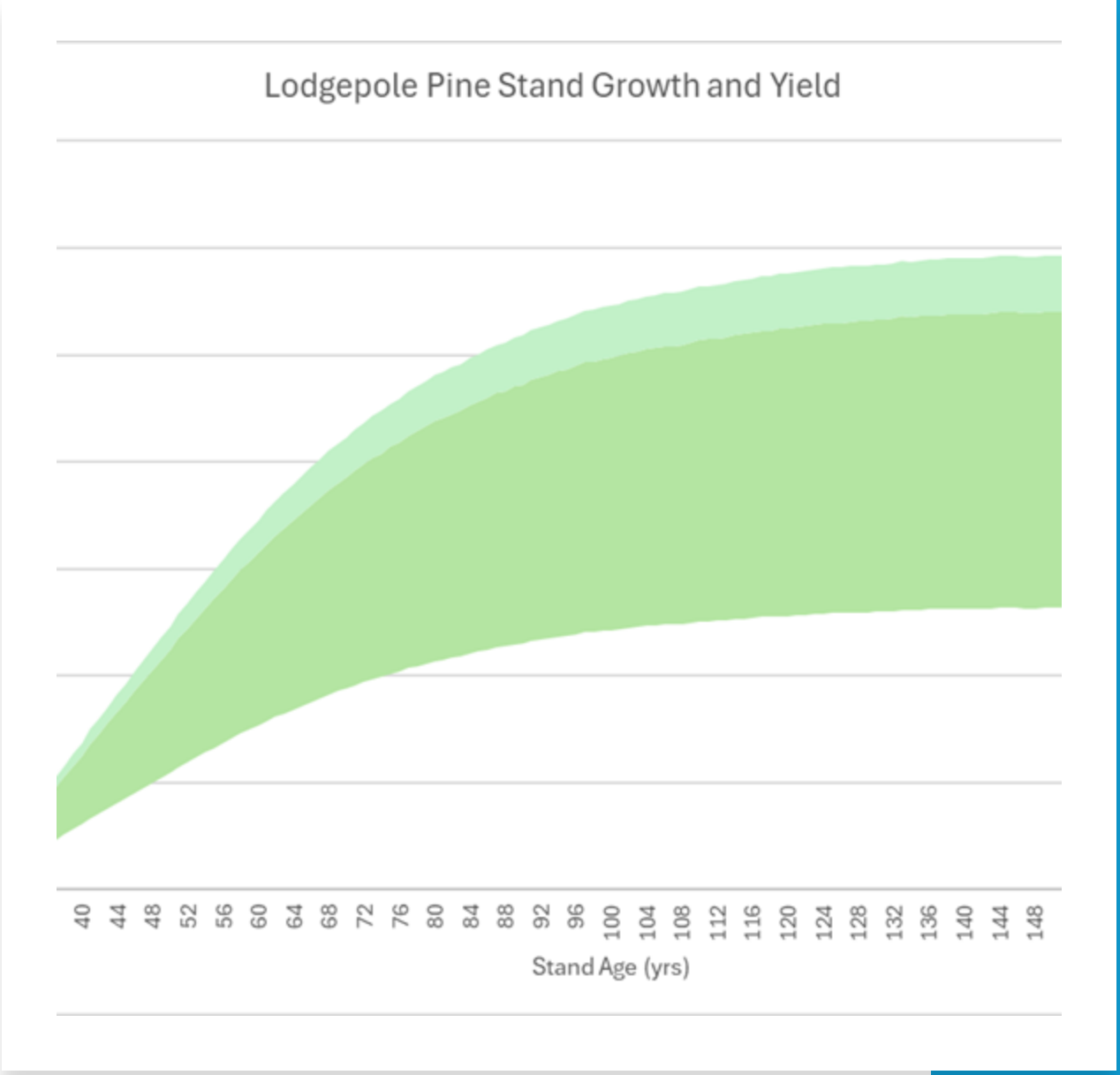
Consequences of ignoring surprises for stand/landscape option value

Components

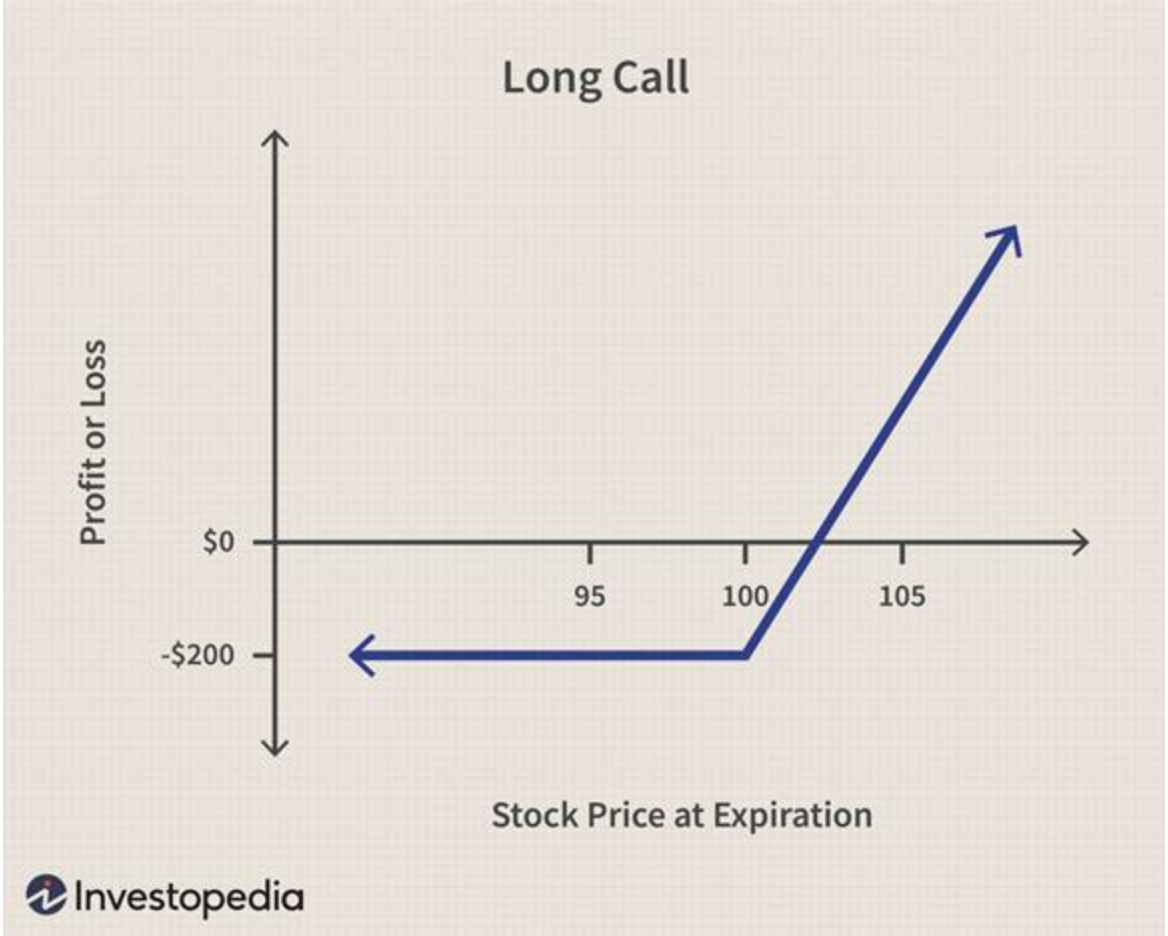
- Growth and yield model
- Price model (mean-reverting)
- Cat-event model

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



Pay-off of a call option

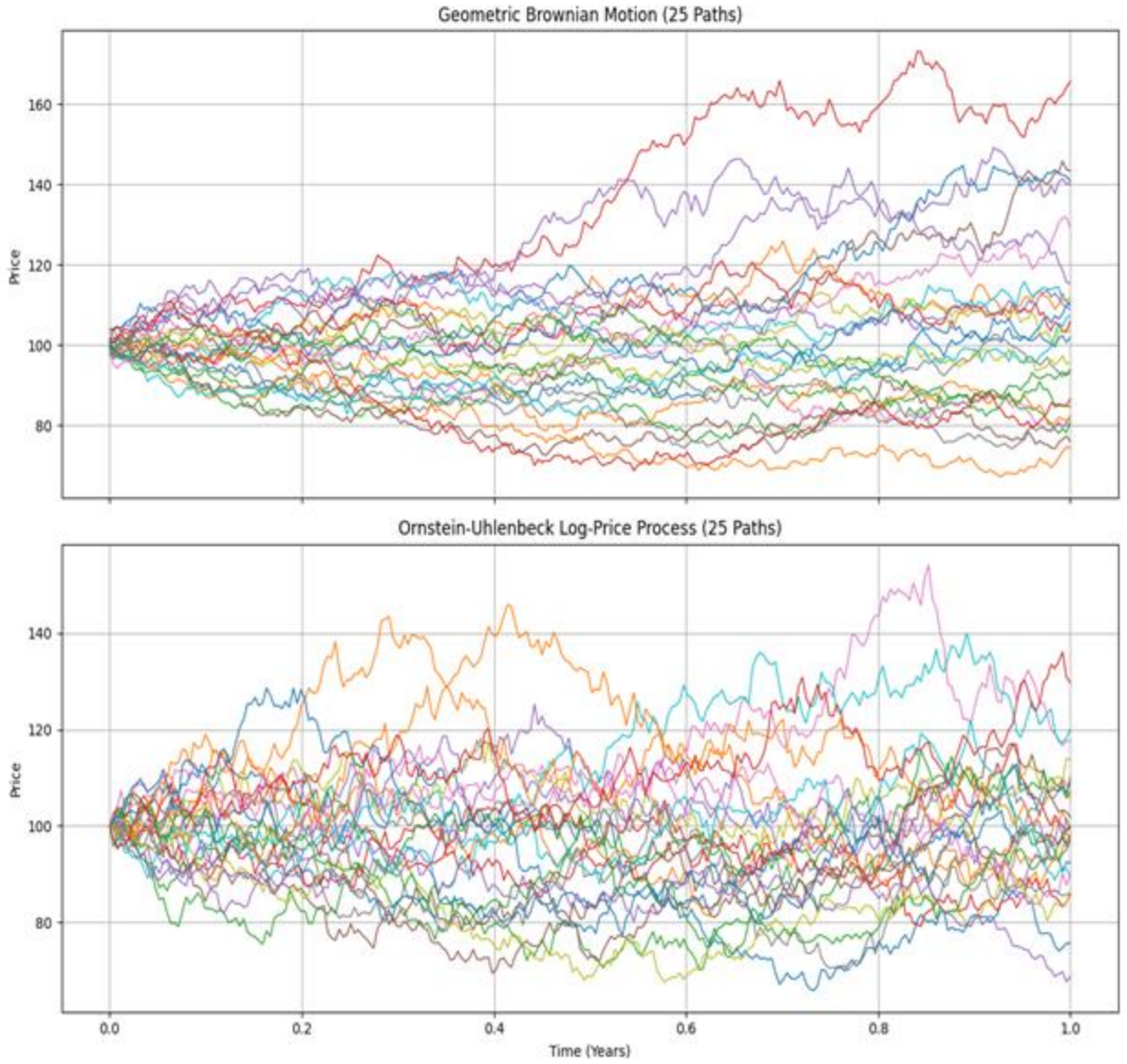


Price Model

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

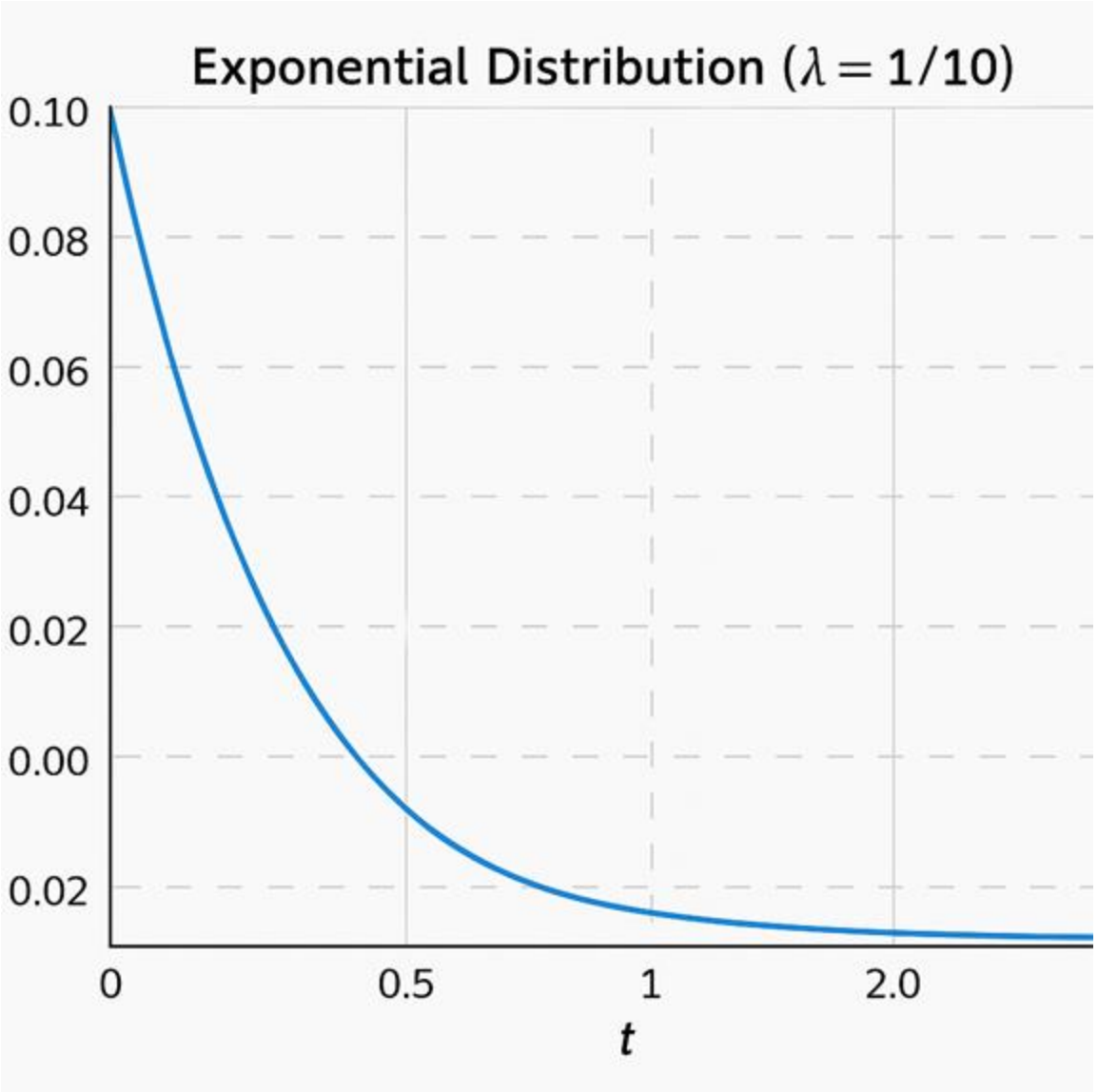
$$OU:\ dS_t = \theta(\mu - S_t)dt + \sigma dW_t$$

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



Poisson process – fire return interval modeled using an exponential distribution

Catastrophic Event Arrival Process



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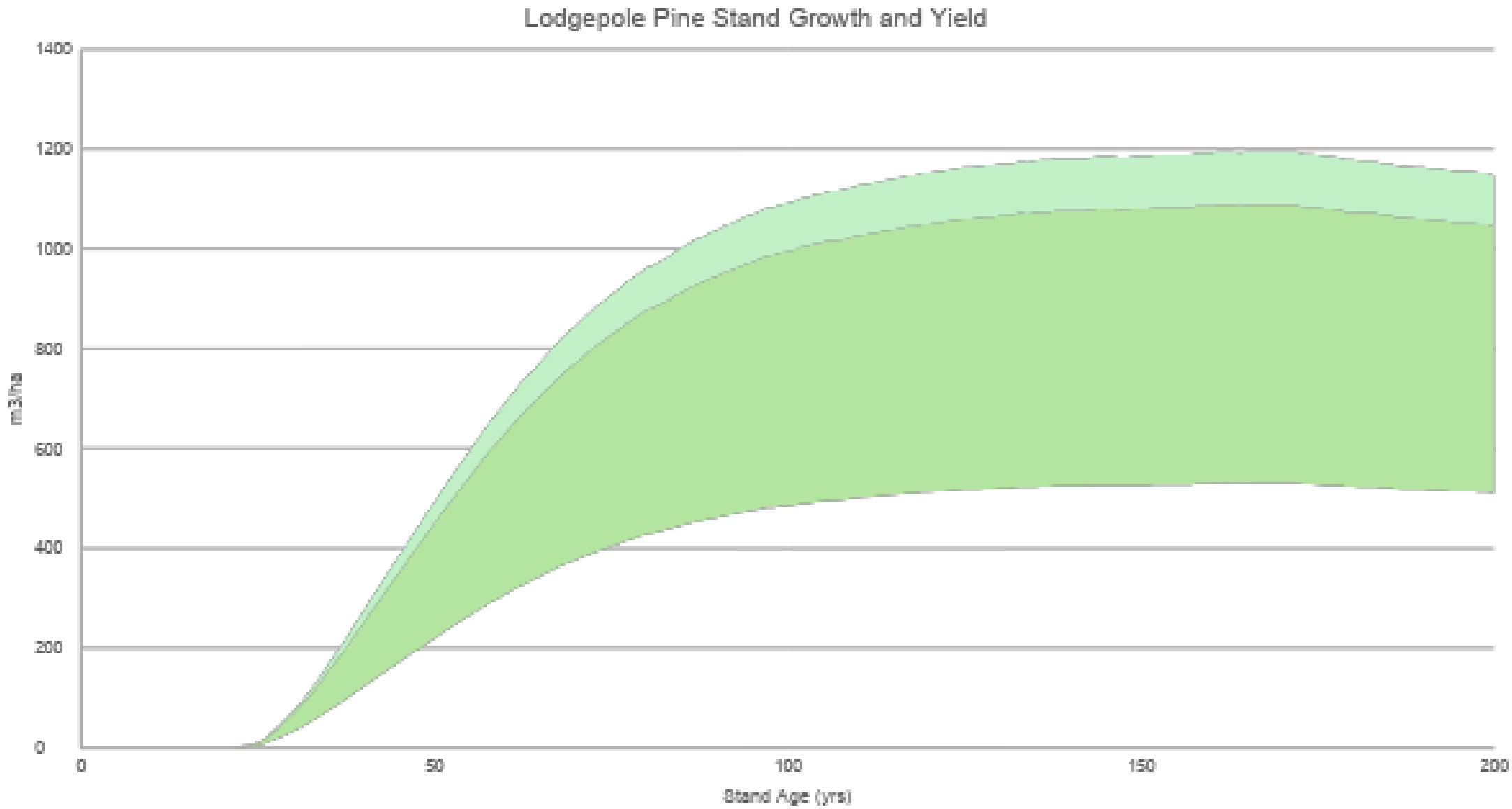
Surprise! Risk (a)symmetry matters. Big downside means that extended rotation isn't worth it.
This is only surprising because we use the wrong model that doesn't account for observed reality.

Perils besides wildfire where this matters

- Bugs
- Wind events
- Drought

Start with observed behaviour not the math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Questions?

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