An improved canopy wind model for predicting wind adjustment factors and wildland fire behavior

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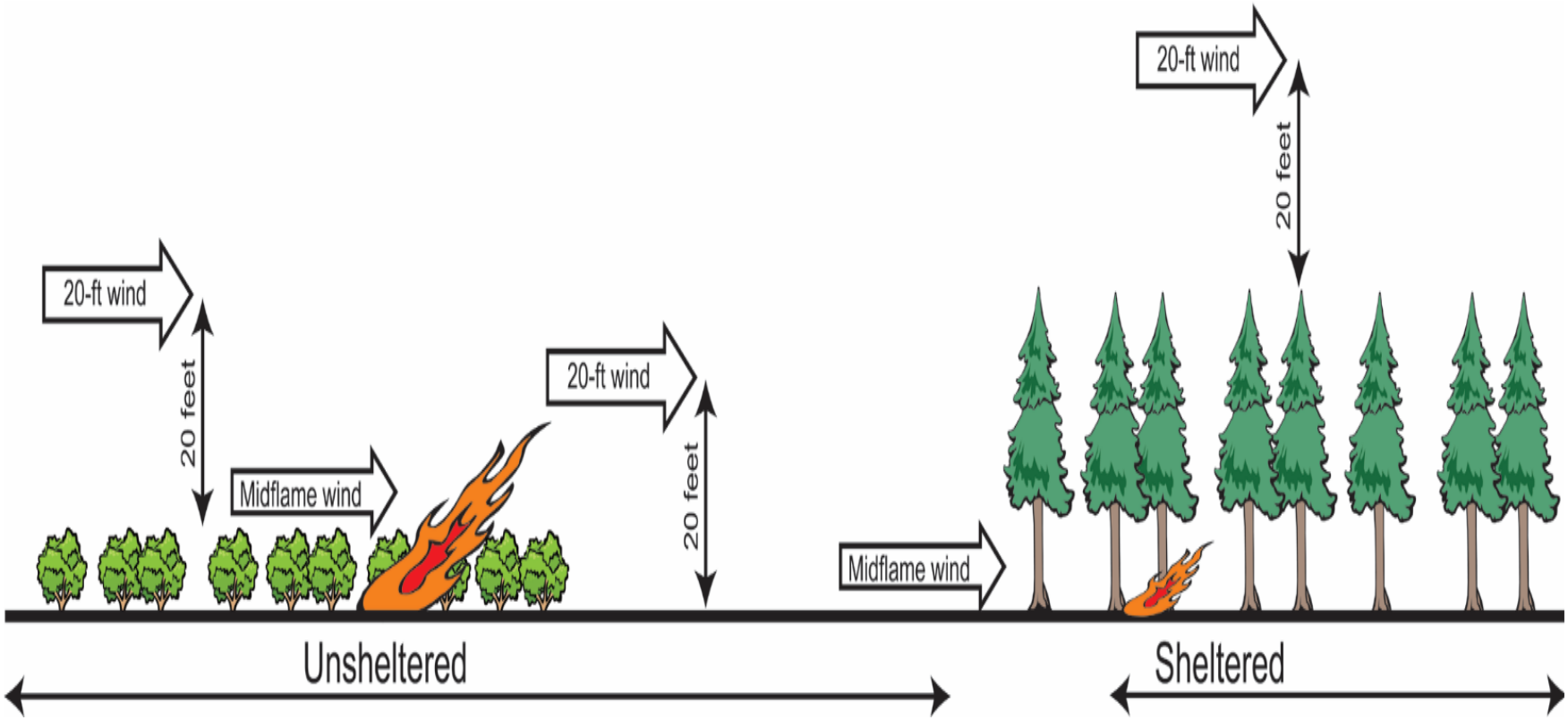
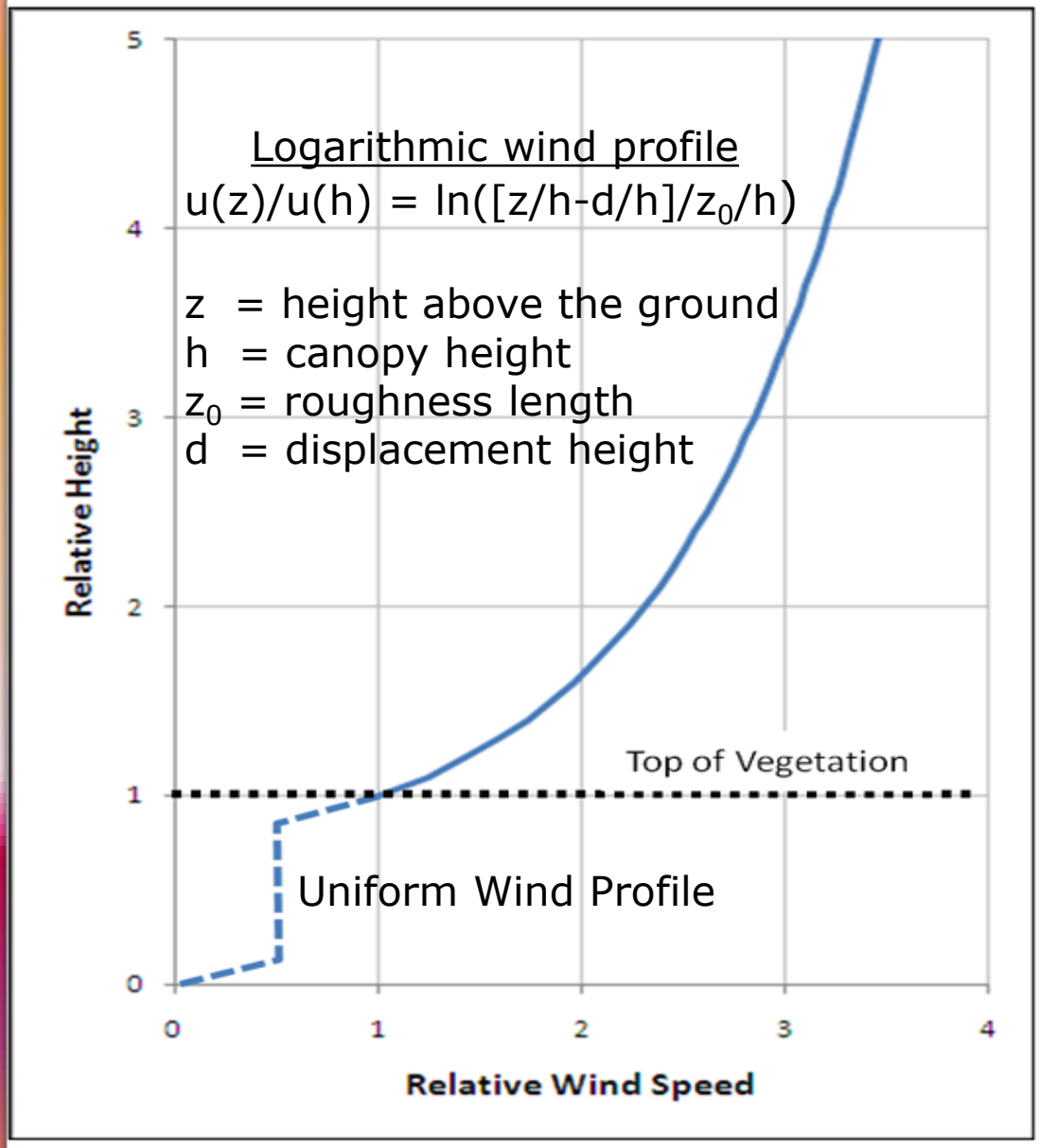
Current models used to predict the spread rate of prescribed fire require input wind speed at a height of 20 feet above the top of a canopy to make a rapid estimate of the output wind speed beneath the canopy or near the ground.

- output wind speed/input wind speed = WAF
- spread rate = Metric of Fire Behavior
- rapid = numerically efficient and robust to uncertainties in input parameters


20-ft wind
20 feet
Midflame wind
20-ft wind
20 feet
Midflame wind
20-ft wind
20 feet
Unsheltered
Sheltered

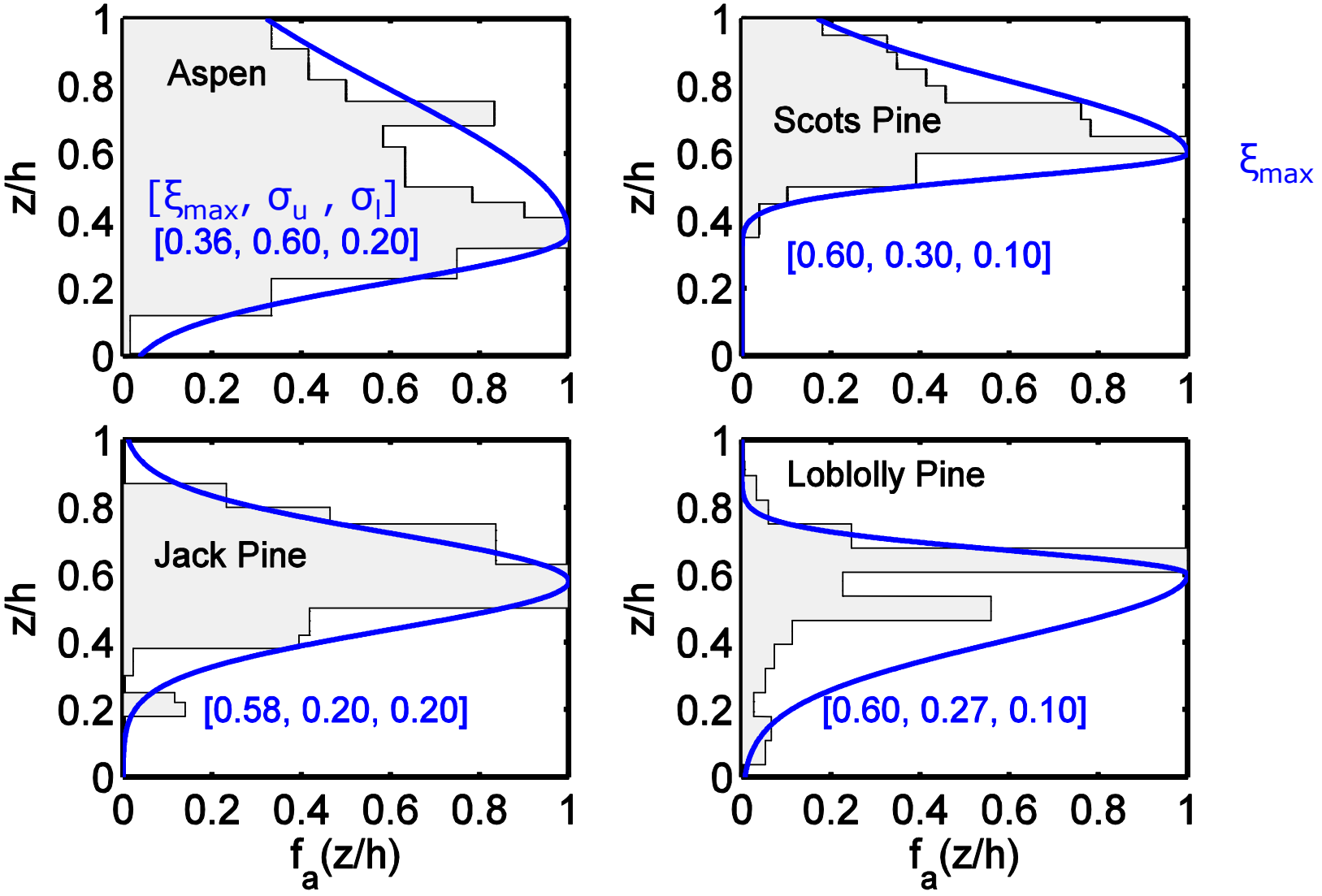


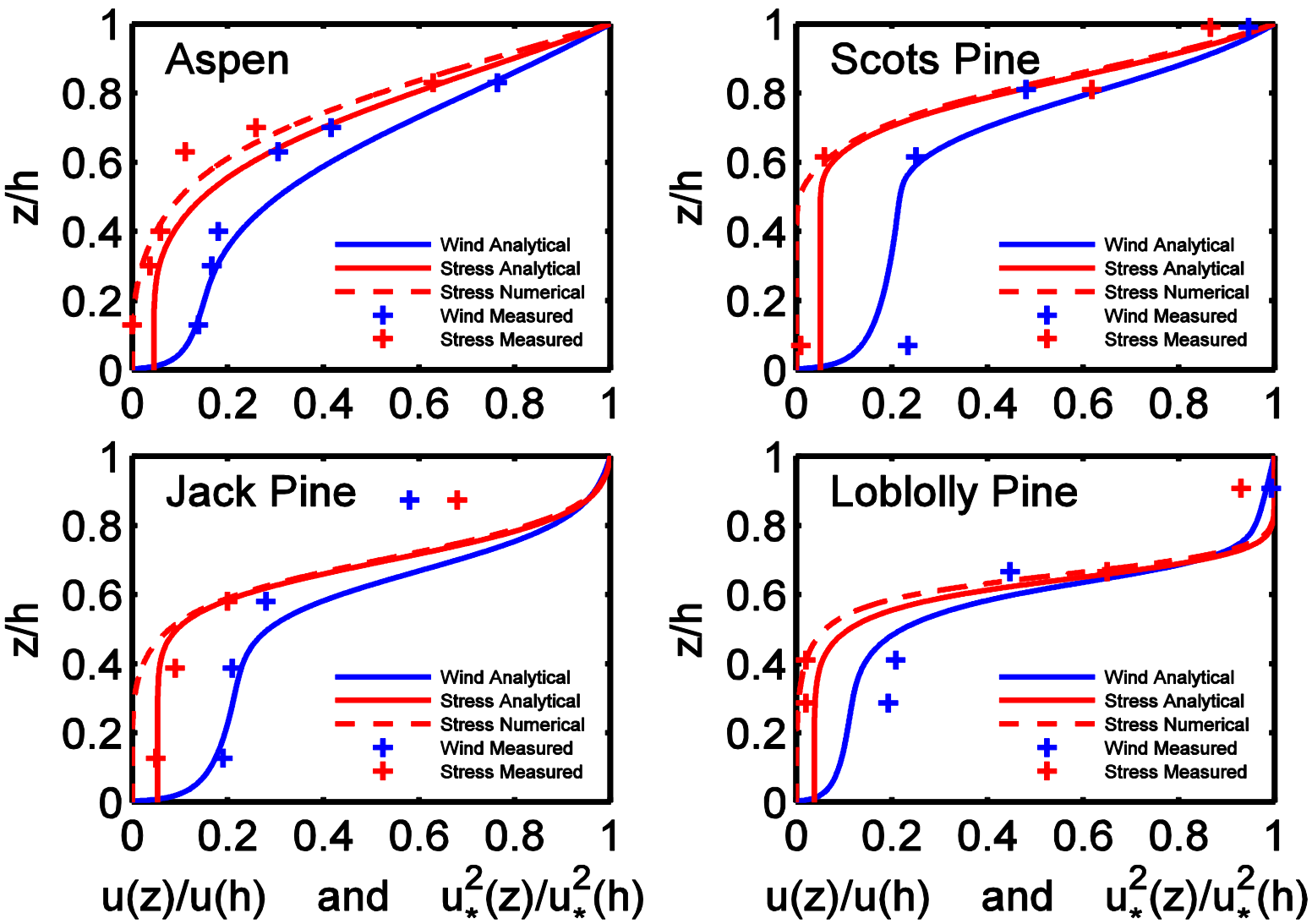
Current (Albini) Wind Model

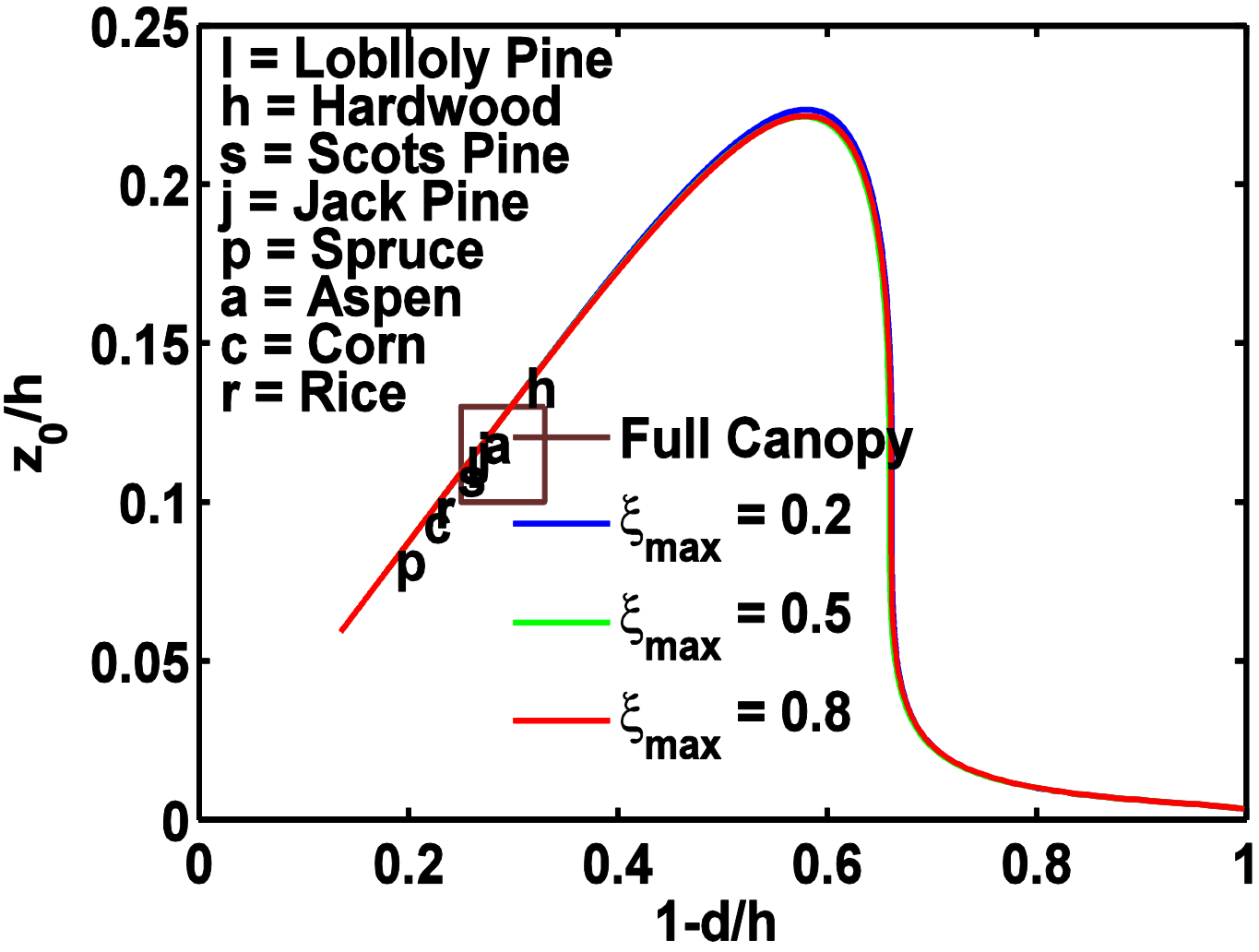
(a)Logarithmic profile above
(b)d/h, z_0/h = full canopy
(c)No foliage structure
(d)Uniform profile within

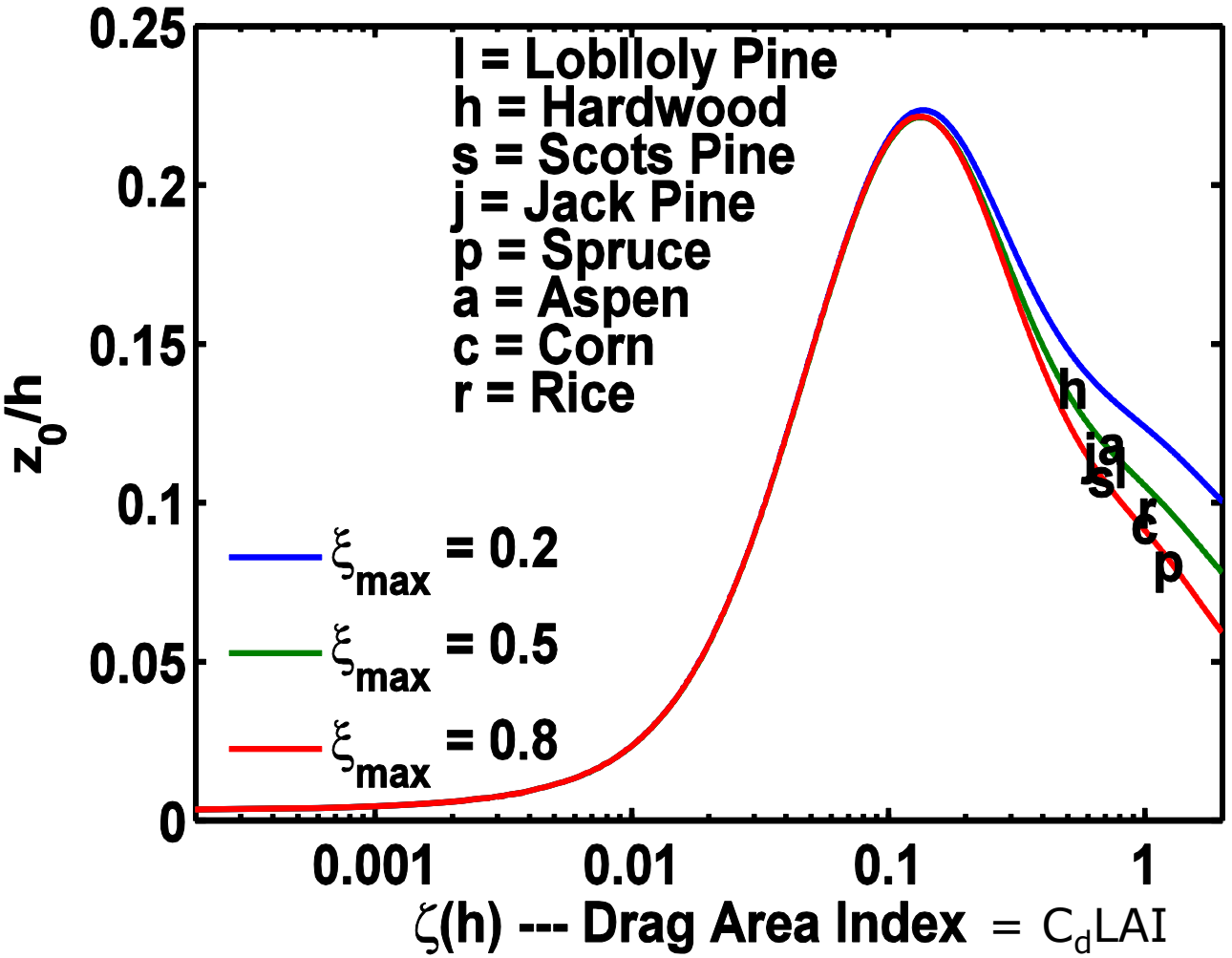
New (Massman) Model

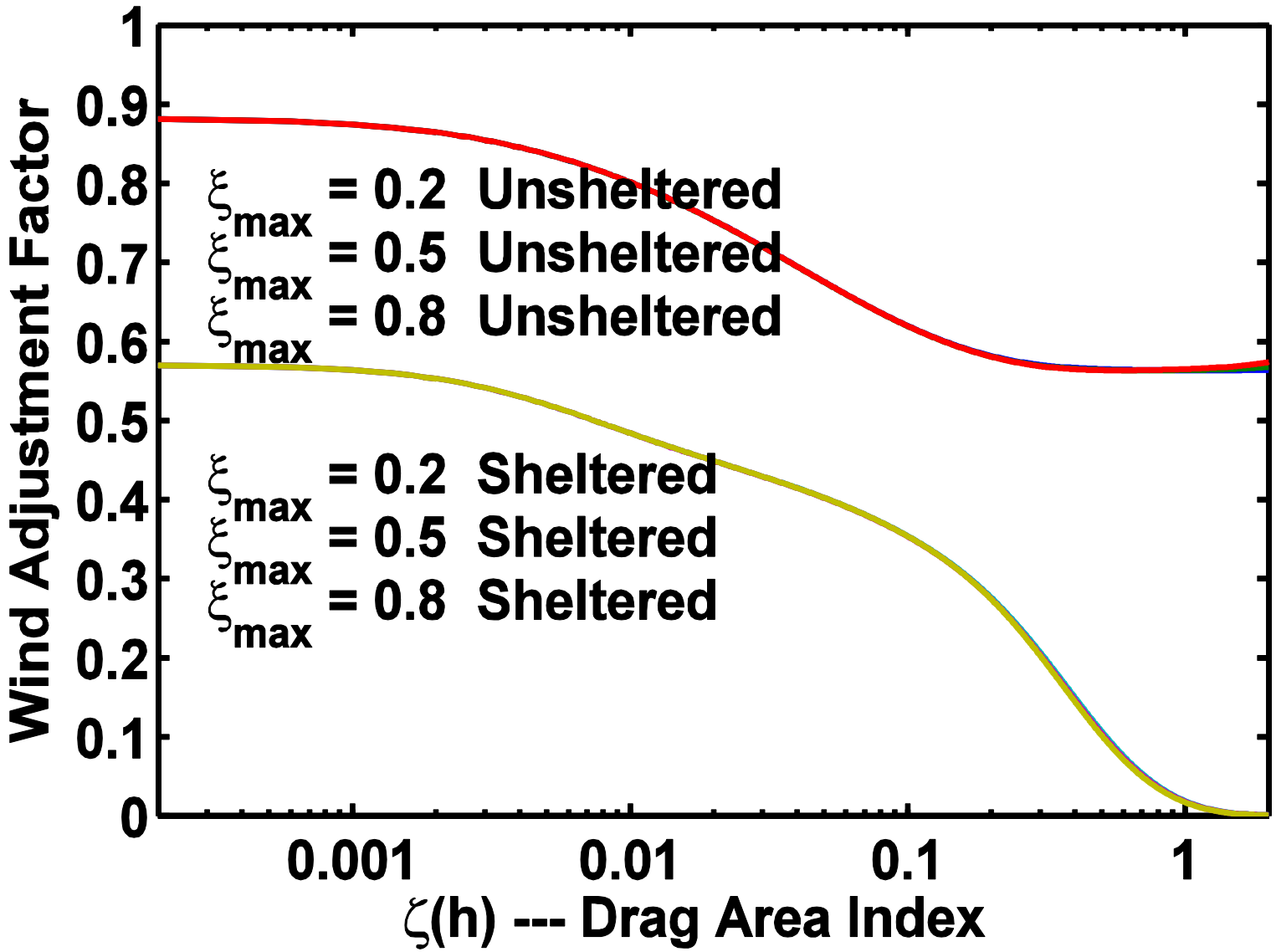
(a)Logarithmic profile above
(b)Function of LAI, a(z), C_d
(c)Variable structure
(d)Function of LAI, a(z), C_d


Aspen
[ξmax, σu , σl]
[0.36, 0.60, 0.20]
Scots Pine
[0.60, 0.30, 0.10]
ξmax
Jack Pine
[0.58, 0.20, 0.20]
Loblolly Pine
[0.60, 0.27, 0.10]
z/h
fa(z/h)
0
0.2
0.4
0.6
0.8
1

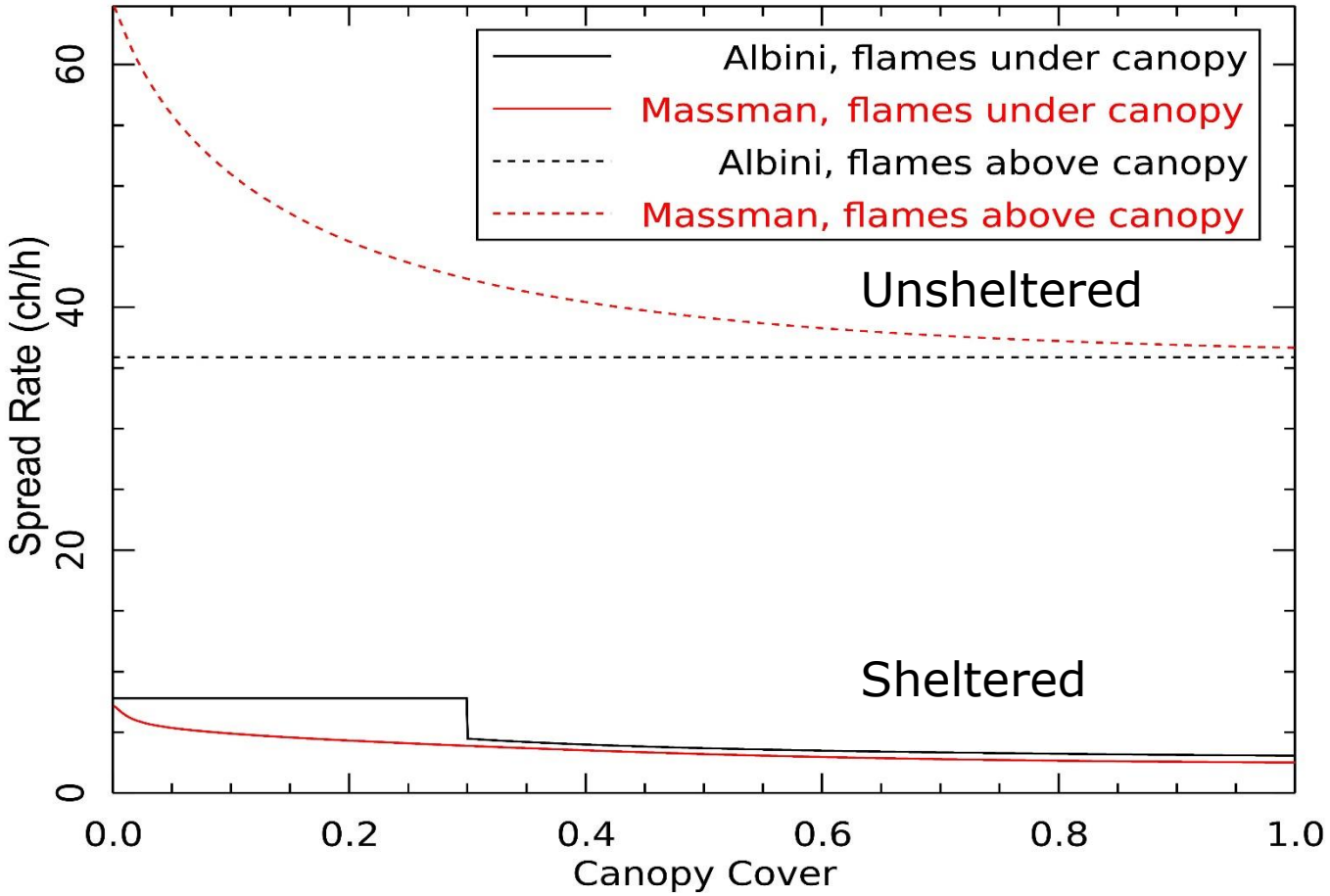

Aspen
Scots Pine
Jack Pine
Loblolly Pine
z/h
0
0.2
0.4
0.6
0.8
1
Wind Analytical
Stress Analytical
Stress Numerical
Wind Measured
Stress Measured
u(z)/u(h) and $u_*^2(z)/u_*^2(h)$


l = Loblloly Pine
h = Hardwood
s = Scots Pine
j = Jack Pine
p = Spruce
a = Aspen
c = Corn
r = Rice
Full Canopy
ξ_{max} = 0.2
ξ_{max} = 0.5
ξ_{max} = 0.8
z_0/h
1-d/h
0.25
0.2
0.15
0.1
0.05
0
0
0.2
0.4
0.6
0.8
1


0.25
0.2
0.15
0.1
0.05
0
z0/h
l = Loblloly Pine
h = Hardwood
s = Scots Pine
j = Jack Pine
p = Spruce
a = Aspen
c = Corn
r = Rice
ξmax = 0.2
ξmax = 0.5
ξmax = 0.8
h
a
j
s
l
r
c
p
0.001
0.01
0.1
1
ζ(h) --- Drag Area Index = CdLAI


Wind Adjustment Factor
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
ξ_{max} = 0.2 Unsheltered
ξ_{max} = 0.5 Unsheltered
ξ_{max} = 0.8 Unsheltered
ξ_{max} = 0.2 Sheltered
ξ_{max} = 0.5 Sheltered
ξ_{max} = 0.8 Sheltered
0.001
0.01
0.1
1
ζ(h) --- Drag Area Index

Albini vs. Massman Spread Rate



Conclusions

(1) New model is more physically realistic than the older model and its predictions of WAF and spread rate are reasonable.

(1) Model WAF is not particularly sensitive to foliage distribution, but it is sensitive to LAI and C_d and to the ground surface roughness length. This latter sensitivity is most significant for unsheltered fires in ecosystems of sparse canopy cover.

(3) The "universal" wind profile developed for this study does work well for full or complete canopies and it needs further verification in sparse or thin canopies where LAI < 1.

Thank you !

Questions?