Fine Root ^{14}C Signatures and Mass Distribution: Implications for the Fine Root Model, Turnover Rates, and Differences with Diameter Size Class and Depth

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Need for Rapid-Turnover Root Pool

2000 Live Roots
$\Delta\ ^{14}C = 428$

Roots still alive in 2001

Mortality
$\Delta\ ^{14}C = 428$

2001 Dead Roots
$\Delta\ ^{14}C = 329$

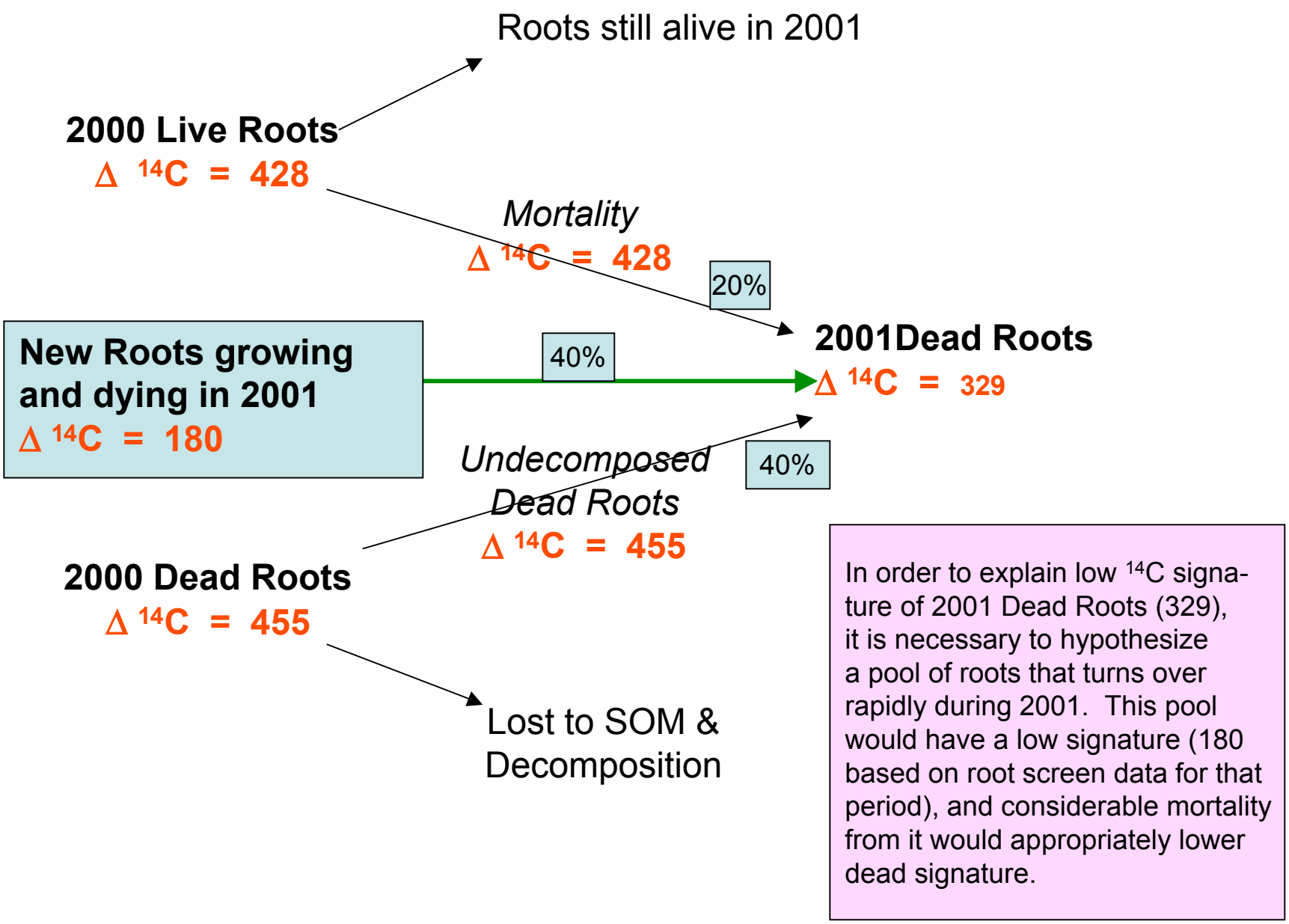
Undecomposed Dead Roots
$\Delta\ ^{14}C = 455$

2000 Dead Roots
$\Delta\ ^{14}C = 455$

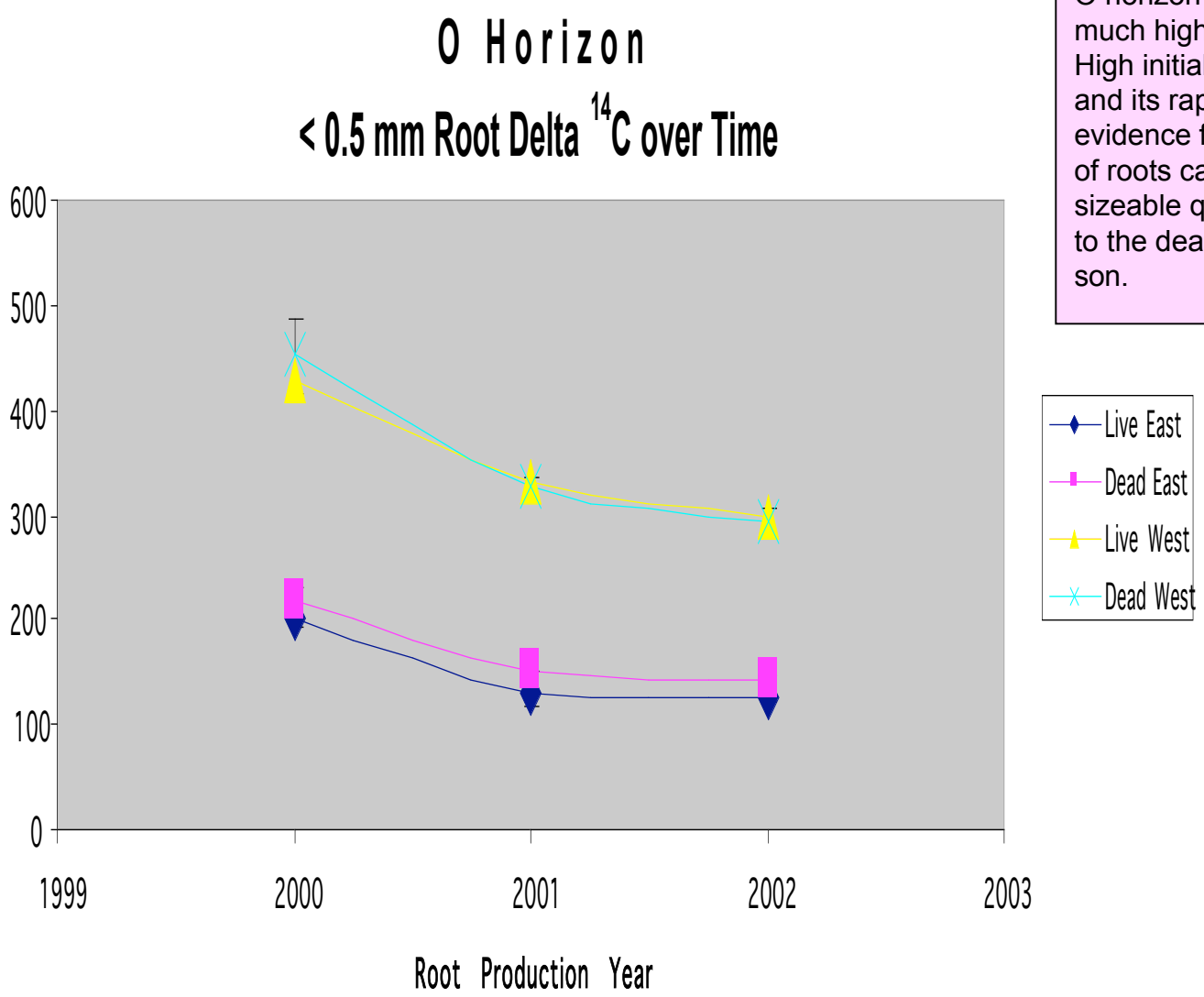
Lost to SOM & Decomposition

2001 Dead Root ^{14}C signature cannot be explained by simply combining signatures from death of known live root pool (Feb. 2000) and carry over from existing dead pool.

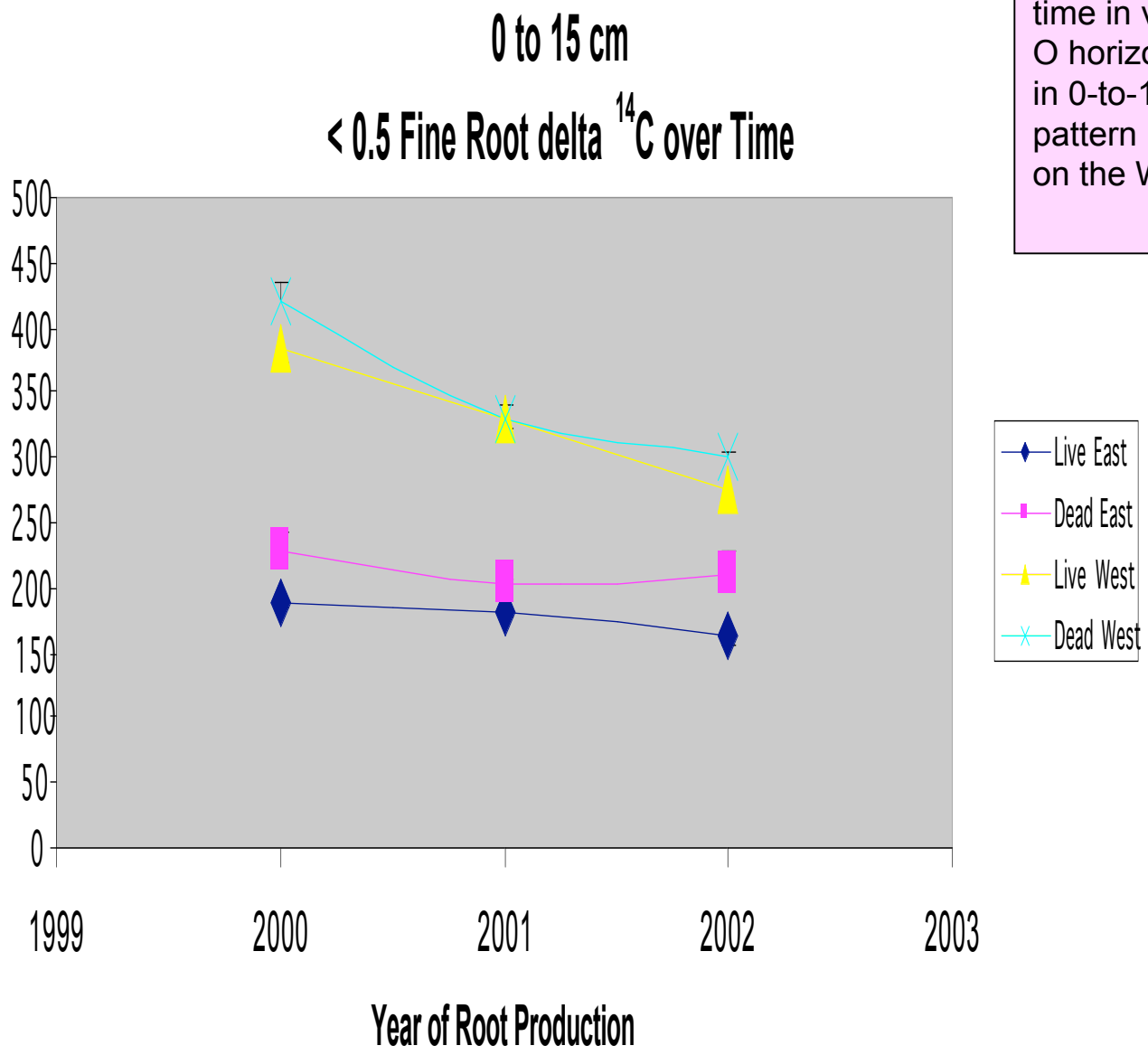
The resultant combination would have to be > 430, yet measured value is 329.



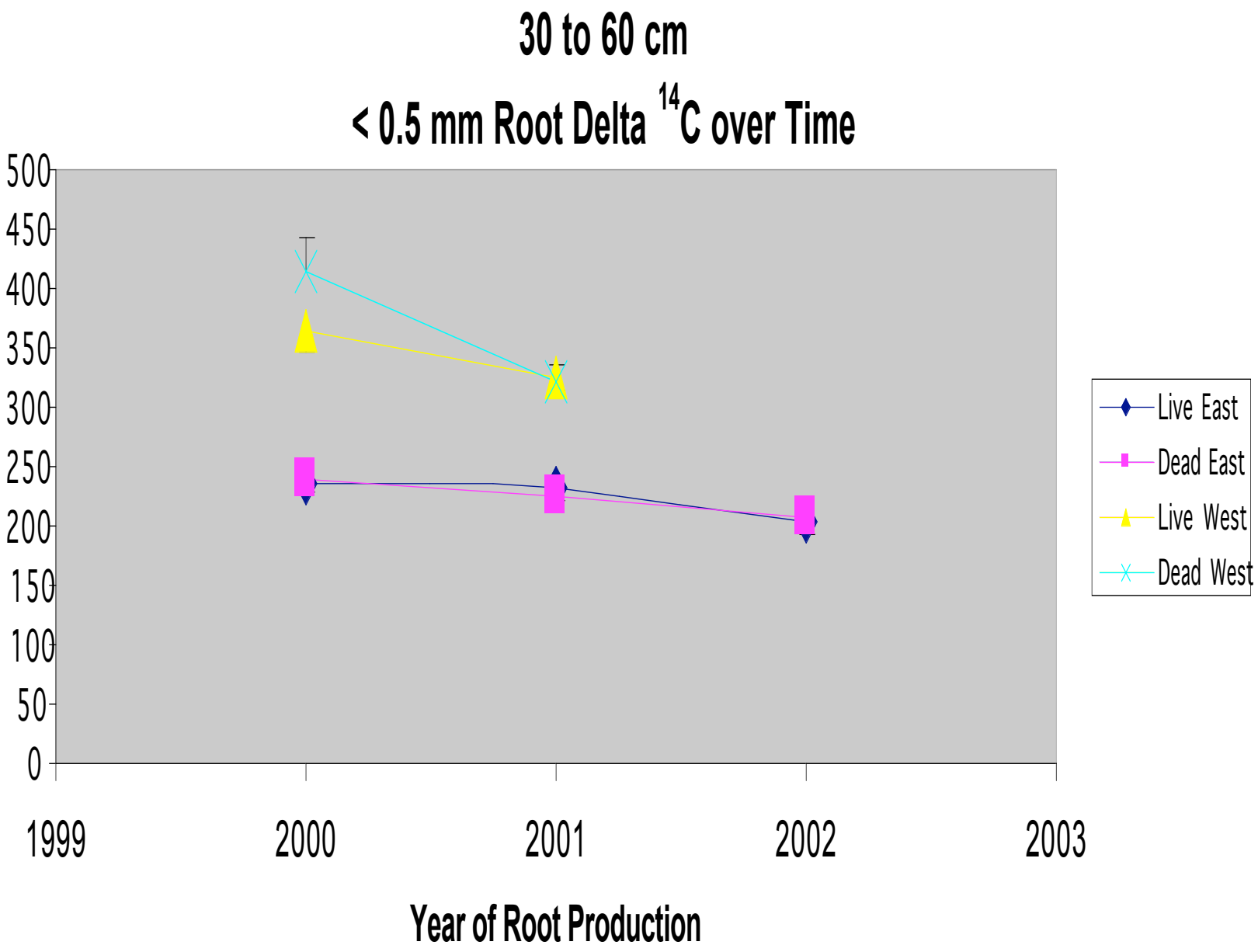
In order to explain low ^{14}C signature of 2001 Dead Roots (329), it is necessary to hypothesize a pool of roots that turns over rapidly during 2001. This pool would have a low signature (180 based on root screen data for that period), and considerable mortality from it would appropriately lower dead signature.

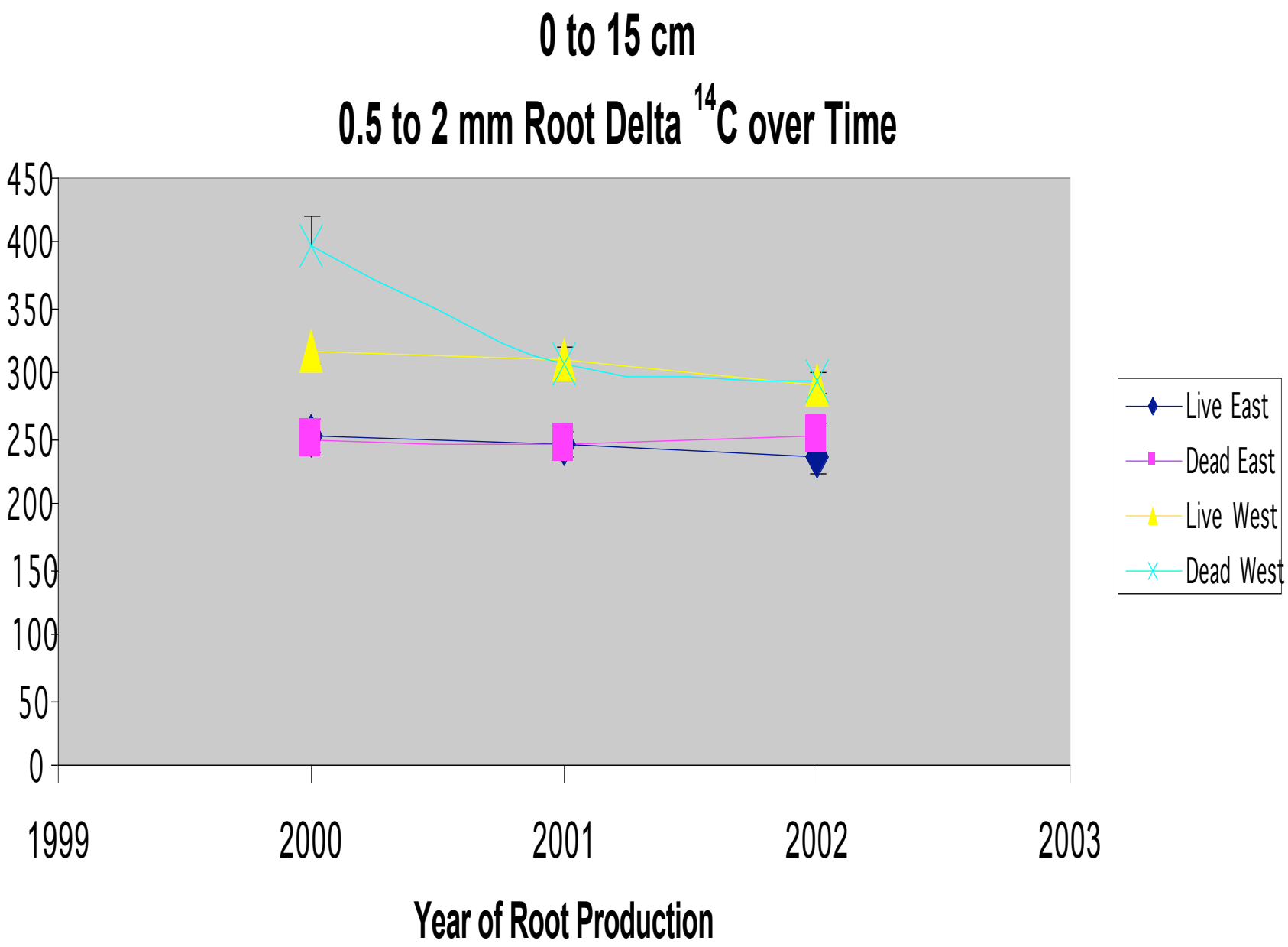


Year 2000 refers to "Time Zero" roots collected in Feb., 2001 and so on.
Delta ^{14}C very fine root signatures in O horizon West side plots consistently much higher than East.
High initial delta ^{14}C of dead roots and its rapid drop over time is evidence for a rapid turnover pool of roots capable of adding a sizeable quantity of short-lived roots to the dead pool each growing season.



Delta ^{14}C pattern of change over time in very fine roots is similar to O horizon roots (previous slide) in 0-to-15-cm layer here. Except pattern is much clearer at plots on the West end.

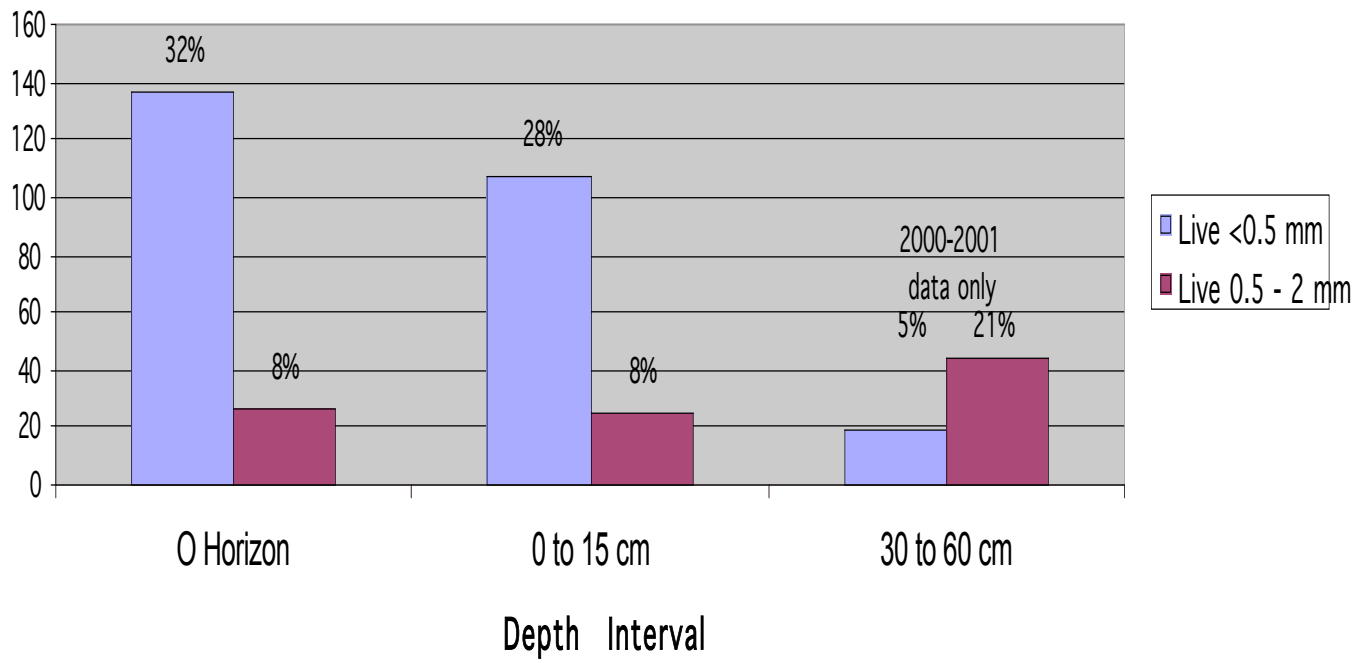

30 to 60 cm
< 0.5 mm Root Delta 14C over Time
500
450
400
350
300
250
200
150
100
50
0
1999
2000
2001
2002
2003
Year of Root Production
Live East
Dead East
Live West
Dead West


0 to 15 cm
0.5 to 2 mm Root Delta 14C over Time
450
400
350
300
250
200
150
100
50
0
1999
2000
2001
2002
2003
Year of Root Production
Live East
Dead East
Live West
Dead West

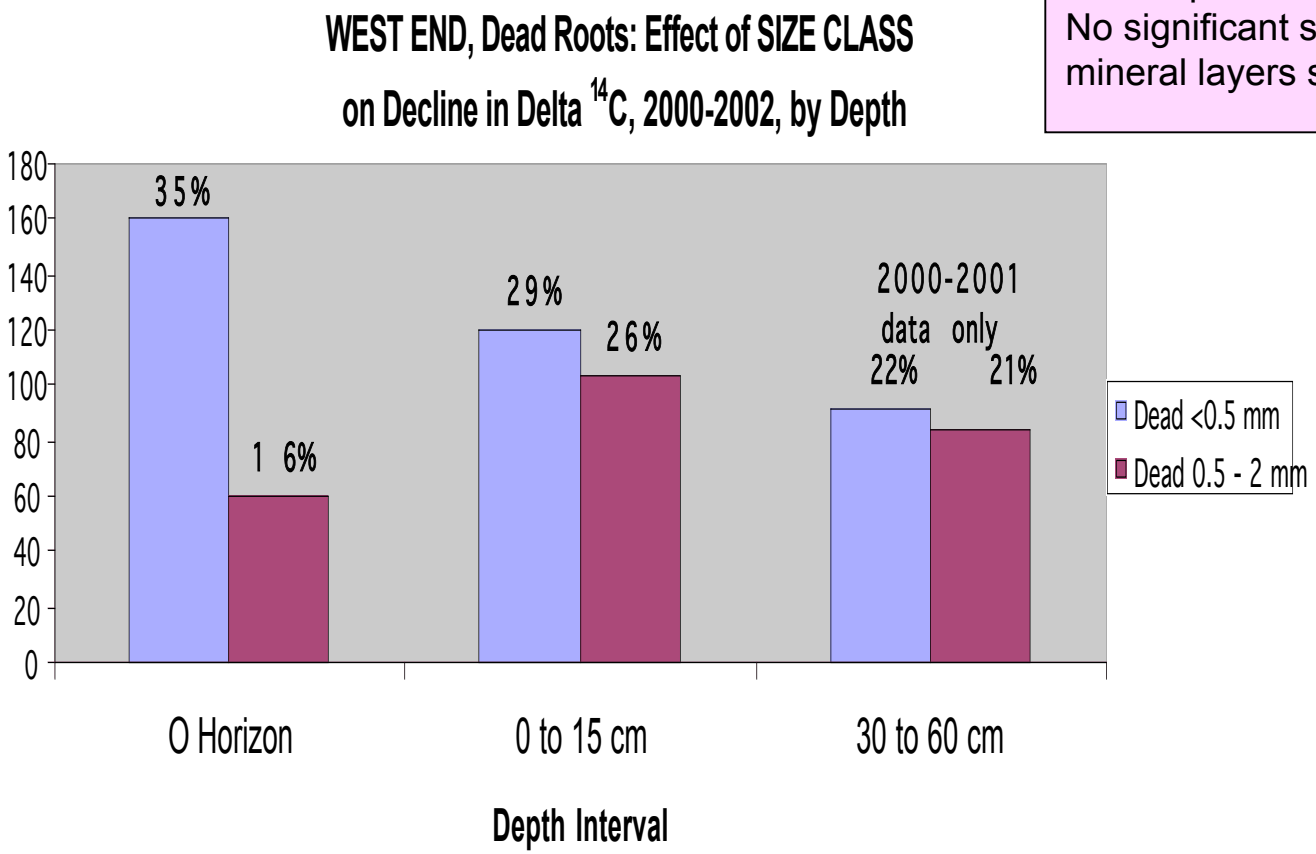
Larger ^{14}C signatures at West end in O horizon dead roots < 0.5 mm compared to 0.5 to 2 mm dead are an indication that the finest diameter roots in the O horizon may be turning over a little more rapidly than their slightly larger fine root counterparts.
No significant differences within mineral soil horizons.

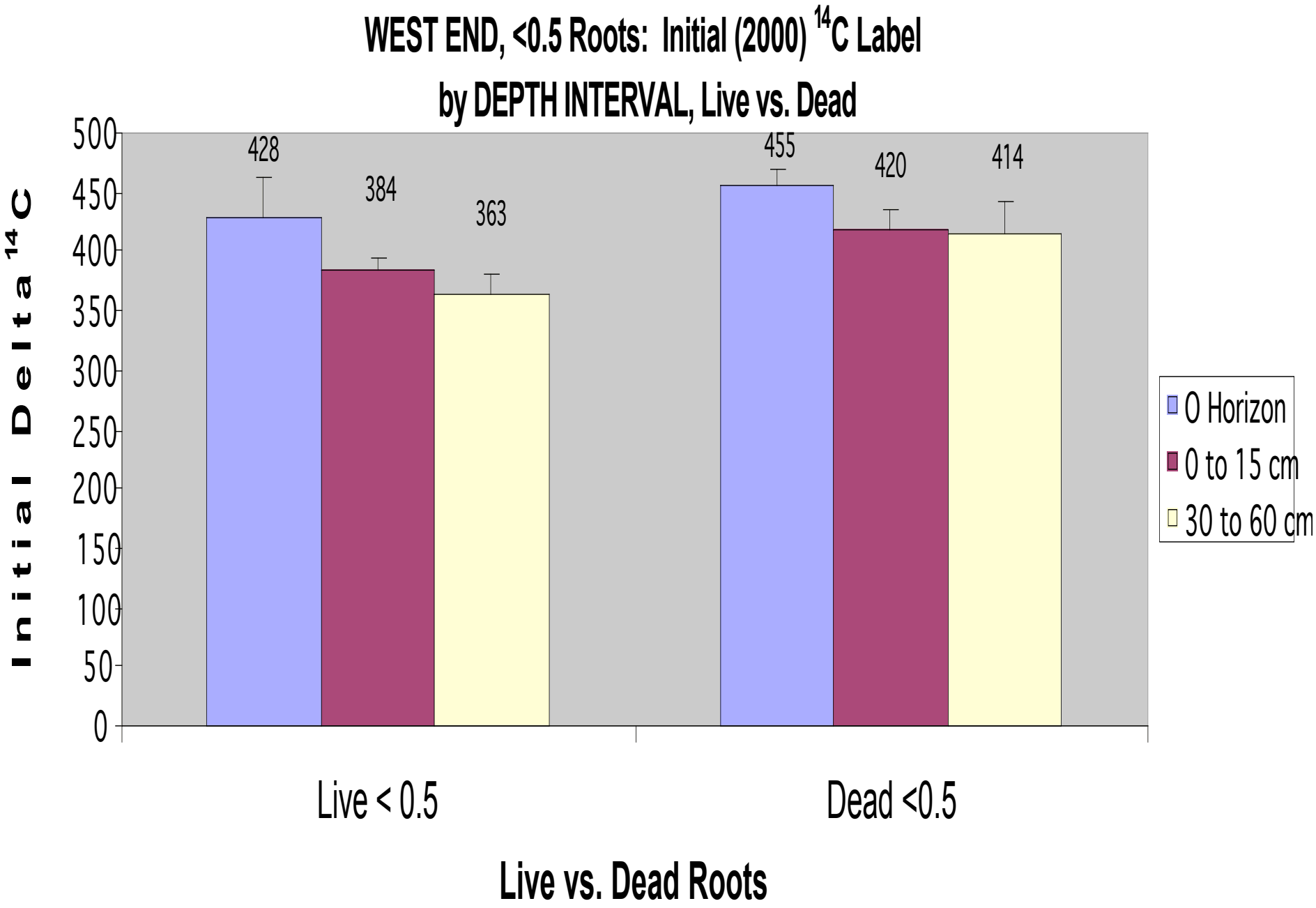
Larger drops in ^{14}C signatures at West end in O horizon and 0-to-15-cm live roots < 0.5 mm compared to 0.5 to 2 mm live are an indication that the finest diameter roots in the O horizon and 0-to-15-cm layers may be turning over a little more rapidly than their slightly larger fine root counterparts. No significant differences within 30-to-60-cm layer so far.

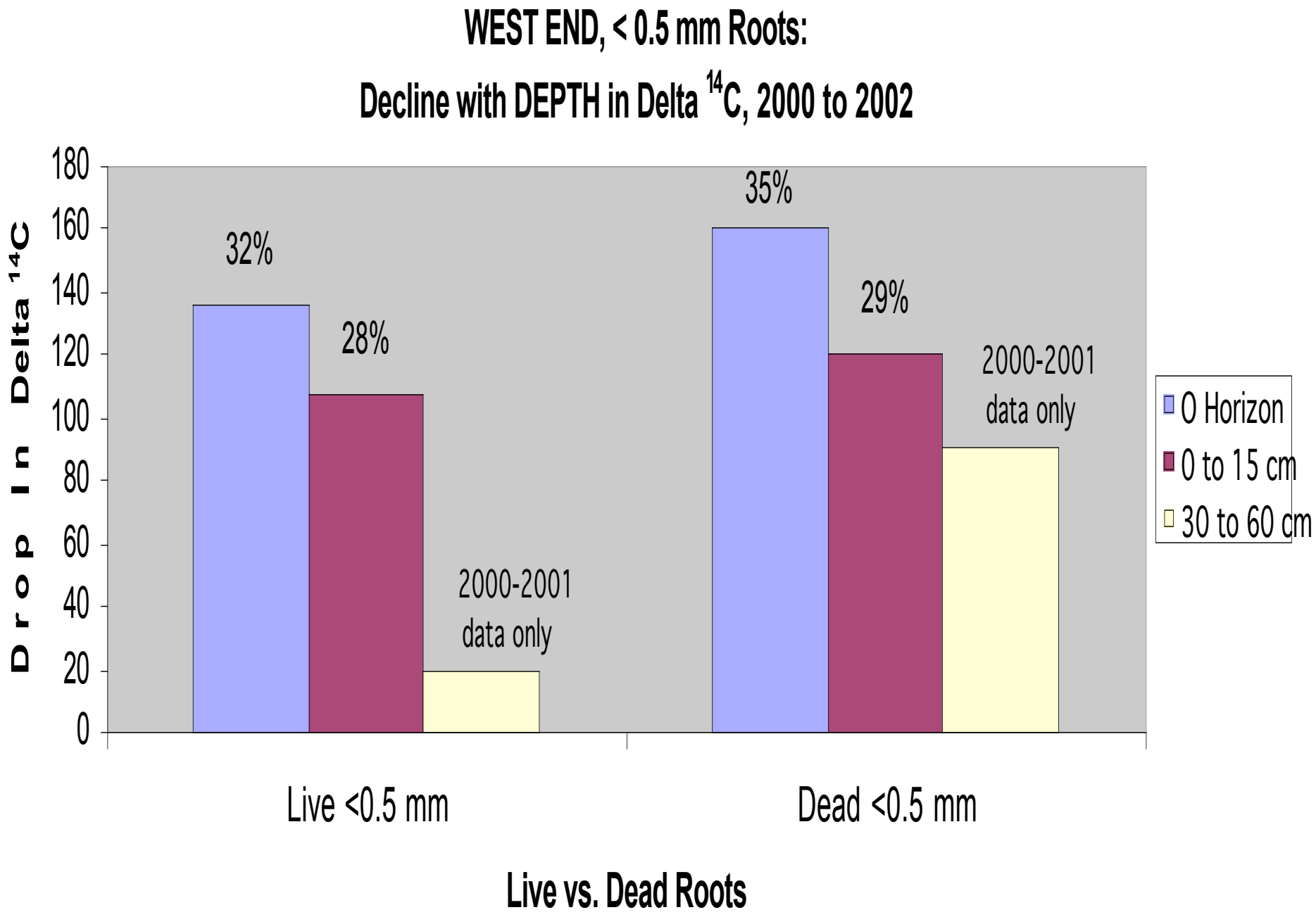
WEST END, Live Roots: Effect of SIZE CLASS on Decline in Delta ^{14}C, 2000-2002, by Depth



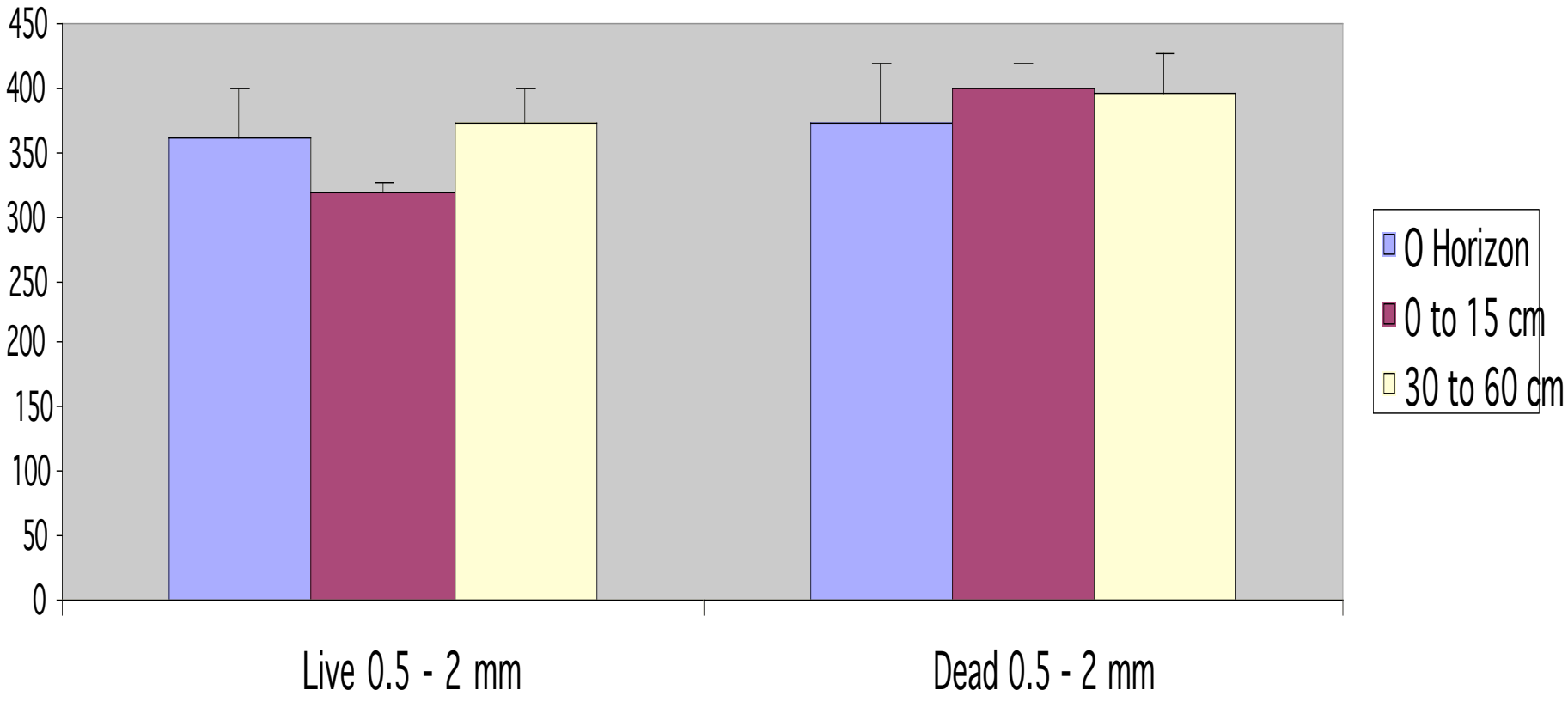
Larger drops in ^{14}C signatures at West end in O horizon dead roots < 0.5 mm compared to 0.5 to 2 mm dead are an indication that the finest diameter roots in the O horizon may be turning over a little more rapidly than their slightly larger fine root counterparts.
No significant size differences within mineral layers so far.



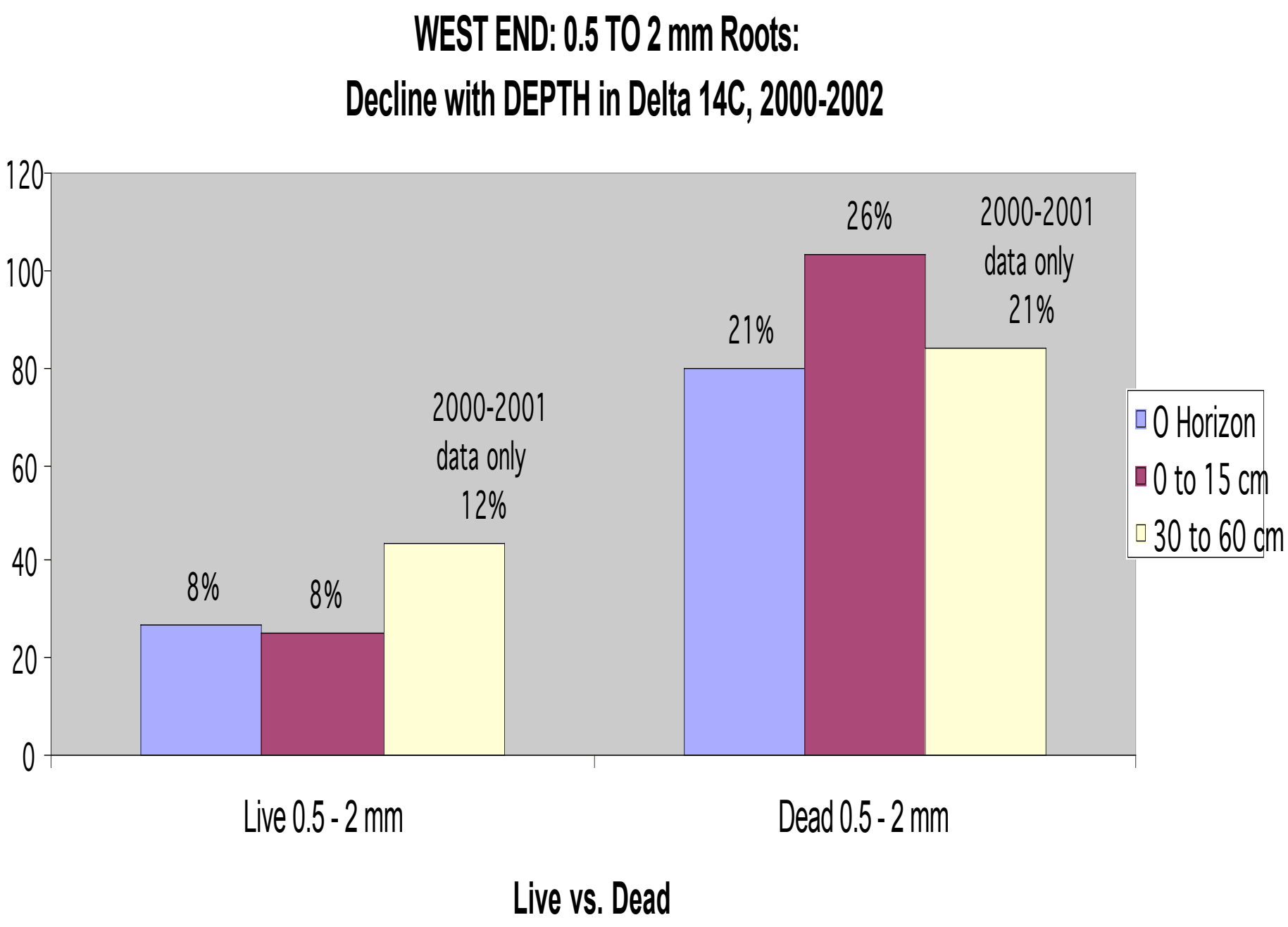

WEST END, <0.5 Roots: Initial (2000) 14C Label
by DEPTH INTERVAL, Live vs. Dead
Initial Delta 14C
500
450
400
350
300
250
200
150
100
50
0
428
384
363
455
420
414
O Horizon
0 to 15 cm
30 to 60 cm
Live < 0.5
Dead <0.5
Live vs. Dead Roots


WEST END, < 0.5 mm Roots:
Decline with DEPTH in Delta 14C, 2000 to 2002
Drop In Delta 14C
180
160
140
120
100
80
60
40
20
0
32%
28%
2000-2001
data only
35%
29%
2000-2001
data only
O Horizon
0 to 15 cm
30 to 60 cm
Live <0.5 mm
Dead <0.5 mm
Live vs. Dead Roots

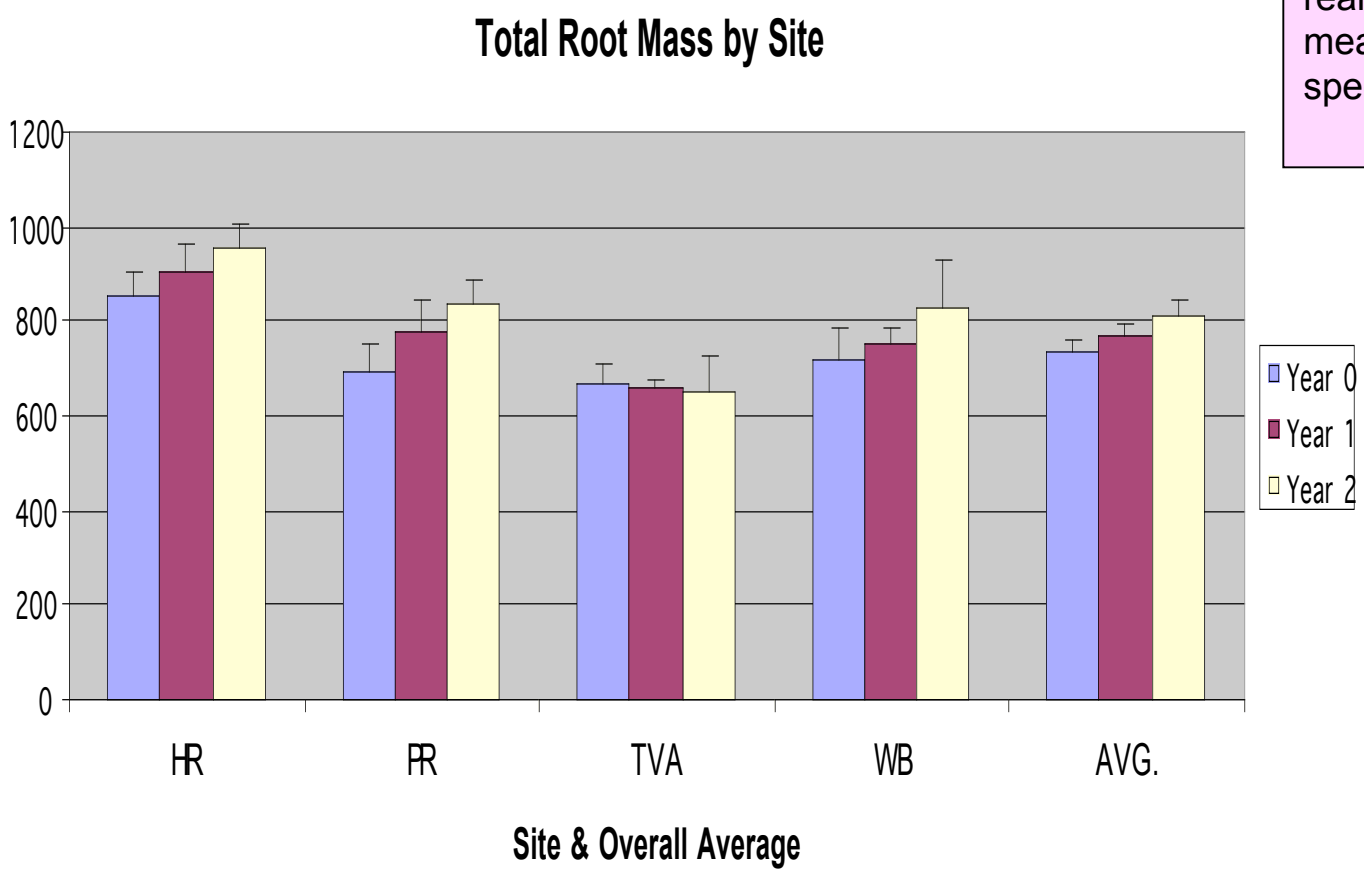
WEST END, 0.5 to 2 mm Roots:
Initial Delta ^{14}C Label by DEPTH

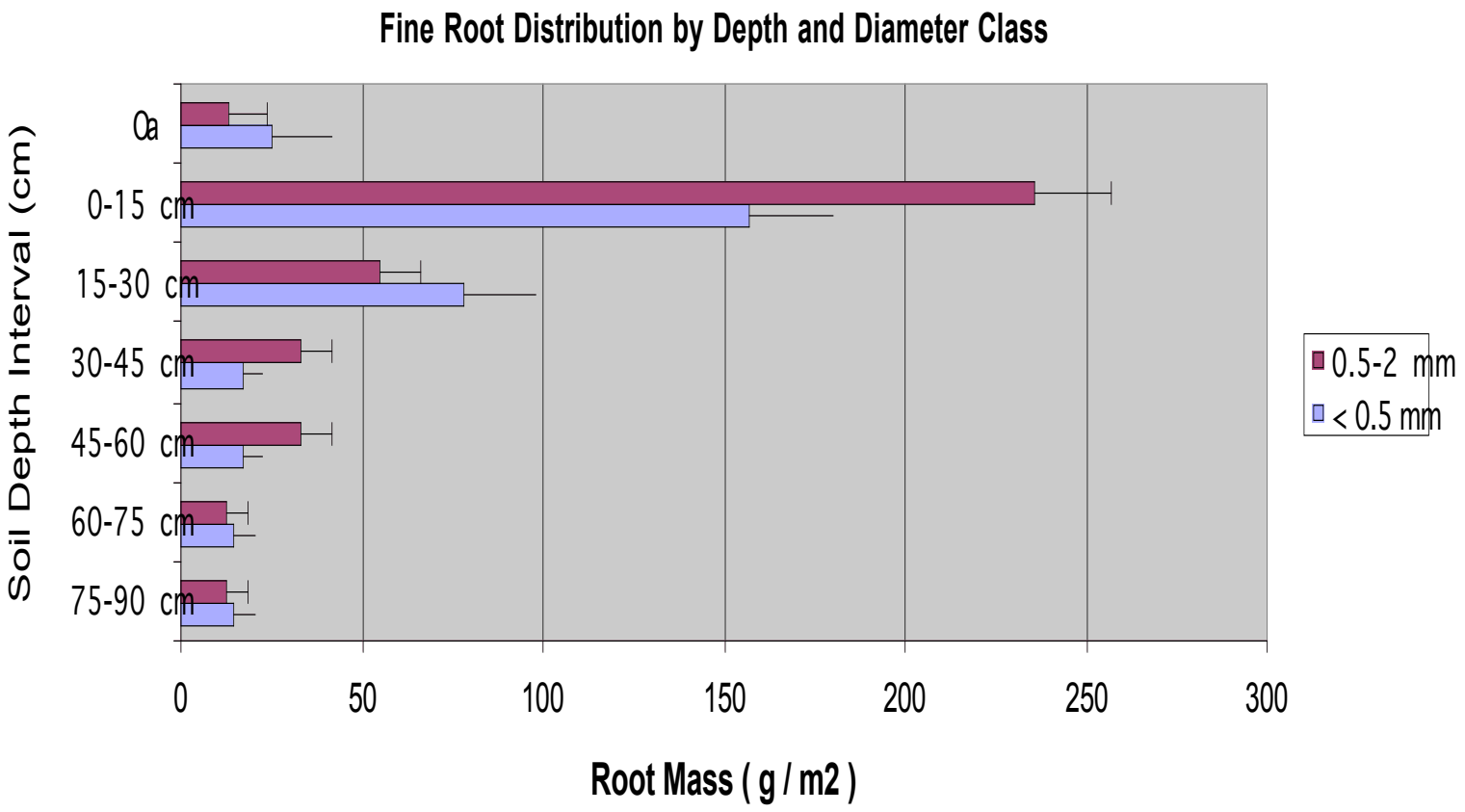


Live vs. Dead


WEST END: 0.5 TO 2 mm Roots:
Decline with DEPTH in Delta 14C, 2000-2002
120
100
80
60
40
20
0
8%
8%
2000-2001
data only
12%
21%
26%
2000-2001
data only
21%
O Horizon
0 to 15 cm
30 to 60 cm
Live 0.5 - 2 mm
Dead 0.5 - 2 mm
Live vs. Dead

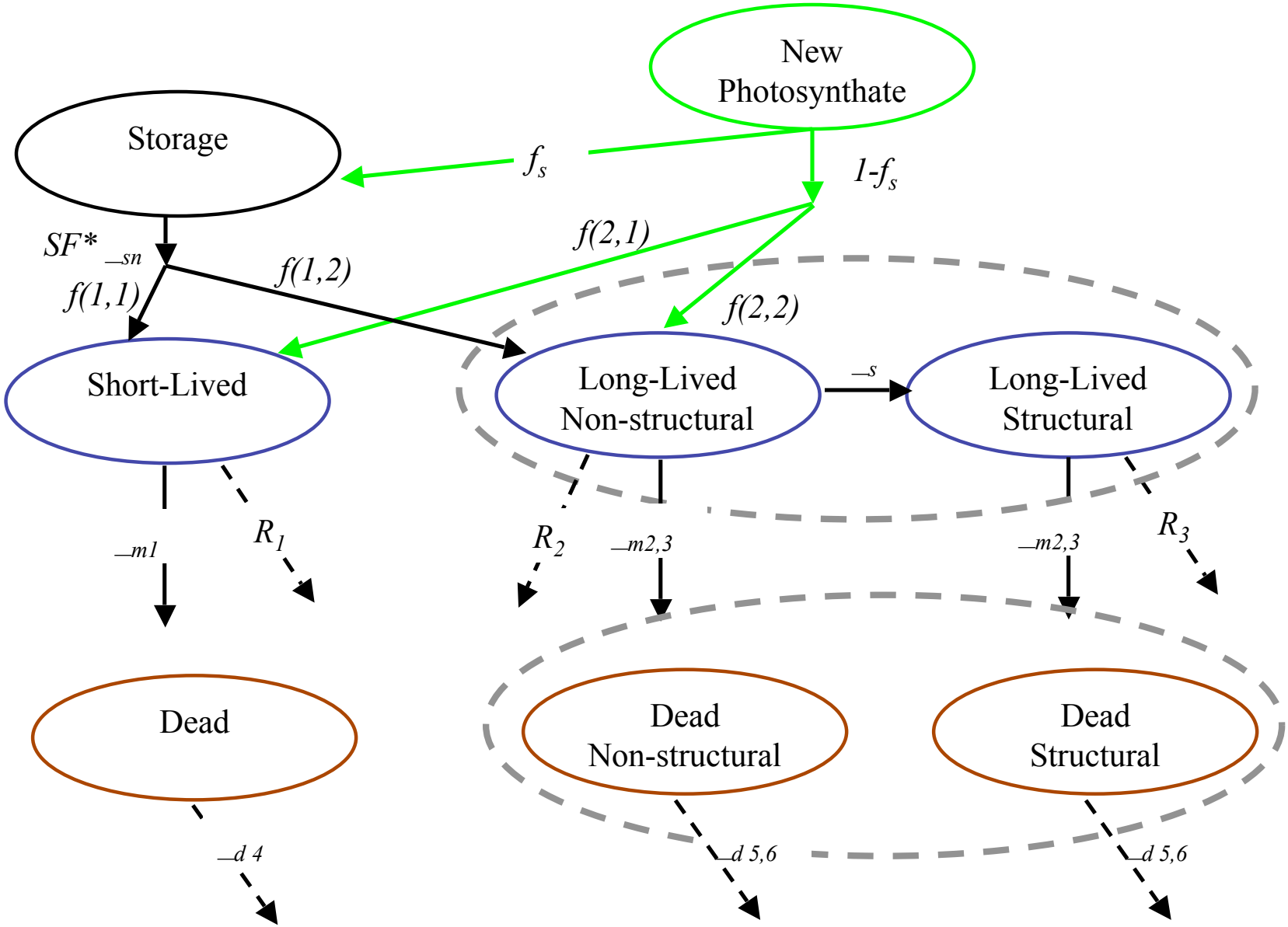
Total fine root mass (< 2 mm live and dead) shows a pattern of slow accretion over 3 years. Whether this is real and what it might mean is subject to speculation.





Largest amount and concentration of fine roots (both size classes—average of 4 sites which are consistent in this regard) is found In 0-to15-cm layer. Approximately 50% of fine roots are found here,

Our New Model



Root Turnover Findings to Date

- **Dead** Root Pools show very **RAPID CHANGE** in Delta ^{14}C between Year 0 and Year 1 (even more than Live Roots):
  - Dead Pool rapid change true for all depths, size classes, but especially on the West End.

- **Dead** Pools show **HIGH INITIAL VALUES** in Year 0 (even higher than Live pools)

- ***Dead*** *Pool Patterns strongly support the existence of multiple cohorts of roots with differing life spans. For simplicity, we are using a* ***2-Cohort Root Model****, with a rapid-turnover pool and a slow-turnover pool.*

Root Turnover Findings to Date

•Some support for **SIZE CLASS** differences in the rates of turnover (both live and dead):

In WEST only: Smaller roots turn over more rapidly in O horizon and 0-15 (live only), but not 30-60 cm.

•Some support for **SOIL DEPTH** differences in the rates of turnover (both live and dead):

- In WEST:root turnover appears slightly more rapid in O horizon and 0-15 cm, but not 30-60 cm, but only with smallest roots.
- Pattern does not hold for larger (0.5-to-2-mm) fine roots at WEST or EAST ends.