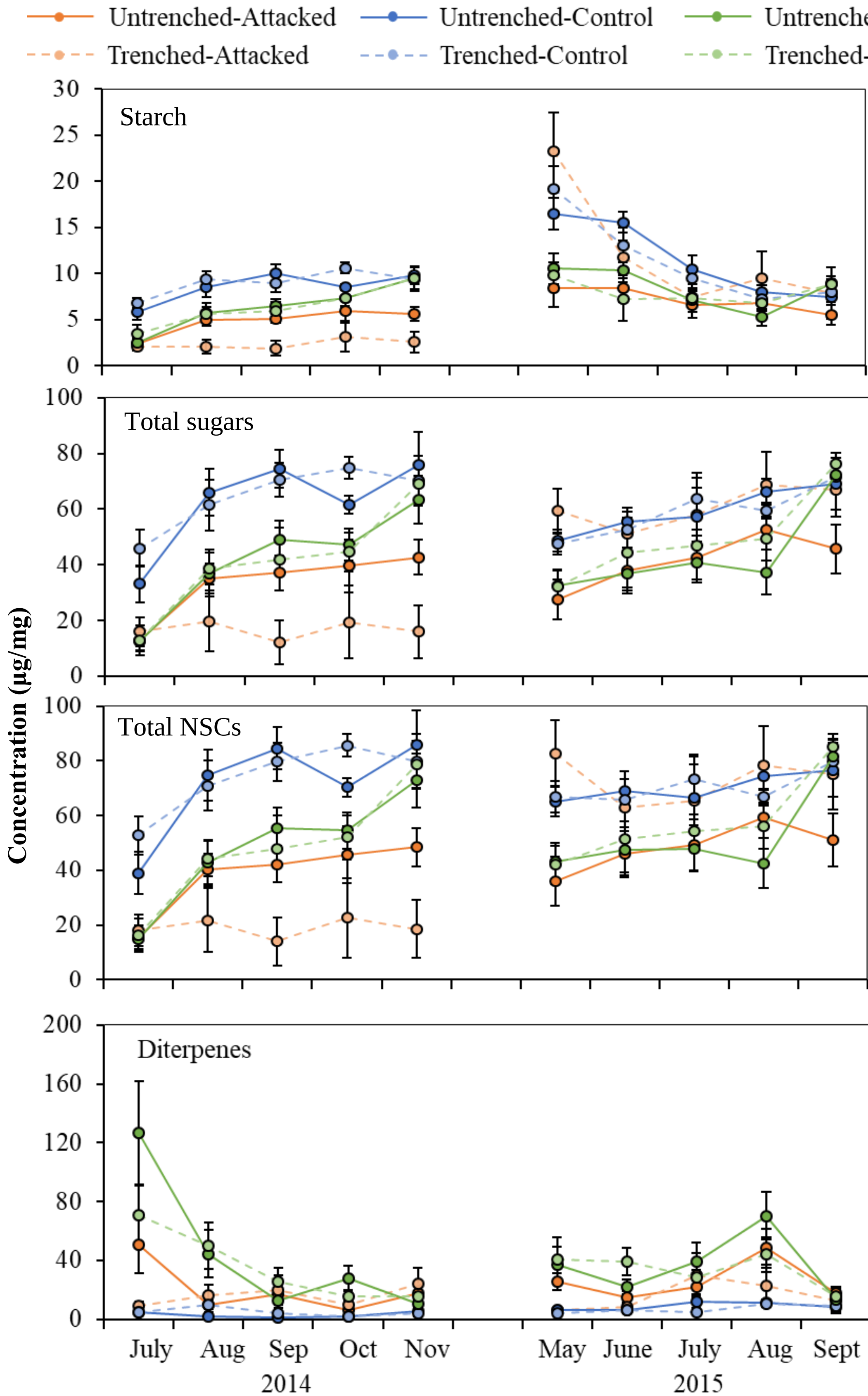


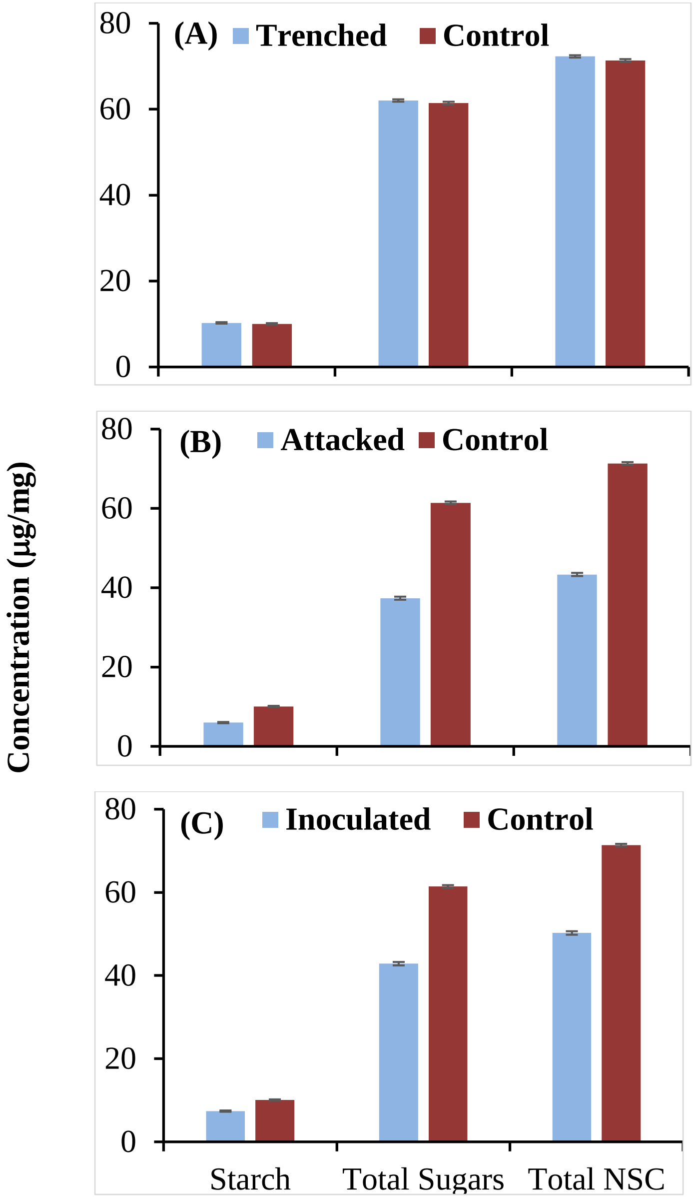
	P-Value
Treatment	<0.0001
Month	<0.0001
Trt*Month	<0.0001

	P-Value
Treatment	<0.0001
Month	<0.0001
Trt*Month	0.0218

	P-Value
Treatment	<0.0001
Month	<0.0001
Trt*Month	0.0141

	P-Value
Treatment	<0.0001
Month	<0.0001
Trt*Month	<0.0001

Figure 1 Mean (±SE) (μg mg^{-1} of dried weight) monthly variation of starch, total sugars, total non-structural carbohydrates (NSC), and diterpenes of *Pinus ponderosa* trees in six treatments from July to November 2014 and May to September 2015.



	P-Value (A)	P-Value (B)	P-Value (C)
Total Sugars			
Treatment	0.893	< 0.001	<0.001
Month	< 0.0001	< 0.0001	< 0.0001
Trt*Month	0.737	0.634	0.398
Starch			
Treatment	0.722	< 0.001	0.001
Month	< 0.0001	< 0.0001	< 0.0001
Trt*Month	0.426	0.007	0.018
Total NSC			
Treatment	0.810	< 0.001	< 0.001
Month	< 0.0001	< 0.0001	< 0.0001
Trt * Month	0.731	0.664	0.337

Figure 2. Means (±SE) (µg mg^{-1} of dried weight) of starch, total sugars, and total non-structural carbohydrates (NSCs) of *Pinus ponderosa* trees in six treatments. Trees included in each comparison were reported in Table 1.

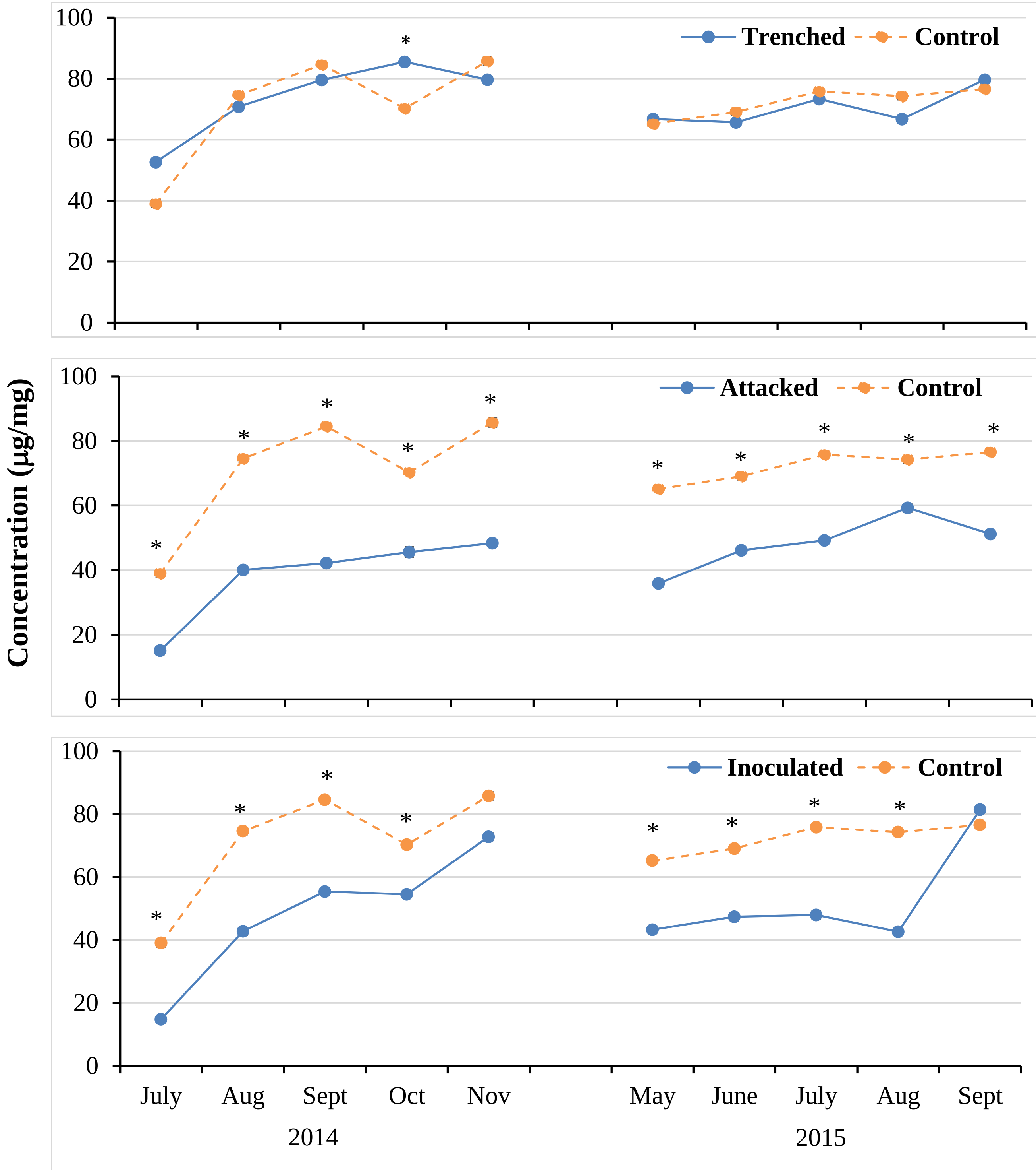
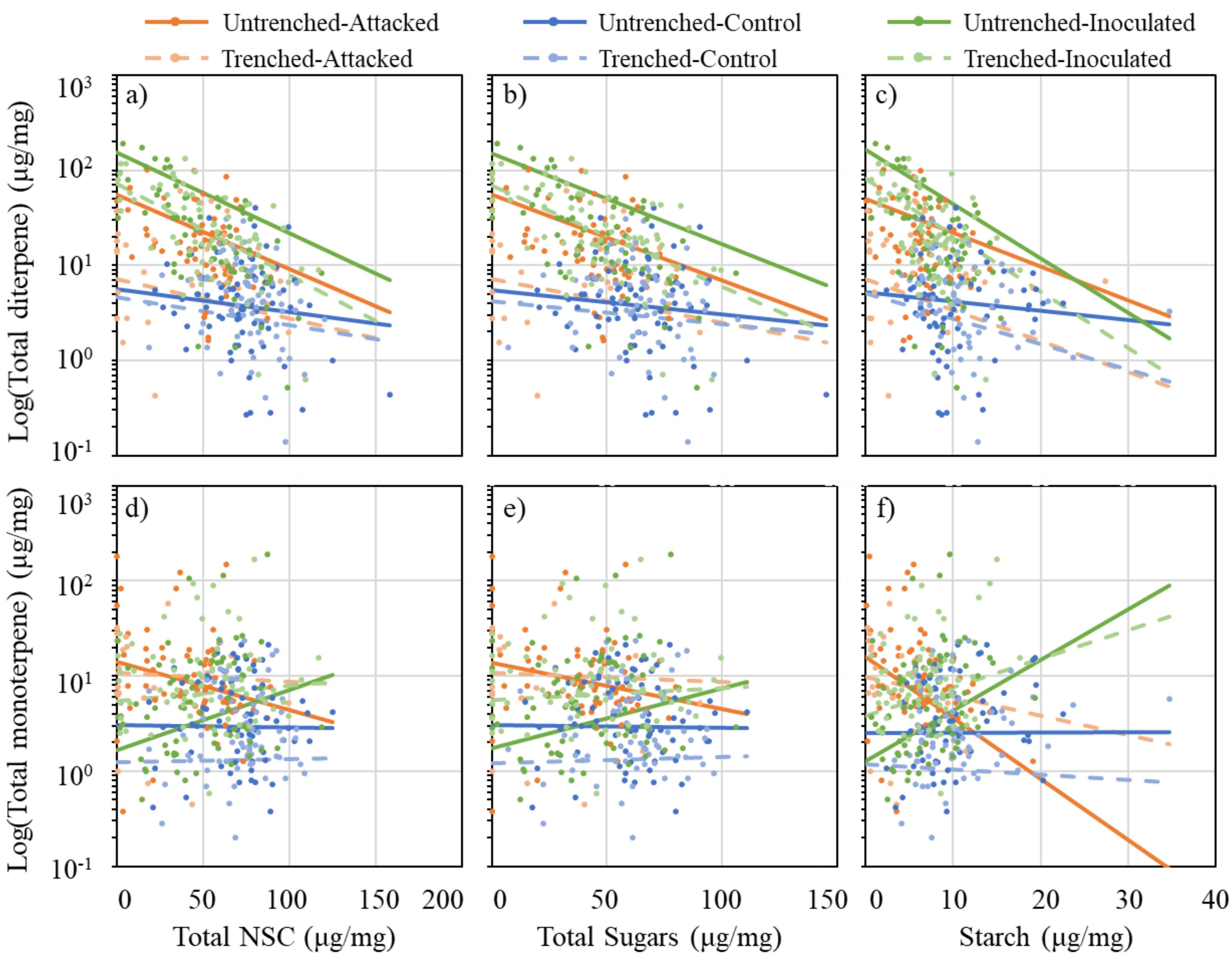
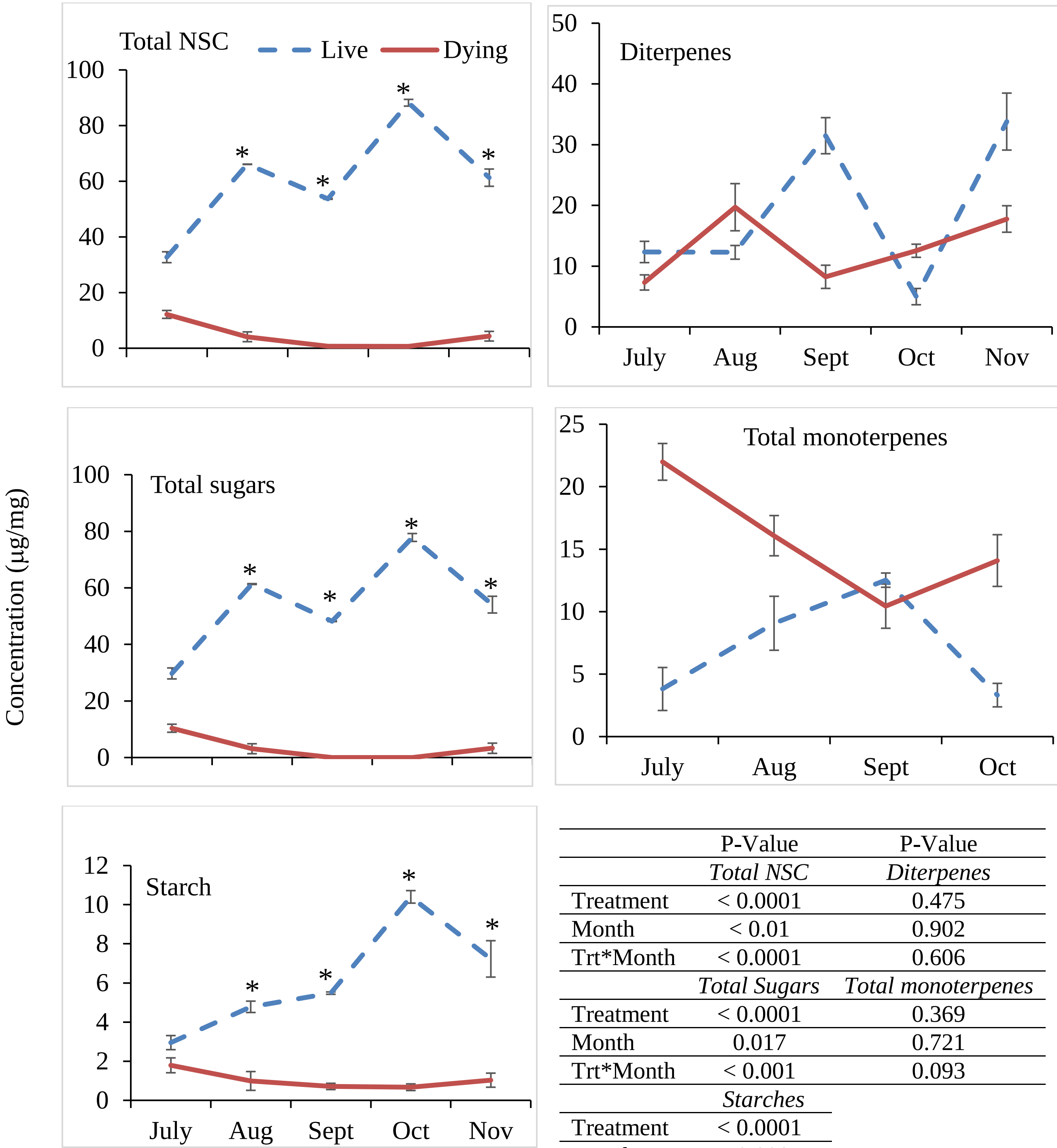


Fig. 3. Monthly means (±SE) (µg mg^{-1} of dried weight) of total non-structural carbohydrates of *Pinus ponderosa* trees in different comparisons. * denotes that concentrations vary in a given month (95% confidence level adjusted with Sidak method for two estimates). Suppl. Table S4 shows statistical results.



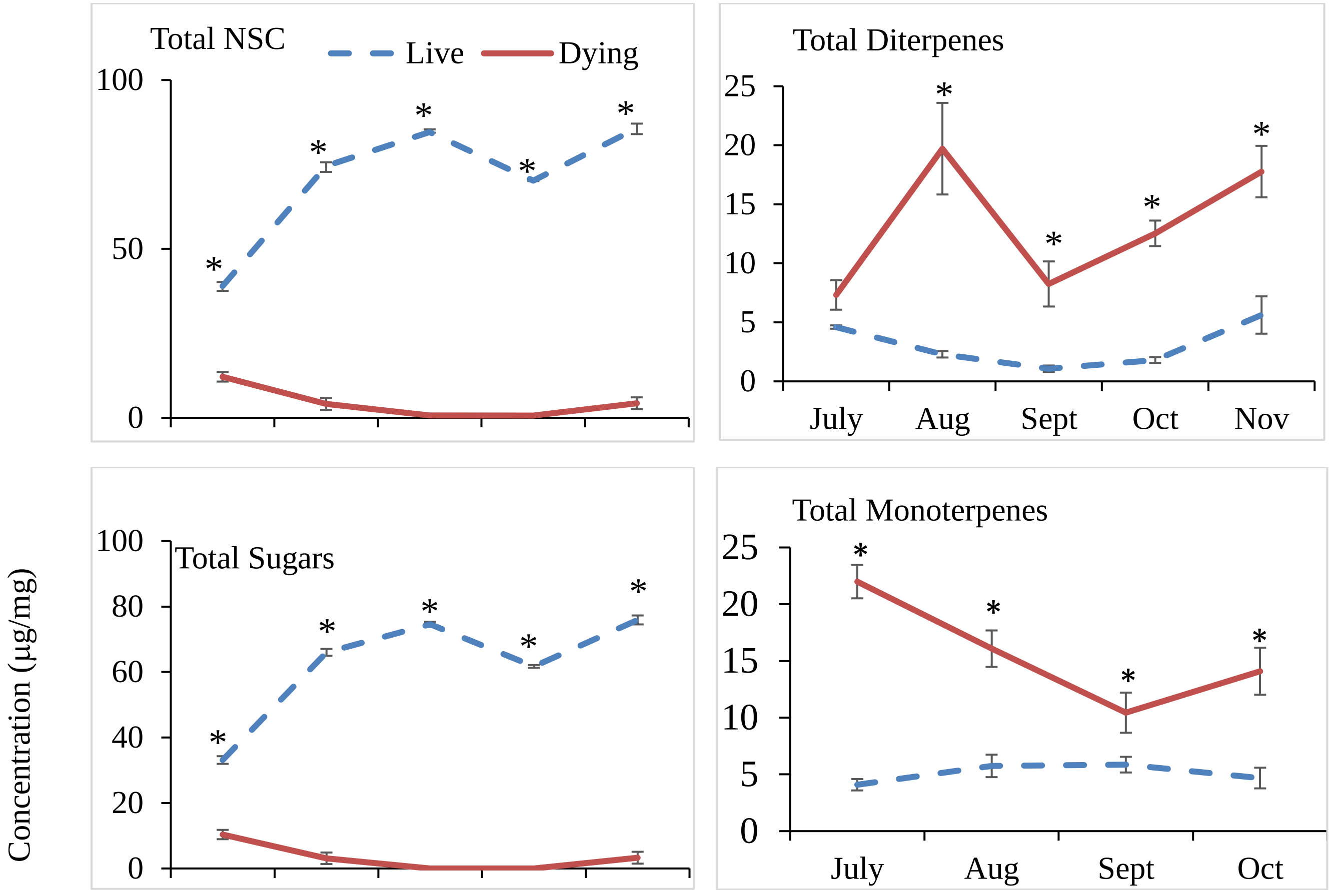
Untrenched-Attacked
Trenched-Attacked
Untrenched-Control
Trenched-Control
Untrenched-Inoculated
Trenched-Inoculated
Log(Total diterpene) (µg/mg)
Log(Total monoterpene) (µg/mg)
a)
b)
c)
d)
e)
f)
10³
10²
10¹
10⁰
10⁻¹
0
50
100
150
200
0
50
100
150
0
10
20
30
40
Total NSC (µg/mg)
Total Sugars (µg/mg)
Starch (µg/mg)

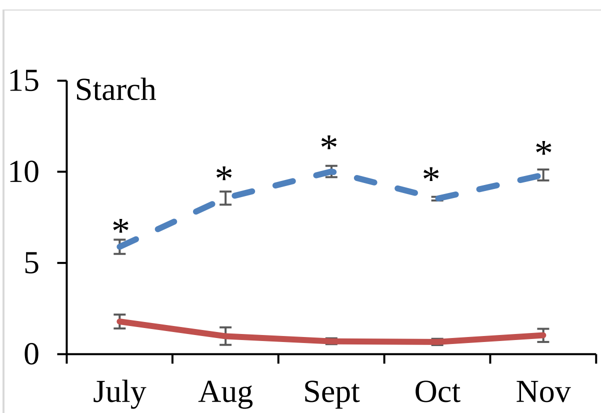
Figure 4. Relationship between concentrations of total diterpenes and non-structural carbohydrates (NSCs) of *Pinus ponderosa* trees by treatments. Regression lines for: (a) NSC, (b) total sugars, and (c) starch are from repeated measures ANCOVAs on the log of total diterpenes. Top figures: Significance of interaction between NSCs and total diterpenes were as follows: (a) Total NSCs: $F_{(5,256)}=1.96$, $P=0.085$, (b) Total sugars: $F_{(5,258)}=2.18$, $P=0.057$, and (c) Starch: $F_{(5,254)}=1.34$, $P=0.247$. Bottom figures. Significance of interaction between NSCs and total monoterpenes were as follows: (d) Total NSCs: $F_{(5,255)}=2.07$, $P=0.069$, (e) Total sugars: $F_{(5,254)}=1.58$, $P=0.166$, (f) Starch: $F_{(5,286)}=4.98$, $P=0.0002$. Degrees of freedom were calculated with Satterthwaite's method.



	P-Value	P-Value
	Total NSC	*Diterpenes*
Treatment	< 0.0001	0.475
Month	< 0.01	0.902
Trt*Month	< 0.0001	0.606
	Total Sugars	*Total monoterpenes*
Treatment	< 0.0001	0.369
Month	0.017	0.721
Trt*Month	< 0.001	0.093
	Starches	
Treatment	< 0.0001	
Month	< 0.0001	
Trt*Month	< 0.0001	

Figure 5. Monthly means (±SE) (µg mg^{-1} of dried weight) of carbohydrates, total diterpenes, and total monoterpenes of dying and live *Pinus ponderosa* trees in the trenched-attacked treatment. Data are from 2014. * shows months where differences among treatments are significant (95% confidence level adjusted with Sidak method for two estimates).





	P-Value	P-Value
	Total NSC	*Total Diterpenes*
Treatment	< 0.0001	< 0.0001
Month	0.063	0.067
Trt*Month	0.001	0.079
	Total Sugars	*Total Monoterpenes*
Treatment	< 0.0001	< 0.0001
Month	0.067	0.111
Trt*Month	0.001	0.023
	Starches	
Treatment	< 0.0001	
Month	0.189	
Trt*Month	0.005	

Figure 6. Monthly means (±SE) (µg mg^{-1} of dried weight) of carbohydrates, total diterpenes, and total monoterpenes of dying *Pinus ponderosa* trees in the trenched-attacked treatment and live trees in the untrenched-control treatment. Data are from 2014. * shows months where differences among treatments are significant (95% confidence level adjusted with Sidak method for two estimates).

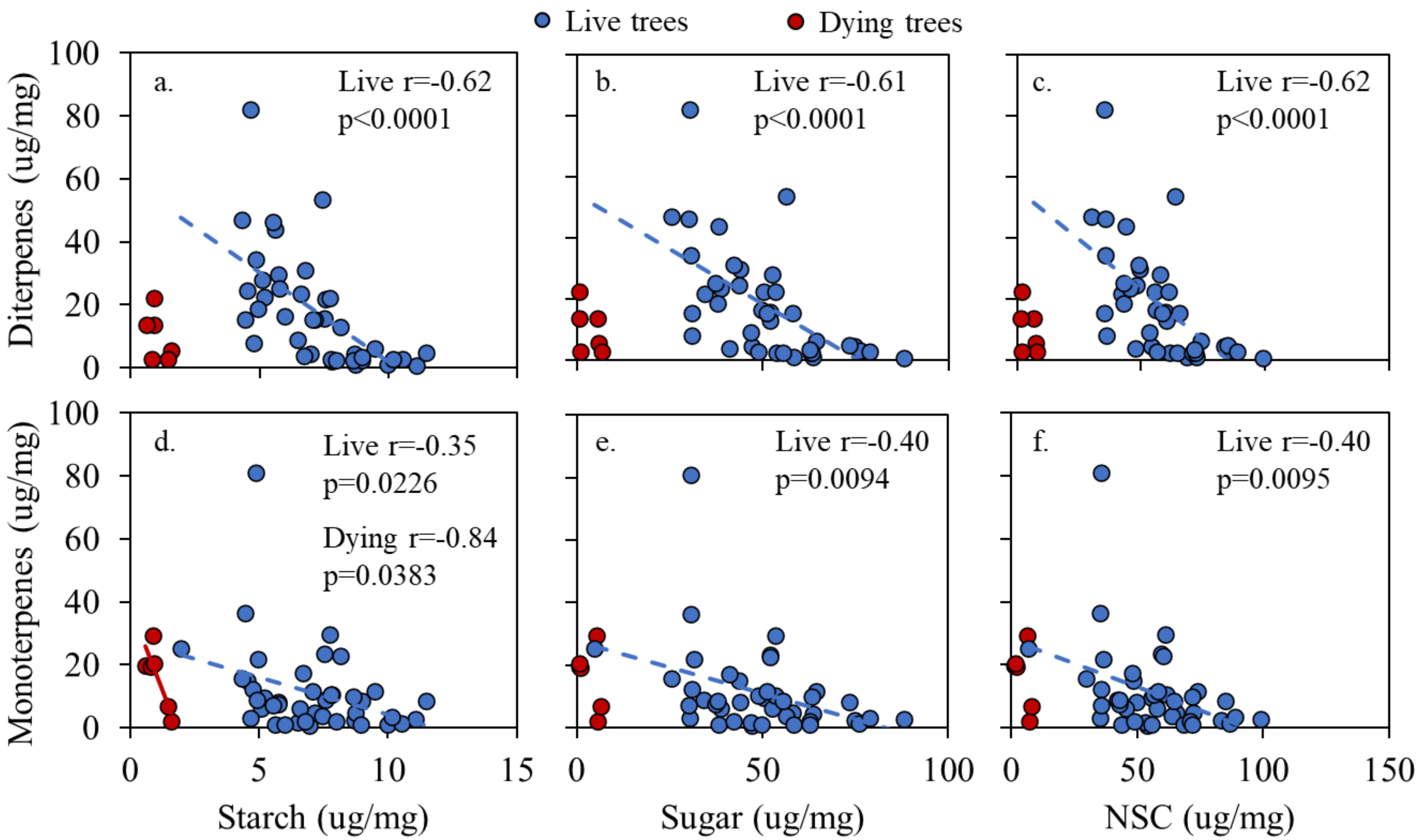


Figure 7. Relationship between carbohydrate and terpene concentrations from 2014 for dying *Pinus ponderosa* trees in the trenched-attacked category and all treatment categories of live trees averaged over months. Solid (dying trees) and dashed (live trees) trend lines indicate significant Pearson correlations. Dying trees n=8 and live trees n=42 (except diterpene comparisons n=40). Total non-structural carbohydrates (NSC) are the sums of starch and total sugar concentrations.

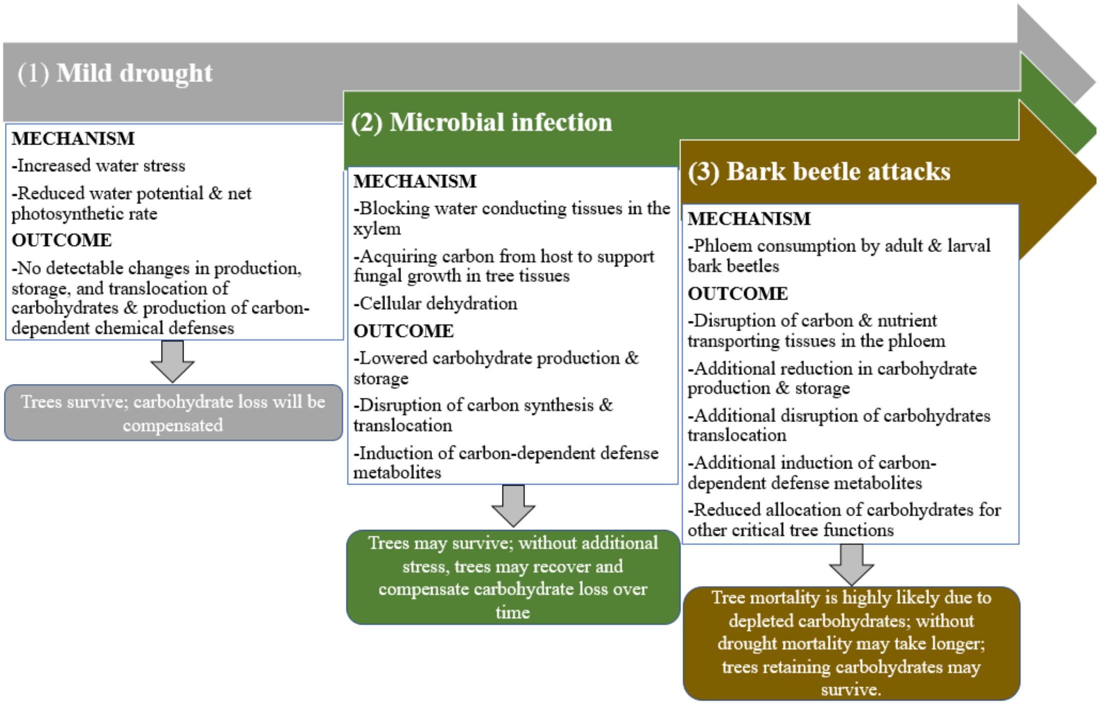


Figure 8. Schematic representation of how mild drought alone or in combination with pathogenic microbial infection and bark beetle attacks affect carbohydrates and carbon-dependent defense metabolites (terpenes) in pines. The arrows extending over stressors at the top of the figure represent cumulative effects. For instance, bark beetle-attacked trees are stressed by drought, microbial infection, and bark beetle attacks as three arrows extend over "Bark beetle attacks" box.

(1) Moderate drought alone may result in increased water stress and reduced water potential and net photosynthetic rates; however, these changes may not lead to any detectable changes in the production, storage and translocation of carbohydrates and in the production of terpenes. Tree survival is highly likely due to compensation of carbohydrates over time. **(2)** However, additional pathogenic fungal infection on the drought-stressed trees can cause further changes in tree physiological processes. Once inside the tree, fungal propagules germinate and fungal hyphae spread and penetrate water conducting tissues in the xylem, causing cellular dehydration. In addition, fungal hyphal growth and expansion in the phloem and xylem become a significant carbon sink. These changes can lower production, storage, and translocation of carbohydrates in the tree but also induce the terpene production. Terpenes limit the growth of fungal infection inside the tree. Trees are likely to survive from fungal infection alone and compensate carbohydrate loss over time. **(3)** During attacks, bark beetles consume phloem in addition to facilitating microbial infection, resulting in stronger changes in carbon production, storage and translocation as well as translocation of nutrients between roots and canopy. These attacks also create stronger sinks for carbohydrates than microbial infection alone by allocation of carbons for the terpene production. Terpenes enhance tree resistance to bark beetle–microbial complexes. These changes may also reduce allocation of carbohydrates for growth and respiration as trees with low carbohydrates prioritize chemical defenses. Tree mortality due to combination of mild drought and bark beetle-microbial symbiont attacks is highly likely and happens quickly. However, if trees retain some carbohydrates, they may survive.