

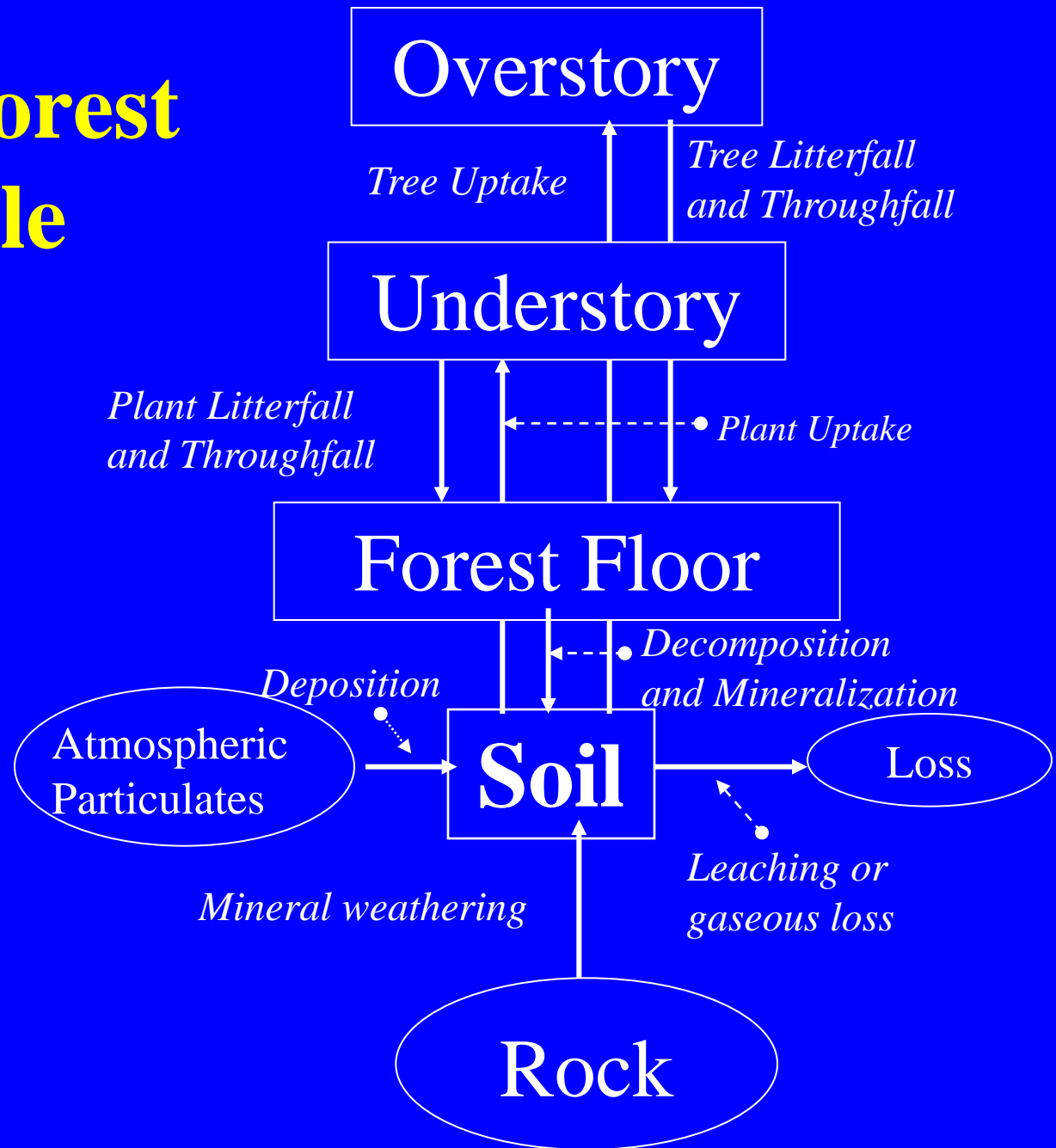
# Nutrient Budget Model Development



Peter G. Mika

2003 IFTNC Annual Meeting

# Modeling the forest nutrient cycle



# The Overstory

- Components
  - Foliage
  - Fine Branches (<0.25")
  - Coarse Branches ( $\geq 0.25$ ")
  - Stem
    - Wood versus Bark
    - Merchantable versus Unmerchantable
- Needed information
  - Biomass
  - Nutrient concentration

# Information in FVS

- Wood
  - Known: CFV, total and merchantable
  - Needed: wood density, nutrient concentrations
- Bark
  - Known: wood/bark ratios by species
  - Needed: bark volumes, bark density, nutrient concentrations
- Crown
  - Known: biomass of foliage, fine branches, and coarse branches
  - Needed: nutrient concentrations

# What do we know?

- Tissue nutrient concentration
  - Variation among species
  - Variation across sites
    - Habitat type
    - Rock type
  - Variation within crowns
    - By position (ie. upper, mid, and lower crown)
    - By age (ie. new foliage, older foliage)

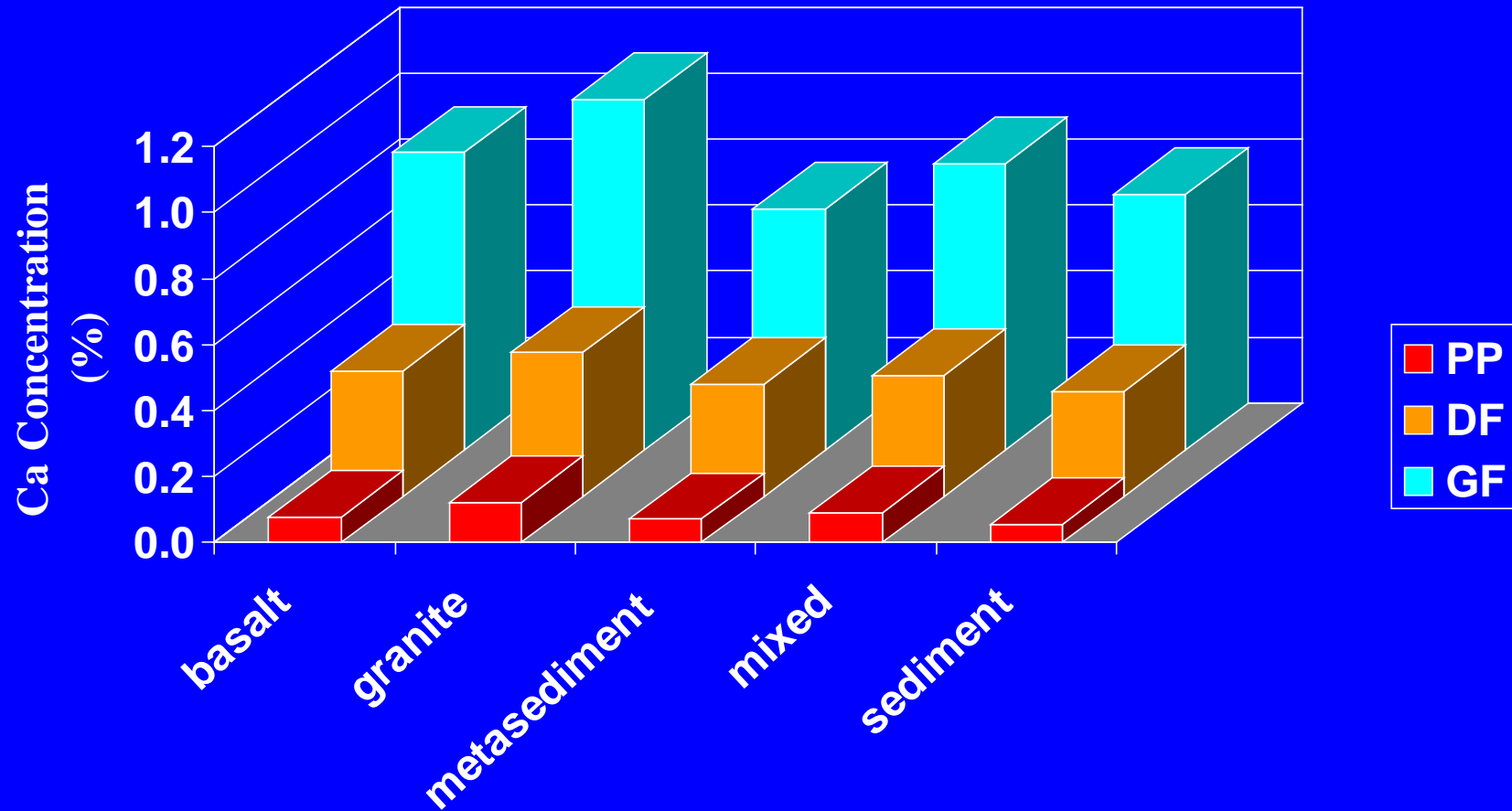
# What information does the IFTNC have?

- Foliar nutrient concentration
  - Species we have sampled across rock and vegetation types
    - Douglas-fir, Ponderosa Pine, Grand Fir, Lodgepole
  - Species we have sampled somewhere
    - Western Redcedar, Western Larch
  - Species we have never sampled
    - Western White Pine, Engelmann Spruce, Subalpine Fir, Western Hemlock, Mountain Hemlock

# Sites Sampled for Foliar Nutrients

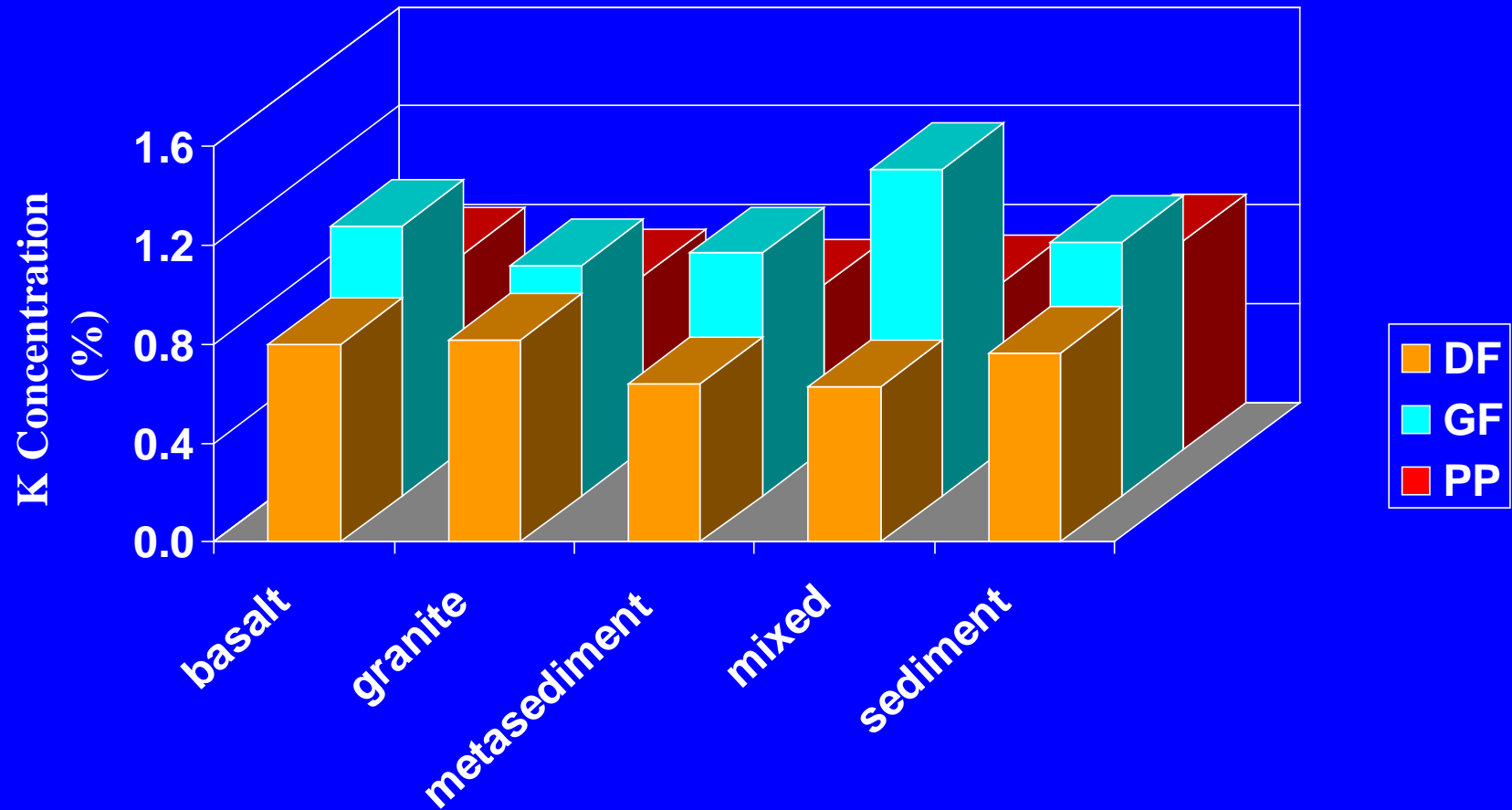
	Tree Species													
	DF					PP		GF				LPP		
	Vegetation Series													
Rock Type	DF	GF	RC	WH	AF	DF	GF	GF	RC	WH	AF	DF	GF	AF
Basalt	15	25	5	3		6	12	5	1	2	1		1	1
Granite	11	9	3	1	1	4	2		1			1		3
Metasediment	8	6	12	2		3	1	1	2					
Mixed	17	4	4	1	1	3	4		1			1	1	1
Sediment	4	3					2							

# Foliar Ca Concentration By Rock Type and Species on WRC Vegetation Series

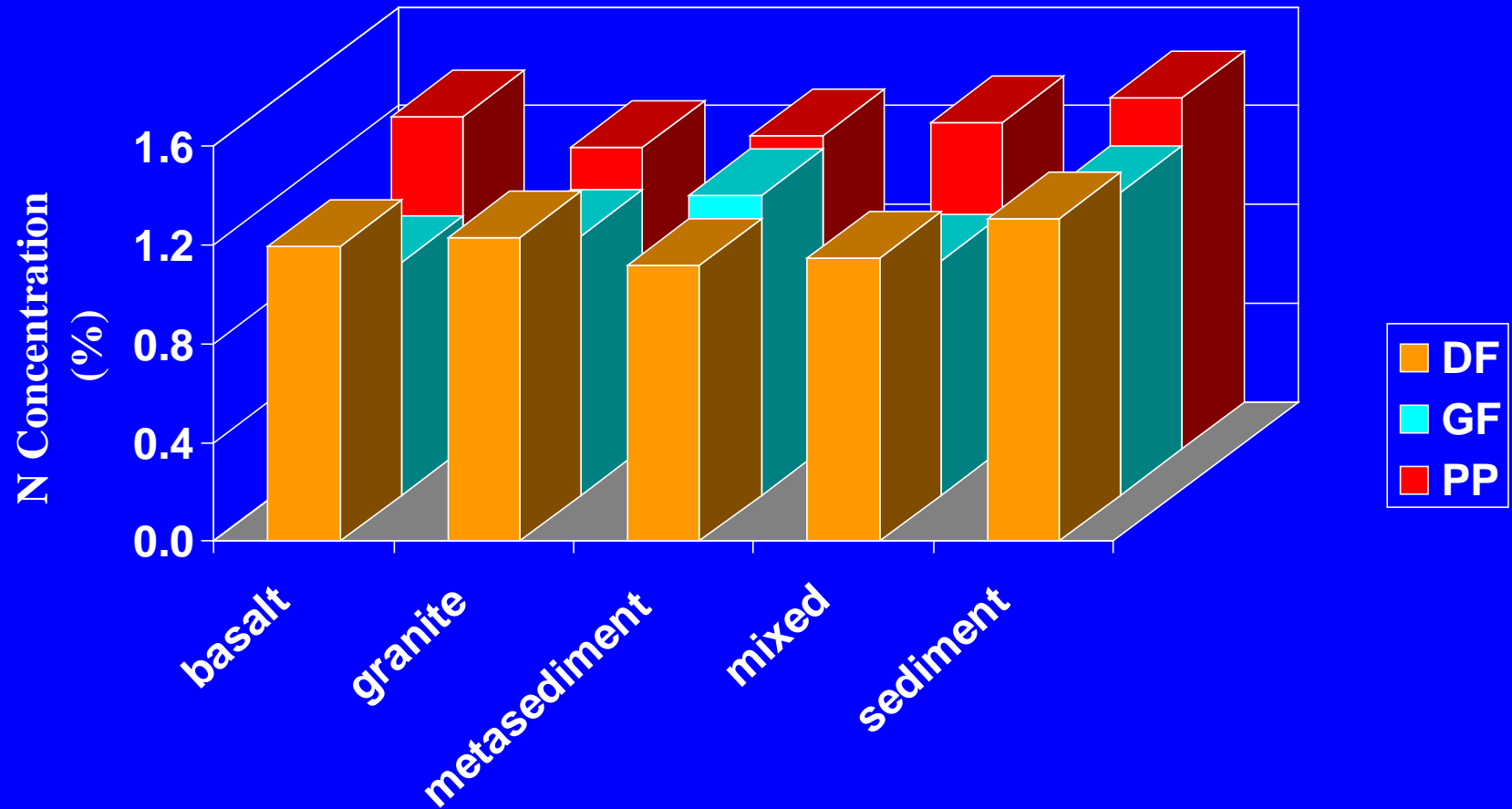




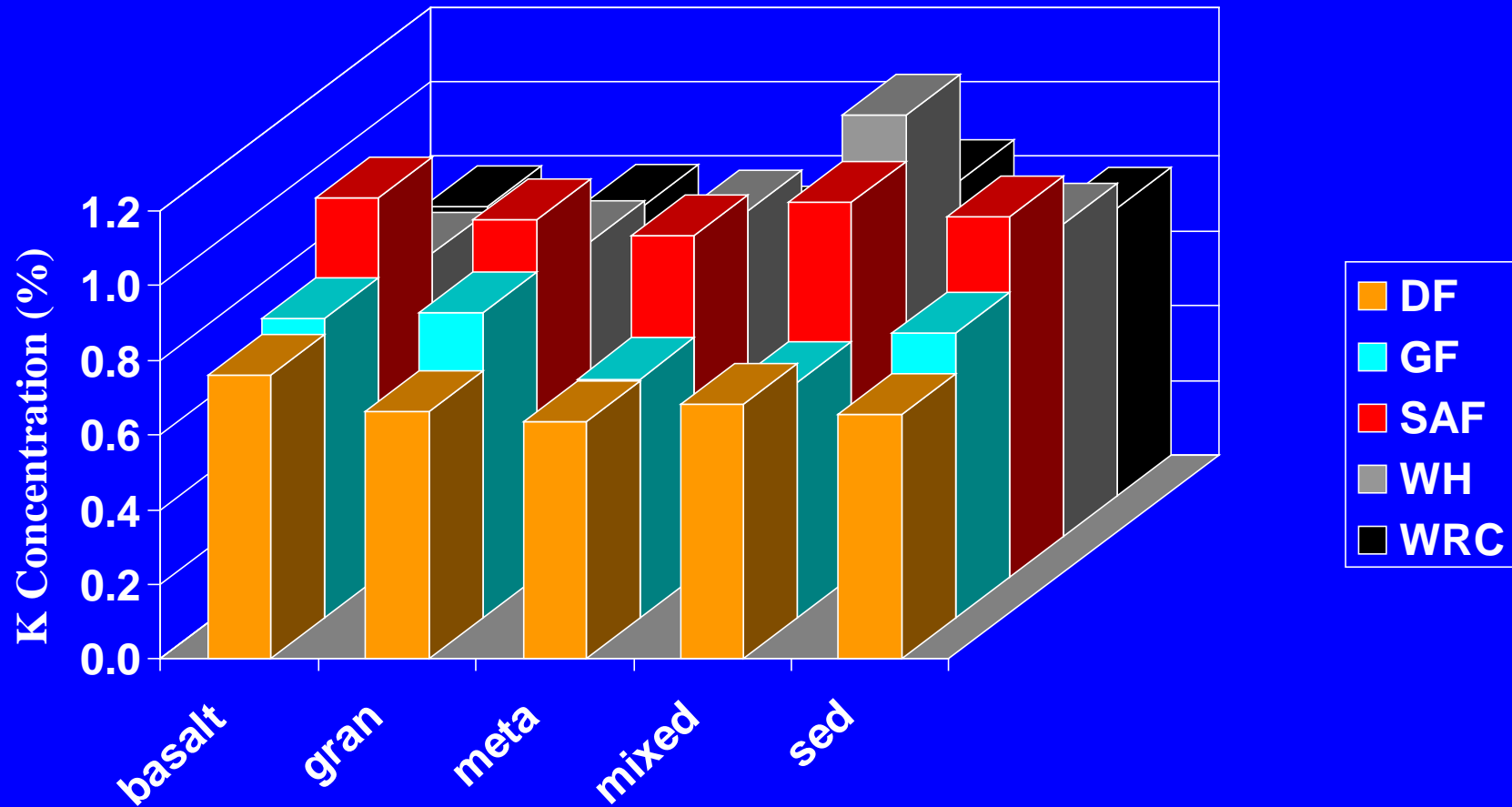
# Foliar K Concentration By Rock Type and Species on GF Vegetation Series



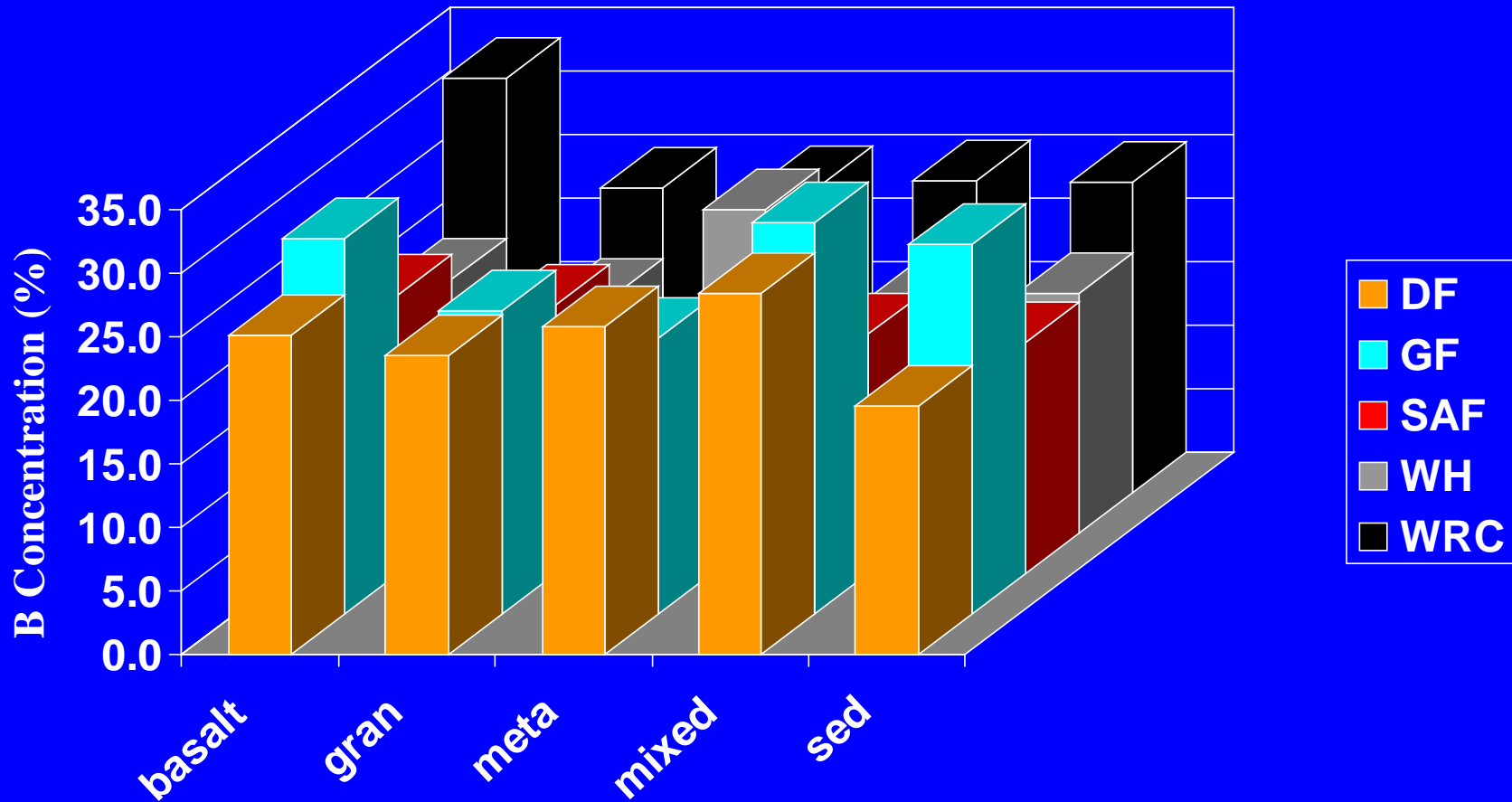
# Foliar N Concentration By Rock Type and Species on WRC Vegetation Series



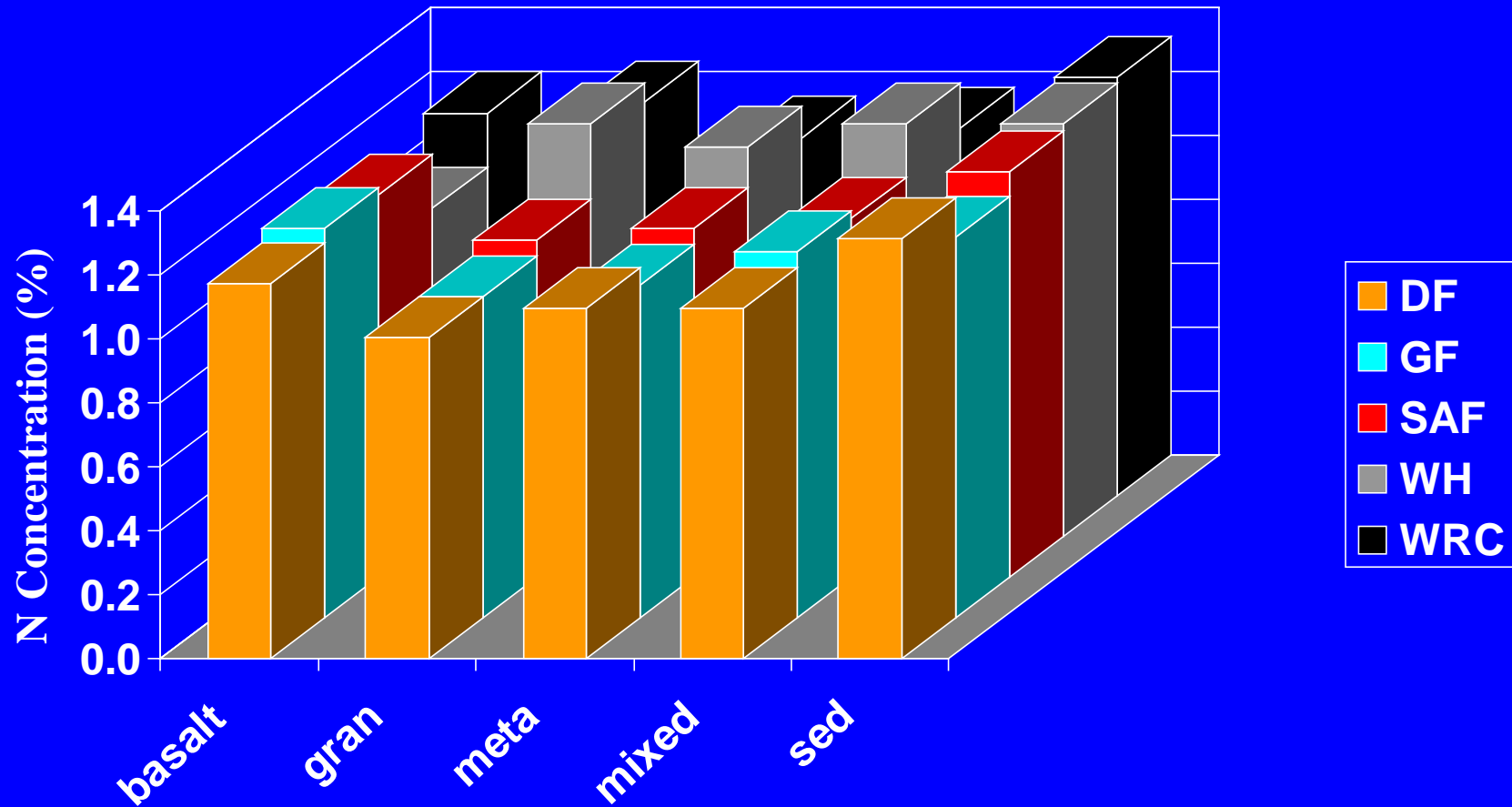
# Douglas-fir Foliar K Concentration by Rock Type and Vegetation Series



# Douglas-fir Foliar B Concentration by Rock Type and Vegetation Series



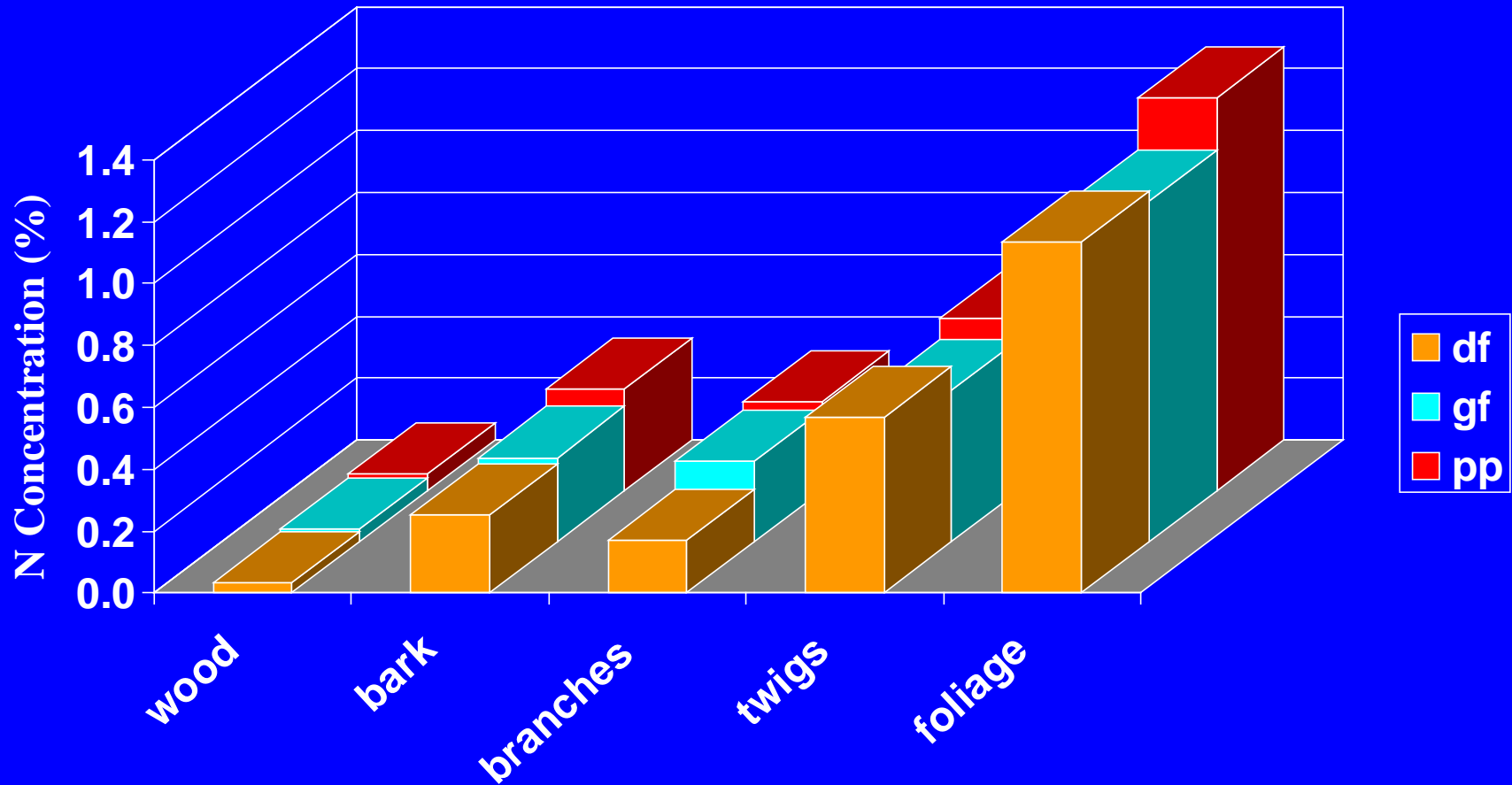
# Douglas-fir Foliar N Concentration by Rock Type and Vegetation Series



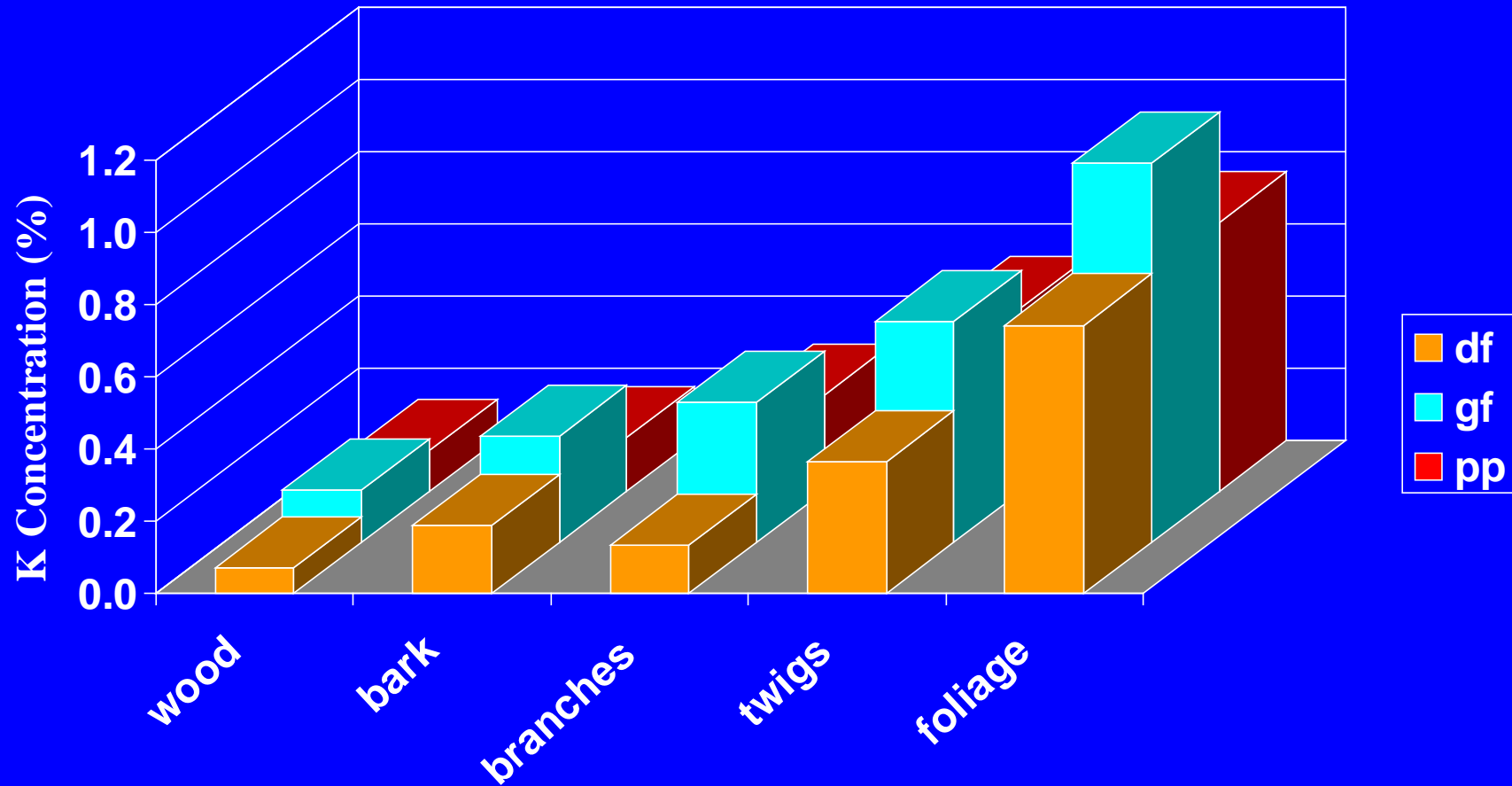
# What other information does the IFTNC have?

- Branch, Bark, and Wood Chemistry
  - Species we have sampled in detail
    - Douglas-fir, Ponderosa Pine, Grand Fir
  - Species we have sampled somewhere
    - Lodgepole Pine, Western Redcedar, Western Larch
  - Species we have never sampled
    - Western White Pine, Engelmann Spruce, Subalpine Fir, Western Hemlock, Mountain Hemlock

# N Concentration by Species and Overstory Component

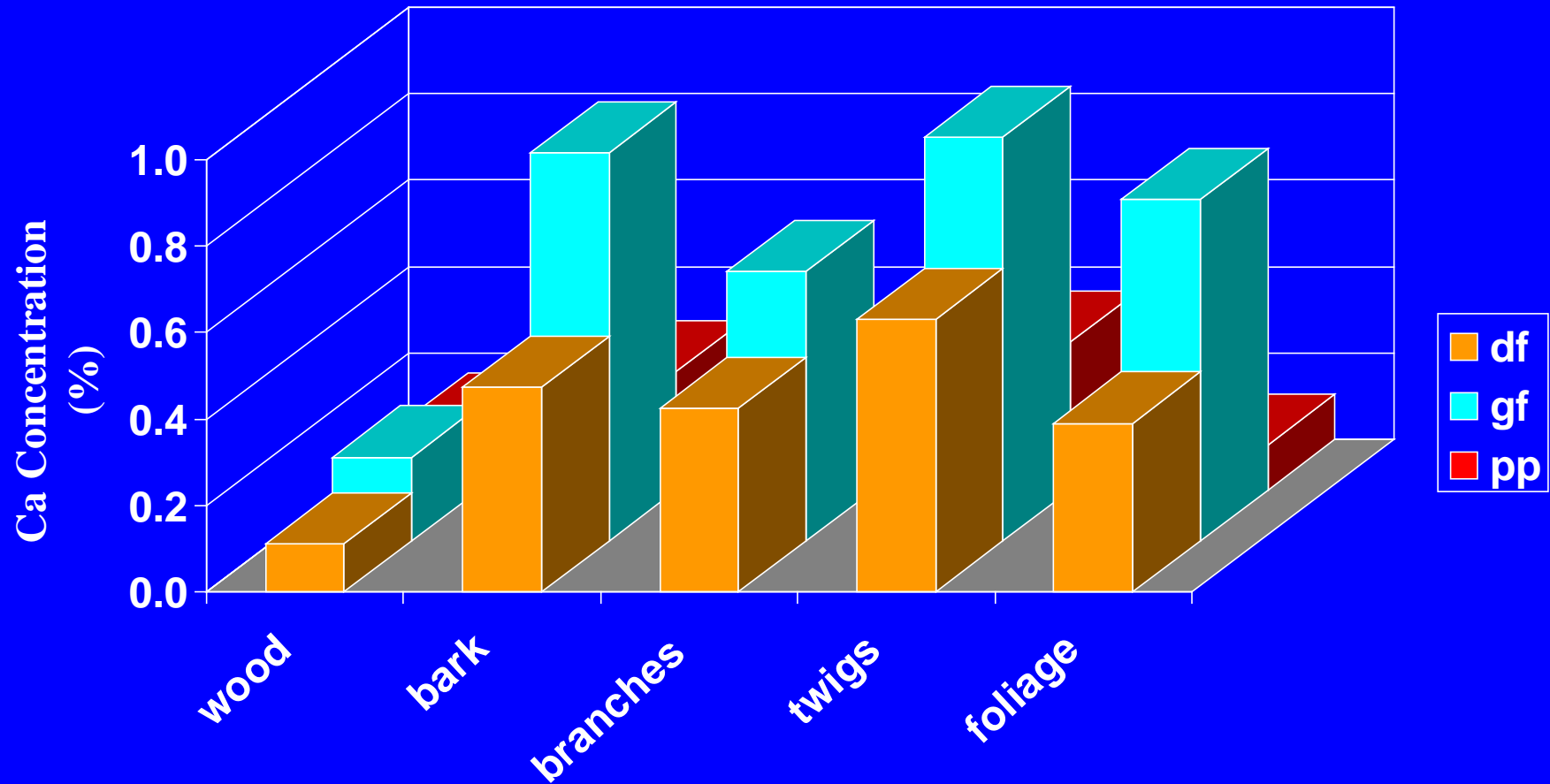


# K Concentration by Species and Overstory Component





# Ca Concentration by Species and Overstory Component



# Model Calculations

- **Crown**

Foliage biomass (from FVS) X nutrient concentration = nutrient content

Same for fine and coarse branches

- **Wood**

Wood volume (from FVS) X wood density X nutrient concentration = nutrient content

- **Bark**

Bark volume = f( wood volume (from FVS), bark/wood ratio (from FVS))

Bark volume X bark density X nutrient concentration = nutrient content

# Stand Nutrient Output from FVS

OVERSTORY NUTRIENT COMPONENTS (lbs/acre)

STAND ID: IFTNC338

MGMT ID: THIN

Amount in standing crop before any cut

Year	Nutr	Foliage	Small Branches	Coarse Branches	Total Crown	Unmerch Bark	Merch Bark	Unmerch Wood	Merch Wood
1994	Bio	11490.2	5268.1	17572.2	34330.5	2607.2	28702.2	17461.8	118722.9
	N	107.153	34.242	58.433	199.827	6.969	75.889	7.022	46.261
	K	61.447	24.637	50.883	136.967	6.474	65.773	20.472	131.156
	P	14.949	6.650	13.316	34.916	1.940	20.418	6.833	46.329
	Ca	145.138	42.854	95.936	283.928	18.673	183.253	28.156	182.466
	Mg	13.365	6.344	13.732	33.441	1.496	15.630	6.109	40.920
	S	7.976	2.647	5.158	15.781	0.581	6.007	1.852	12.532
	Mn	3.966	0.998	2.334	7.298	0.571	5.069	0.653	4.058
	Fe	0.959	1.228	1.612	3.799	0.205	2.140	1.002	6.826
	Zn	0.131	0.216	0.605	0.952	0.079	0.921	0.230	1.506
	B	1.284	0.079	0.154	1.518	0.022	0.242	0.076	0.508
	Cu	0.027	0.089	0.419	0.536	0.035	0.387	0.160	1.097

# Stand Nutrient Output from FVS

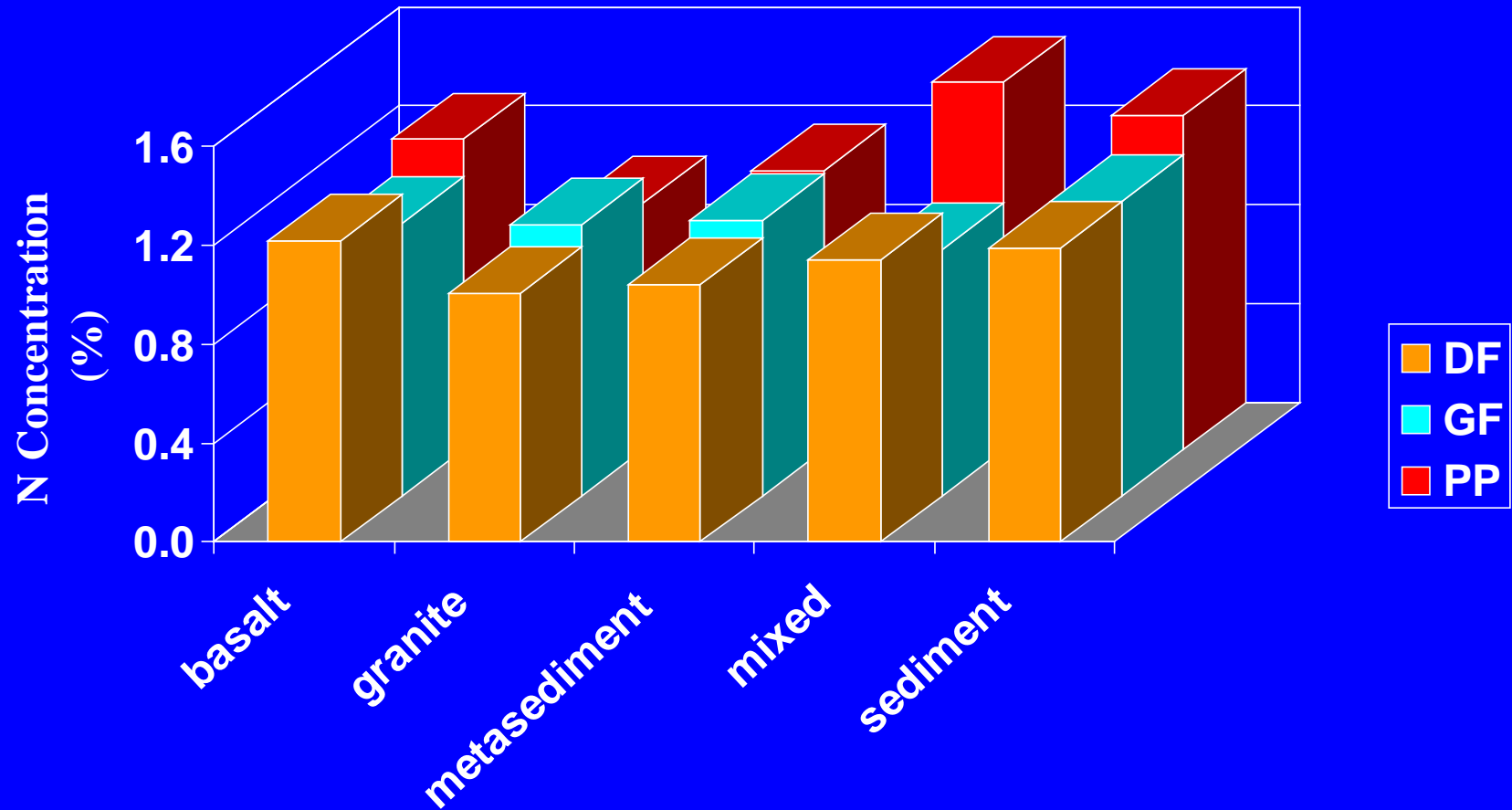
Amount removed in cut

Year	Nutr	Foliage	Small	Coarse	Total	Unmerch	Merch	Unmerch	Merch
			Branches	Branches	Crown	Bark	Bark	Wood	Wood
2014	Bio	3801.7	1553.5	4865.4	10220.7	941.1	7374.6	6191.5	36510.7
	N	38.489	9.187	17.067	64.744	2.566	20.065	2.665	15.662
	K	25.125	8.555	17.932	51.613	2.725	21.009	8.901	51.789
	P	4.558	2.196	4.735	11.489	0.766	5.941	2.460	14.558
	Ca	51.526	15.145	31.976	98.647	8.338	64.128	11.819	68.819
	Mg	4.178	2.090	4.342	10.609	0.601	4.701	2.181	13.037
	S	2.358	0.766	1.586	4.710	0.237	1.840	0.667	3.926
	Mn	0.415	0.362	0.853	1.630	0.292	2.212	0.314	1.804
	Fe	0.247	0.421	0.384	1.052	0.082	0.649	0.344	2.083
	Zn	0.072	0.055	0.141	0.268	0.025	0.199	0.090	0.538
	B	0.119	0.024	0.043	0.186	0.008	0.066	0.029	0.169
	Cu	0.005	0.026	0.088	0.119	0.012	0.089	0.055	0.332

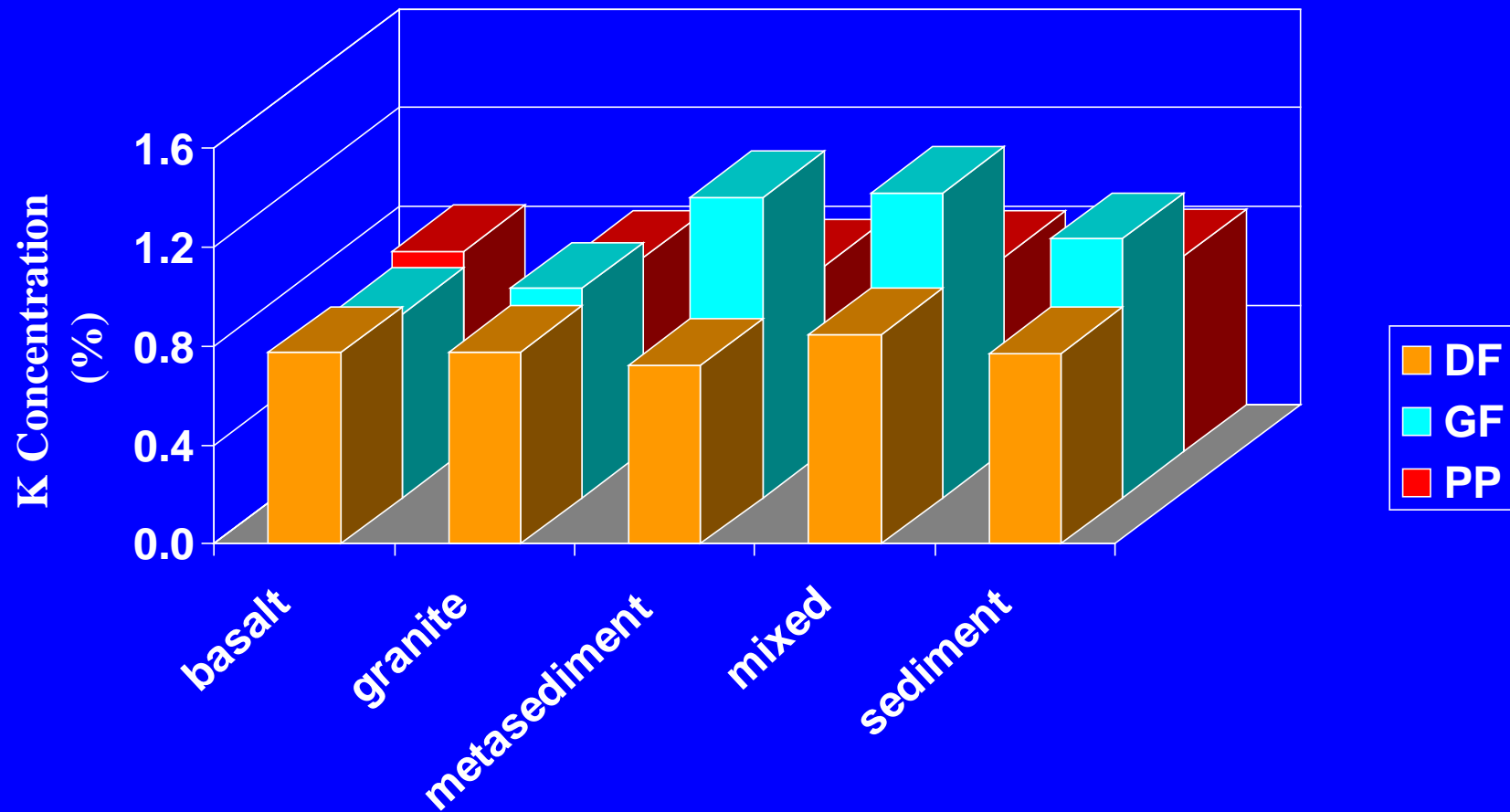
# Further Work Needed

- Budget calculations for overstory components need to include volume removed in thinning and harvest.
- FVS currently models biomass of litter, duff, and downed woody material. Sufficient information to add those components to the budget model needs to be collected.

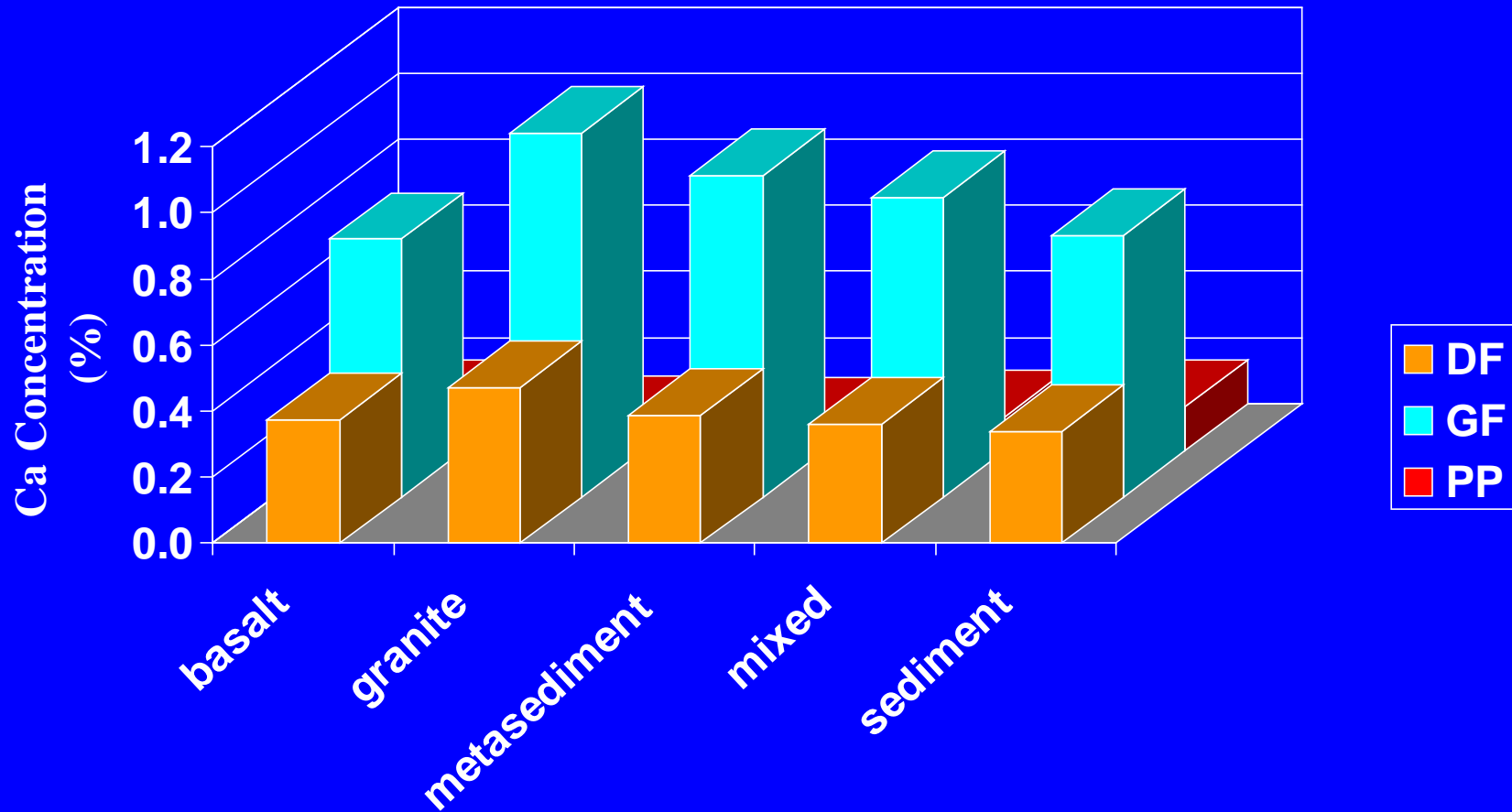
# Foliar N Concentration By Rock Type and Species on GF Vegetation Series



# Foliar K Concentration By Rock Type and Species on WRC Vegetation Series

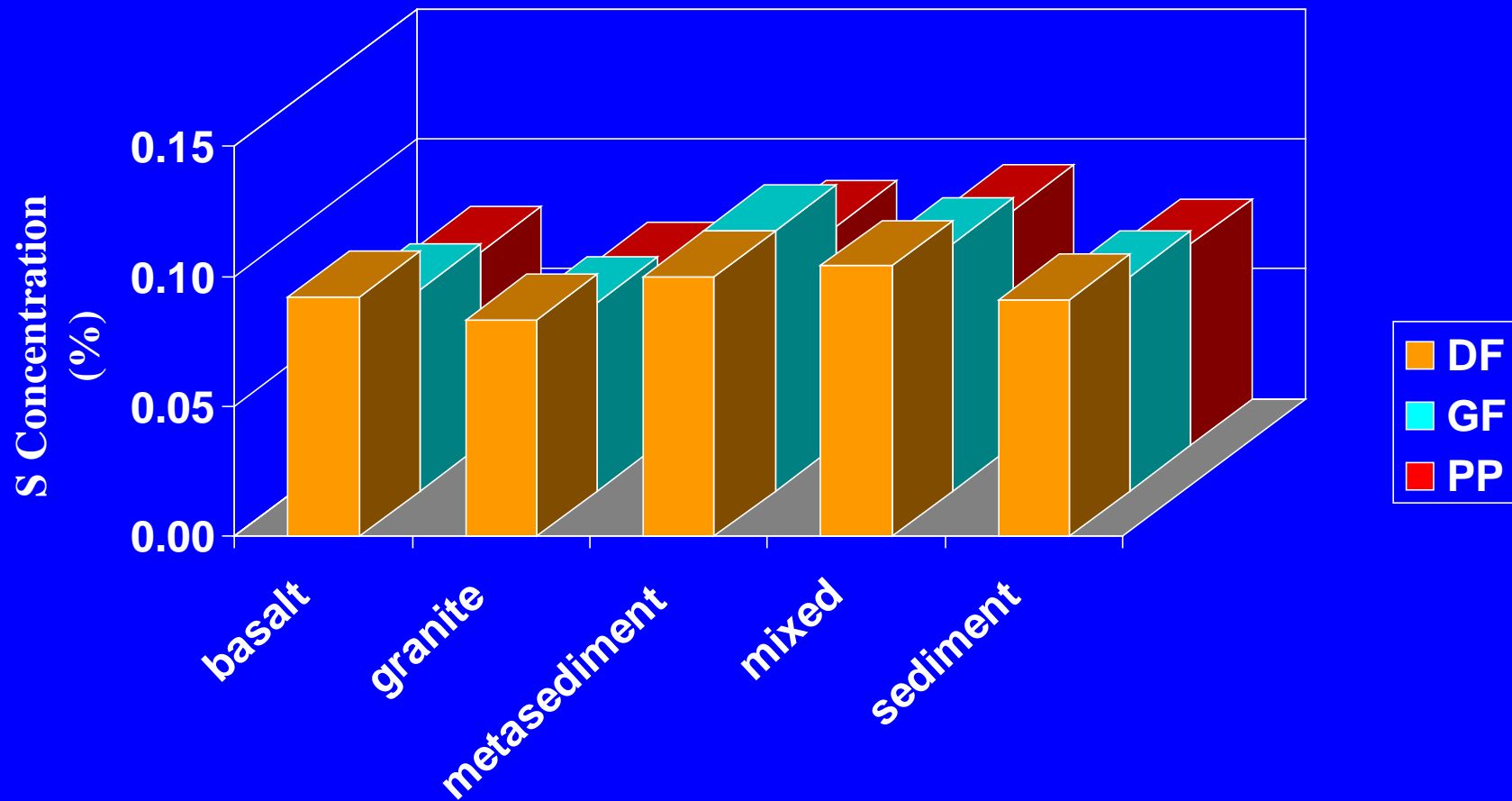


# Foliar Ca Concentration By Rock Type and Species on GF Vegetation Series

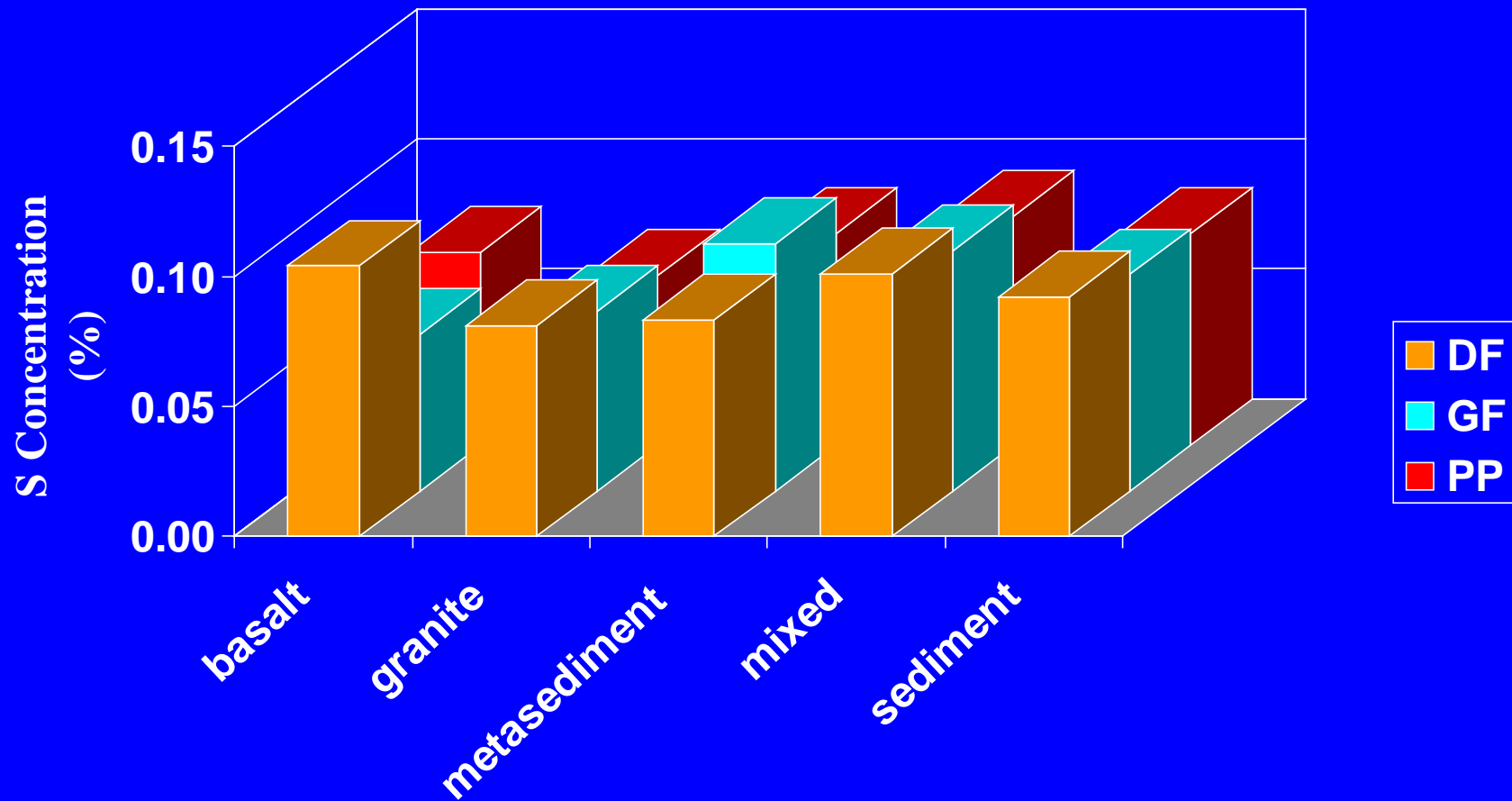




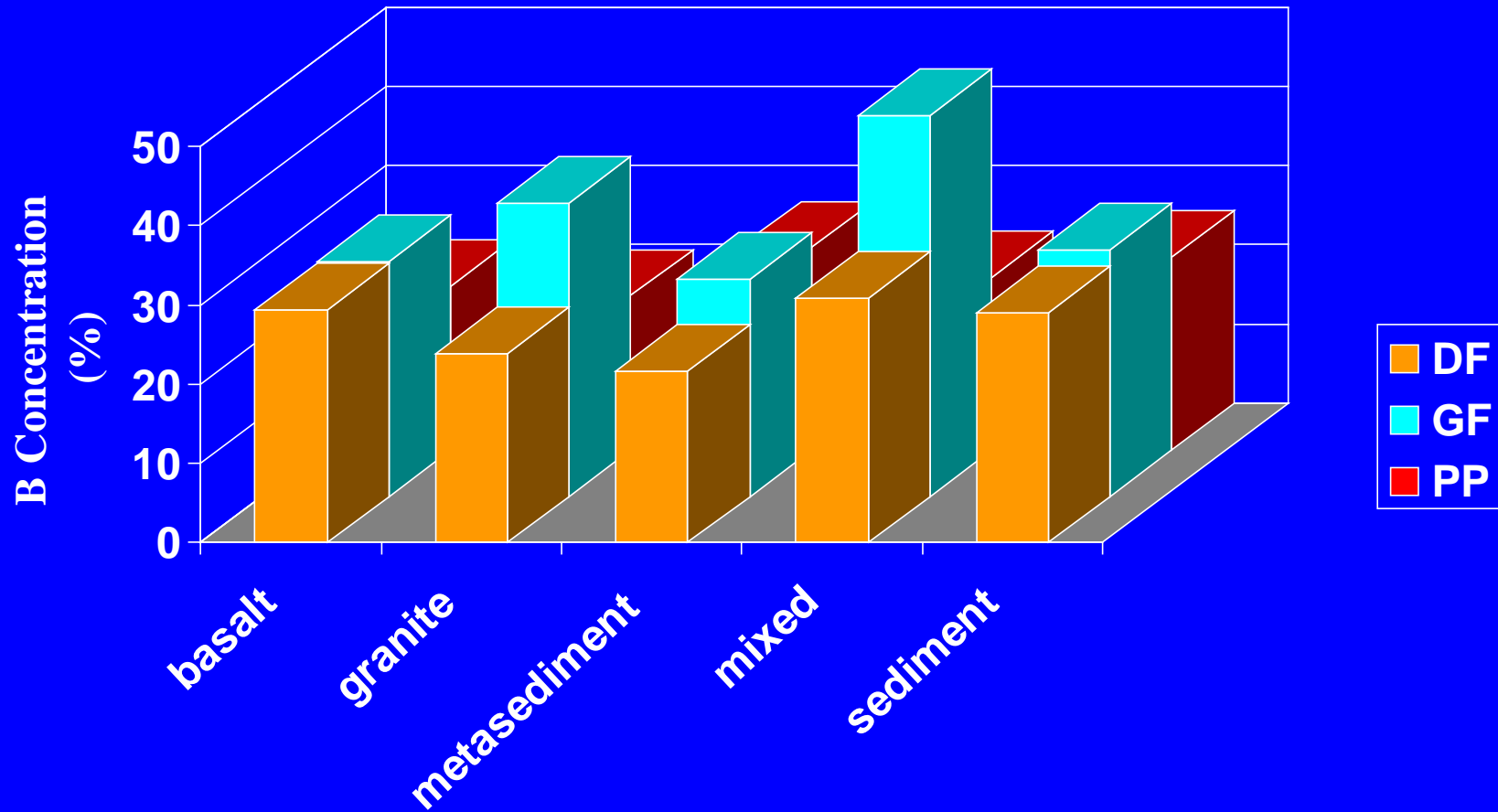
# Foliar S Concentration By Rock Type and Species on GF Vegetation Series



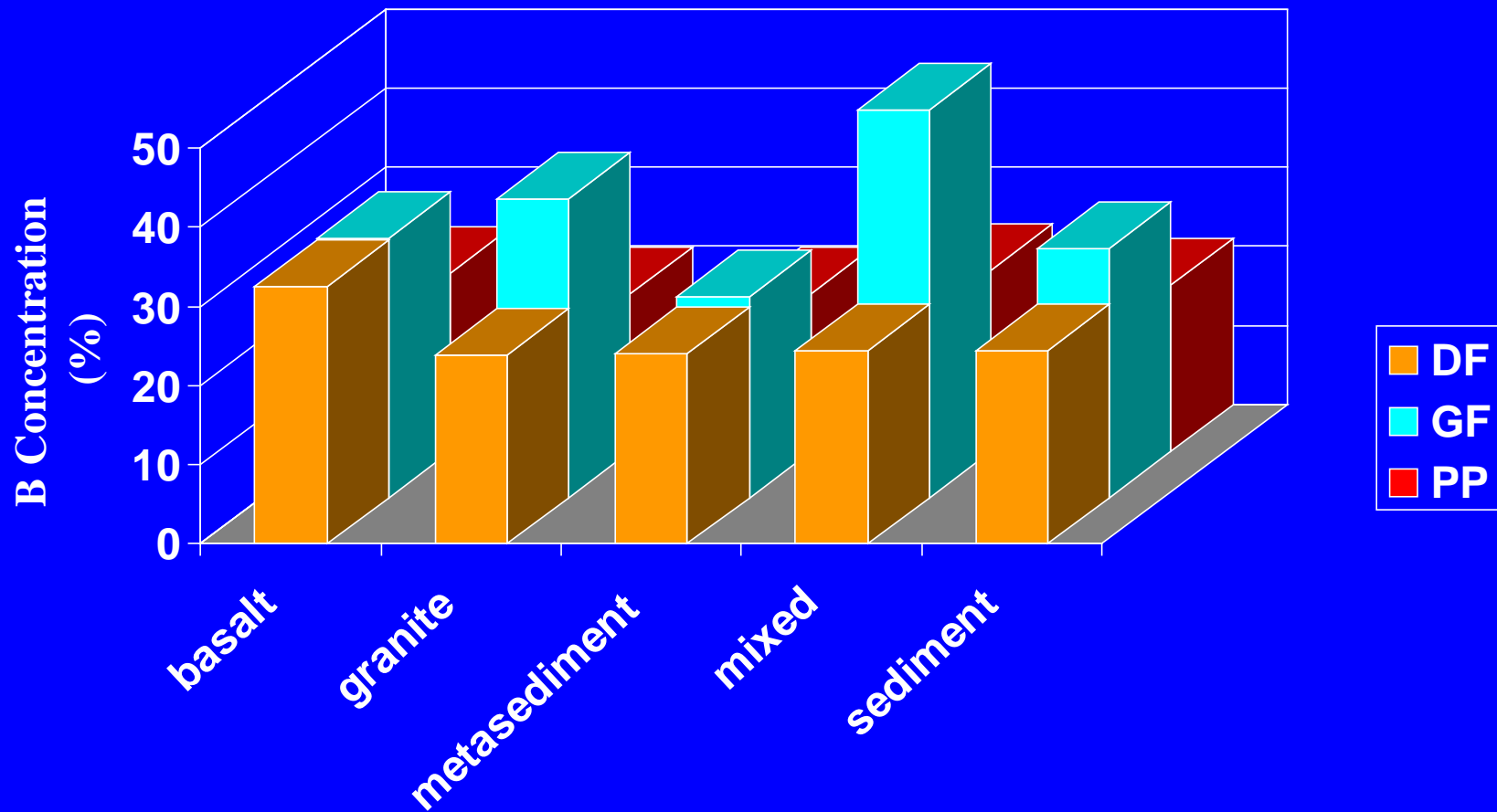
# Foliar S Concentration By Rock Type and Species on WRC Vegetation Series



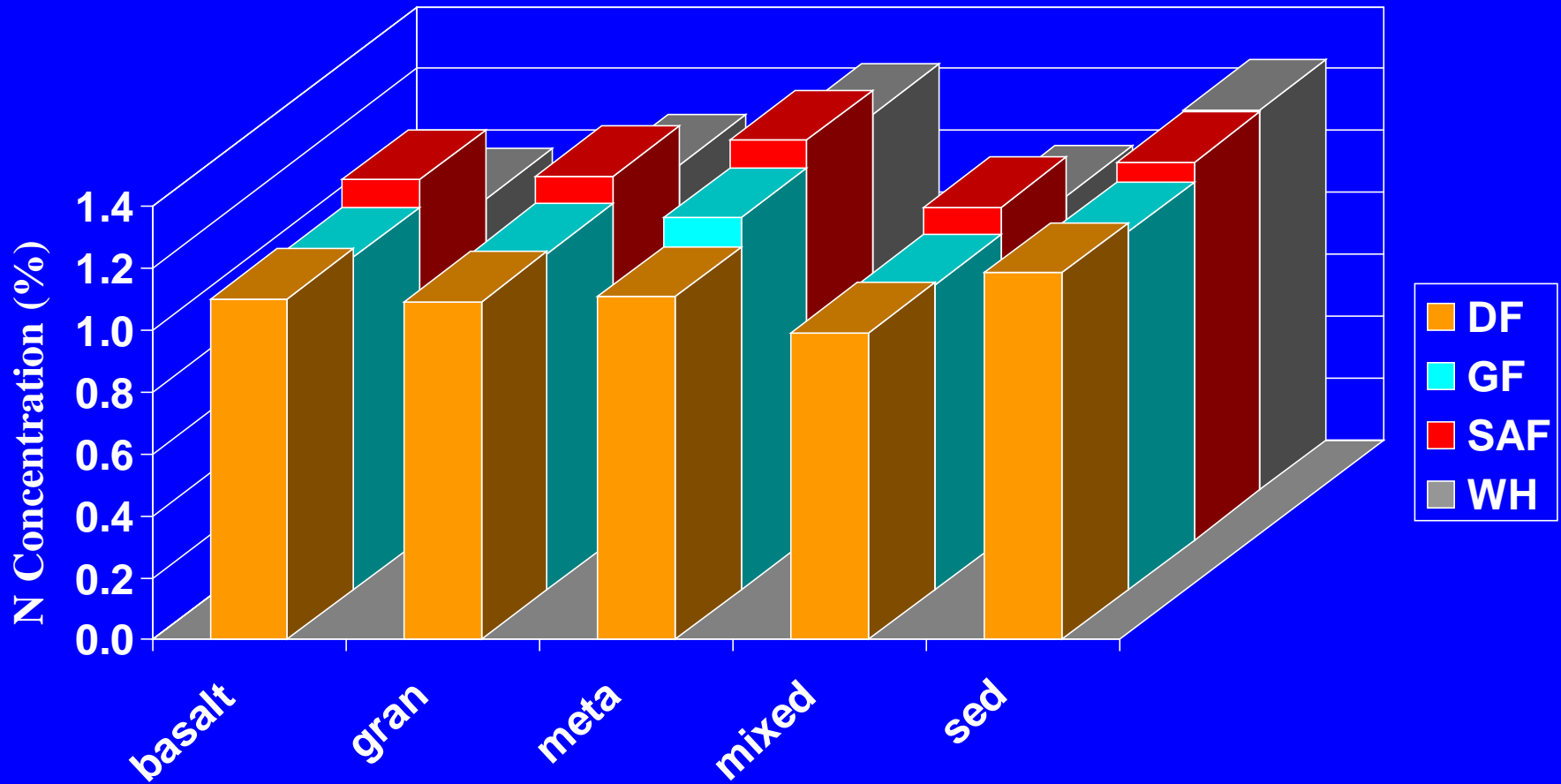
# Foliar B Concentration By Rock Type and Species on GF Vegetation Series



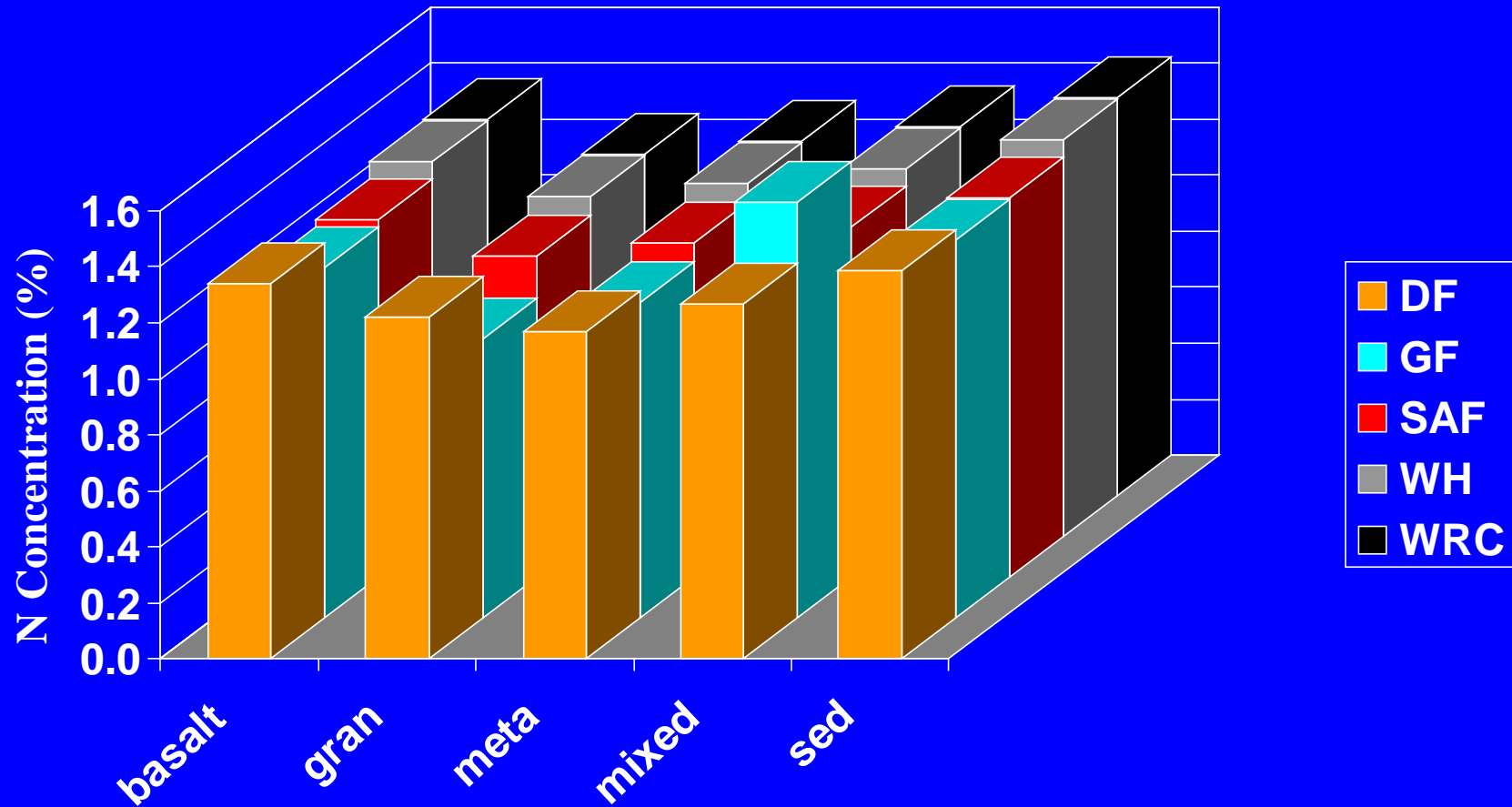
# Foliar B Concentration By Rock Type and Species on WRC Vegetation Series



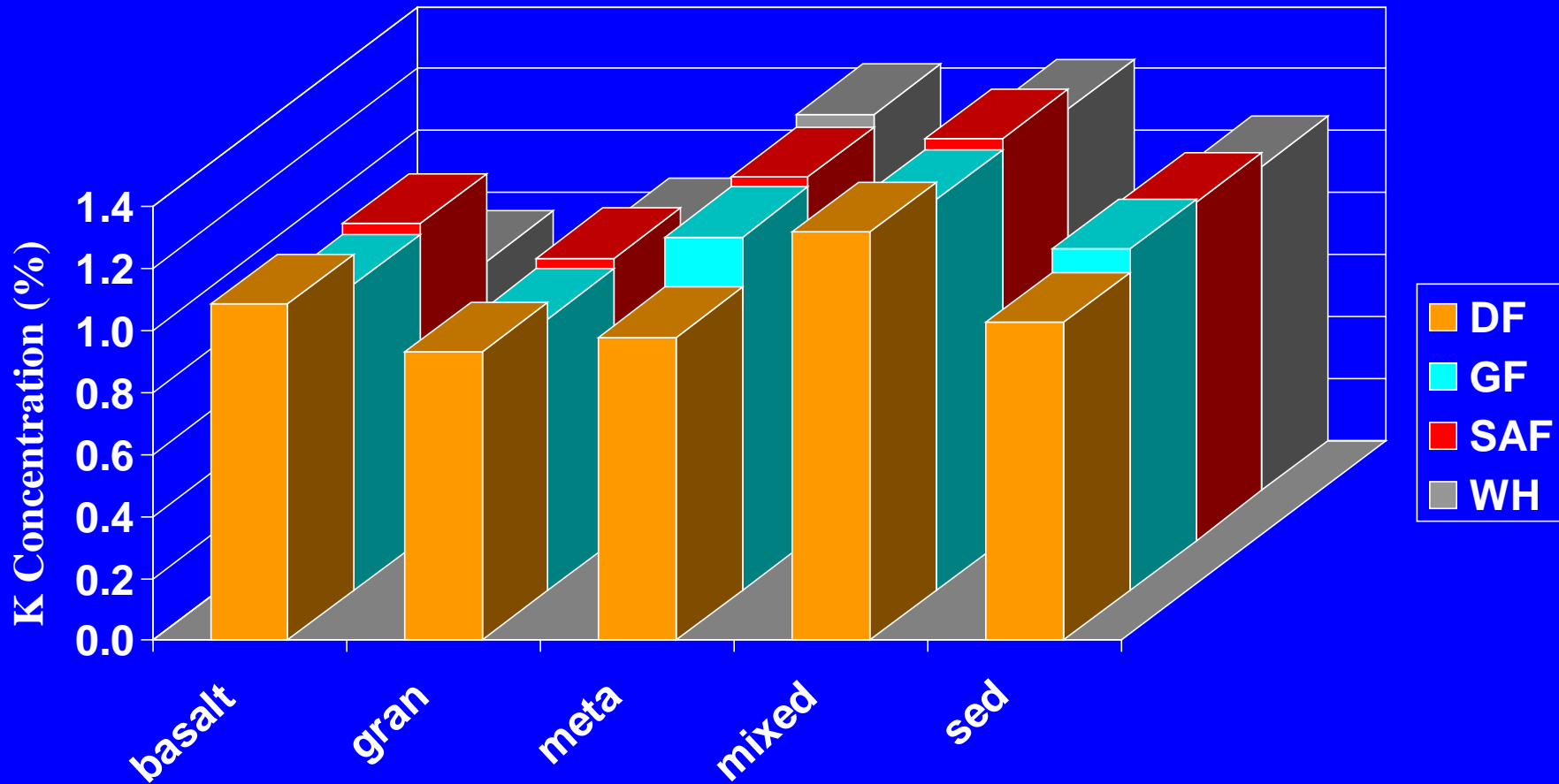
# Grand Fir Foliar N Concentration by Rock Type and Vegetation Series



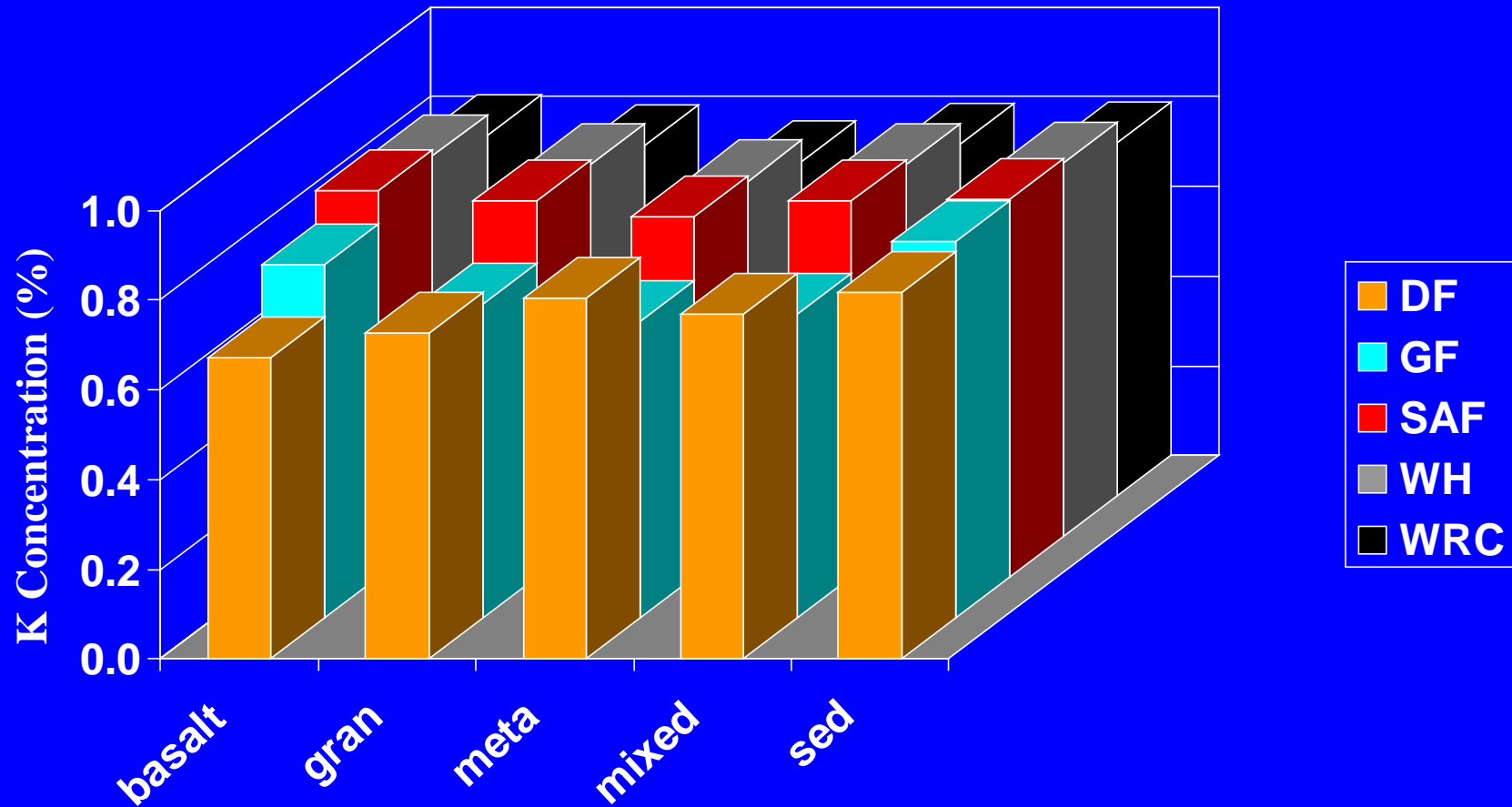
# Ponderosa Pine Foliar N Concentration by Rock Type and Vegetation Series



# Grand Fir Foliar K Concentration by Rock Type and Vegetation Series

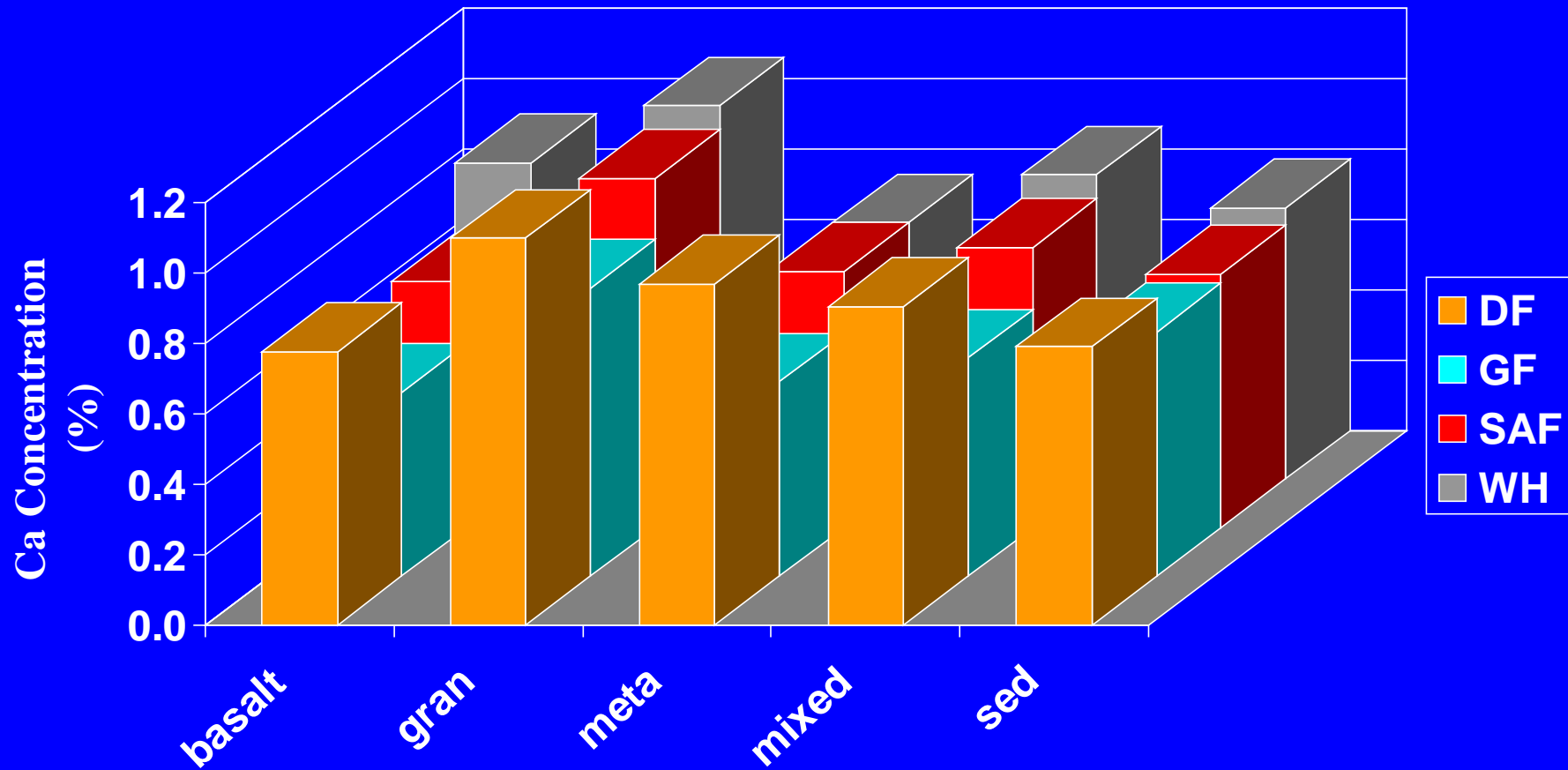


# Ponderosa Pine Foliar K Concentration by Rock Type and Vegetation Series

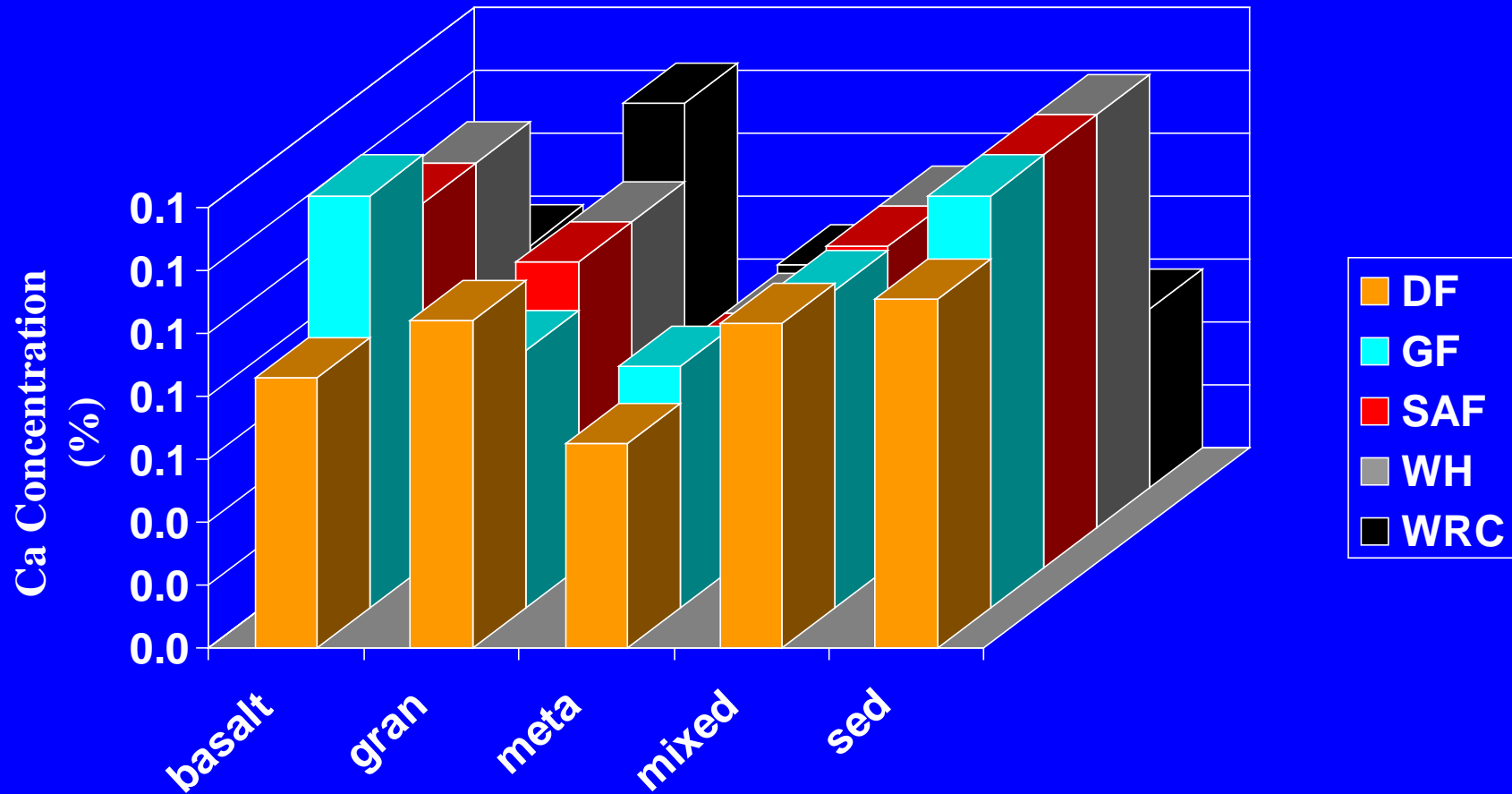




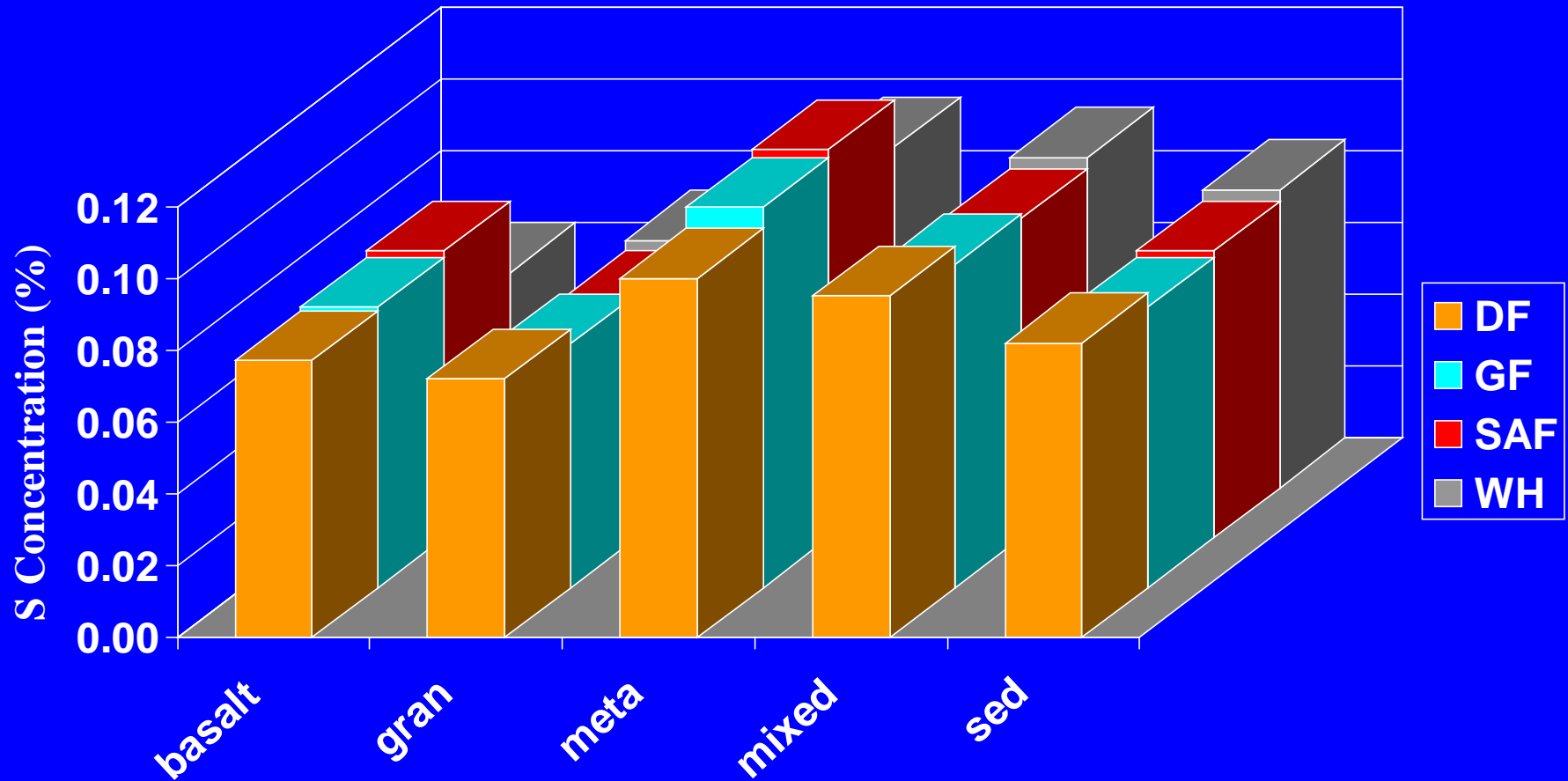
# Grand Fir Foliar Ca Concentration by Rock Type and Vegetation Series



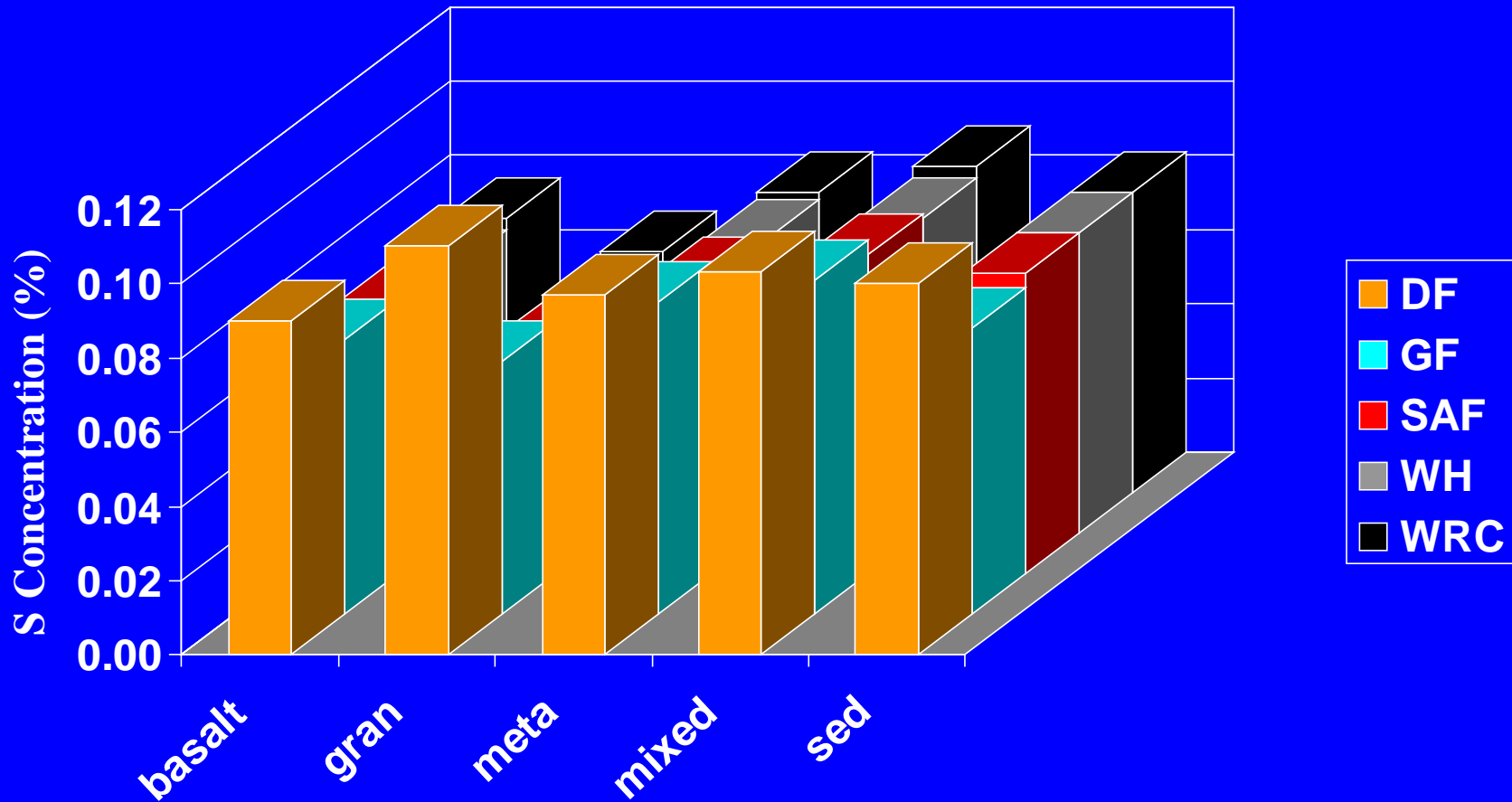
# Ponderosa Pine Foliar Ca Concentration by Rock Type and Vegetation Series



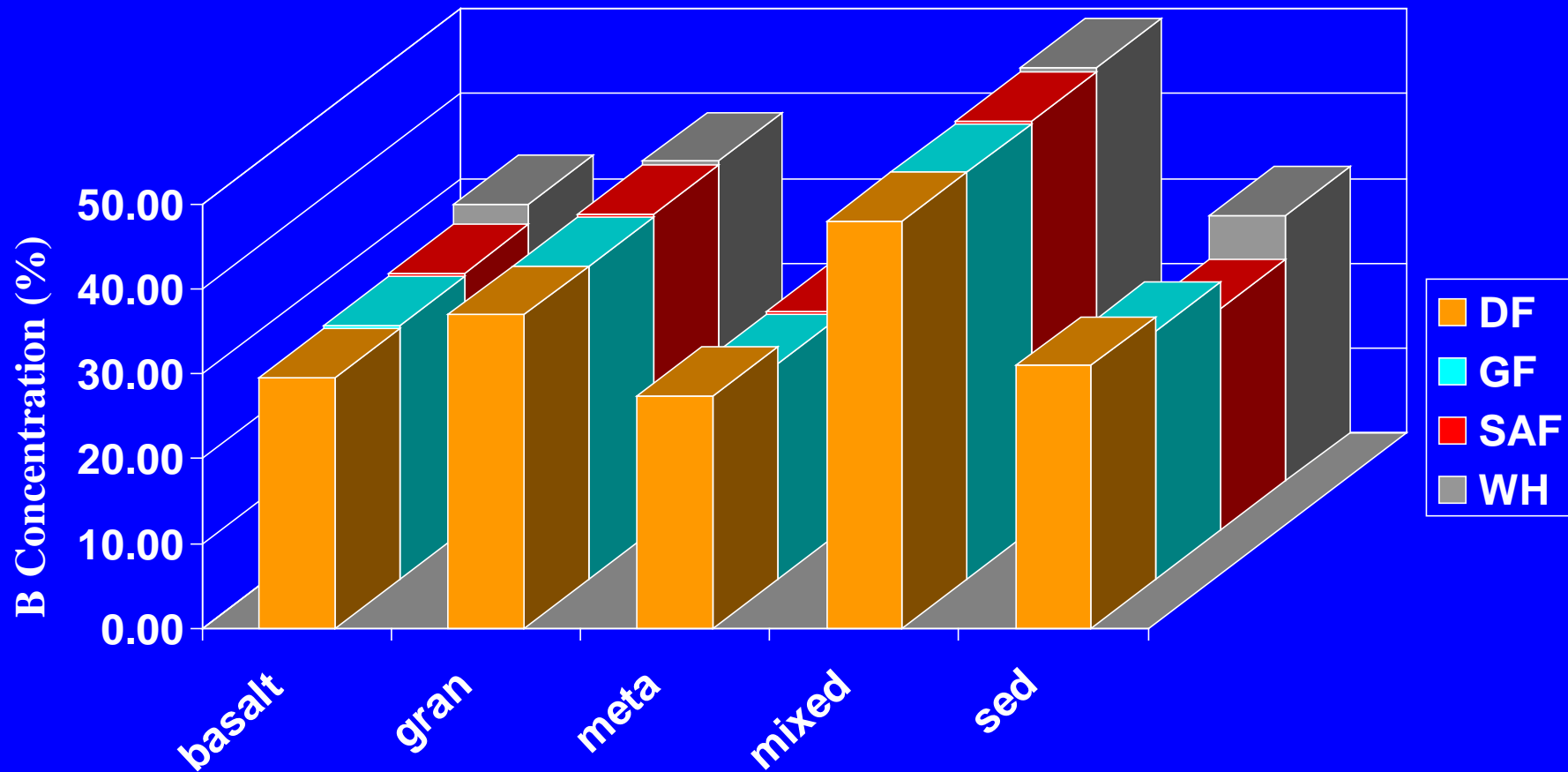
# Grand Fir Foliar S Concentration by Rock Type and Vegetation Series



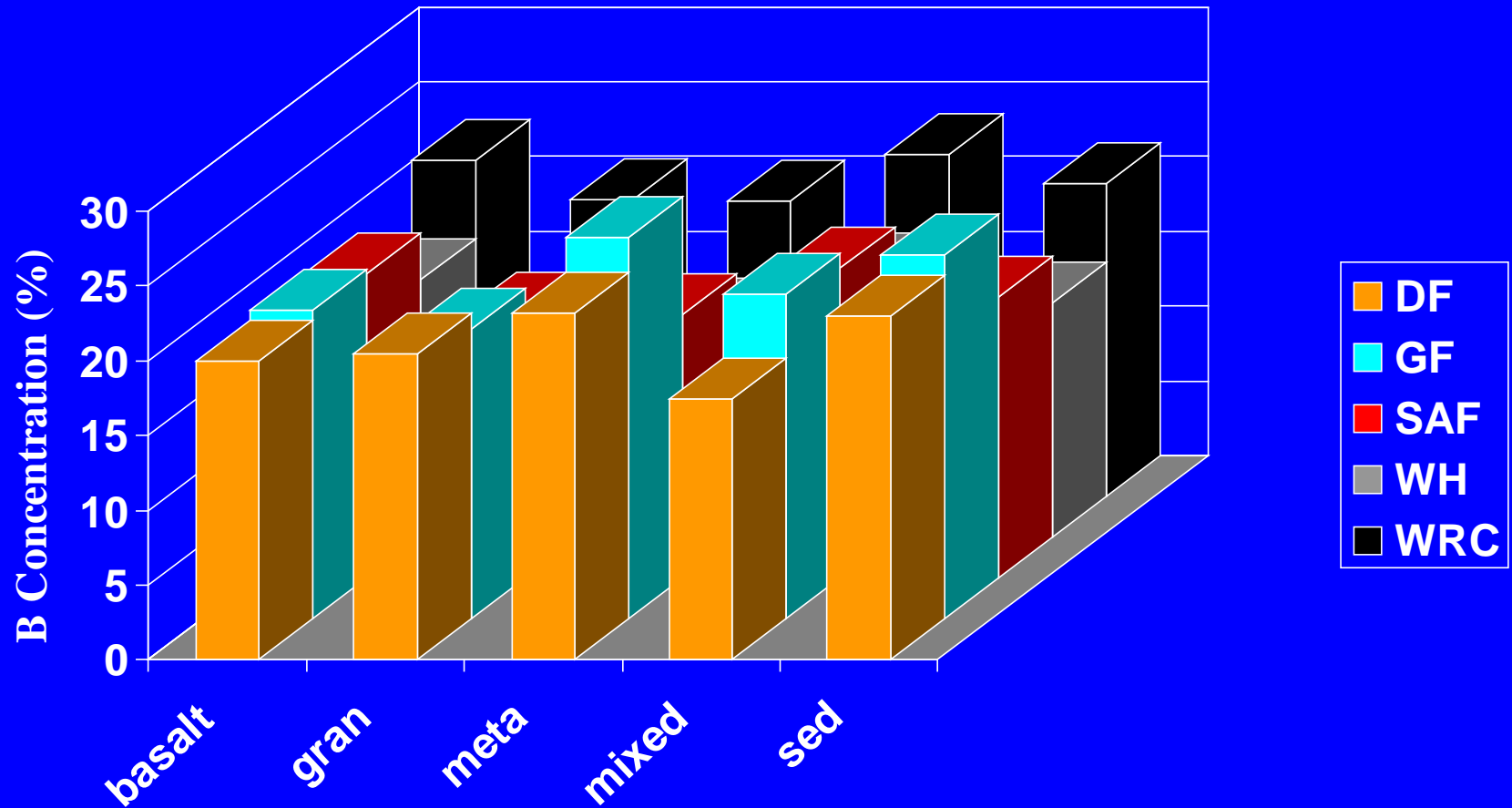
# Ponderosa Pine Foliar S Concentration by Rock Type and Vegetation Series



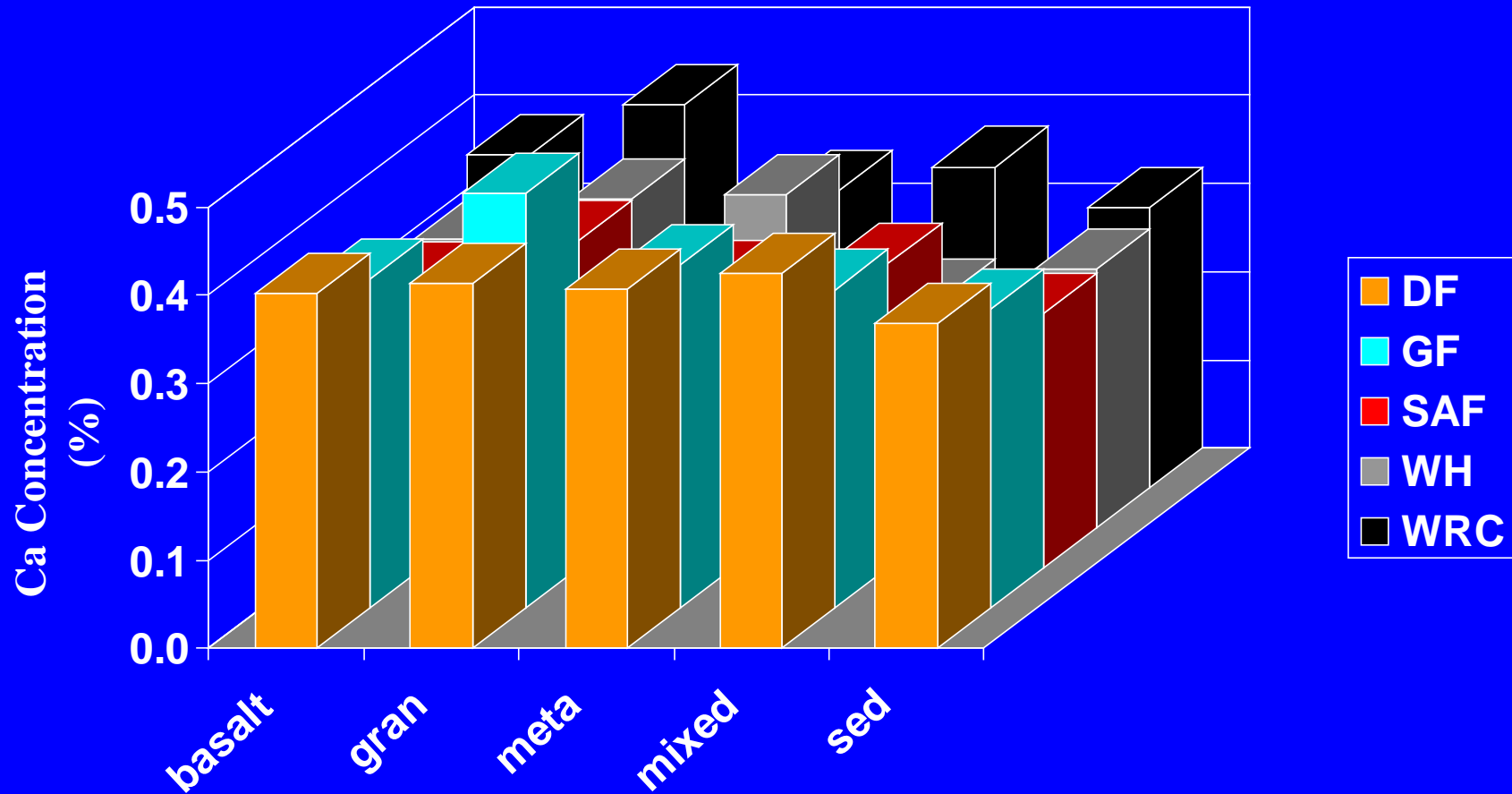
# Grand Fir Foliar B Concentration by Rock Type and Vegetation Series



# Ponderosa Pine Foliar B Concentration by Rock Type and Vegetation Series



# Douglas-fir Foliar Ca Concentration by Rock Type and Vegetation Series



# Douglas-fir Foliar S Concentration by Rock Type and Vegetation Series

