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Why we need long-term monitoring to understand ecosystem change

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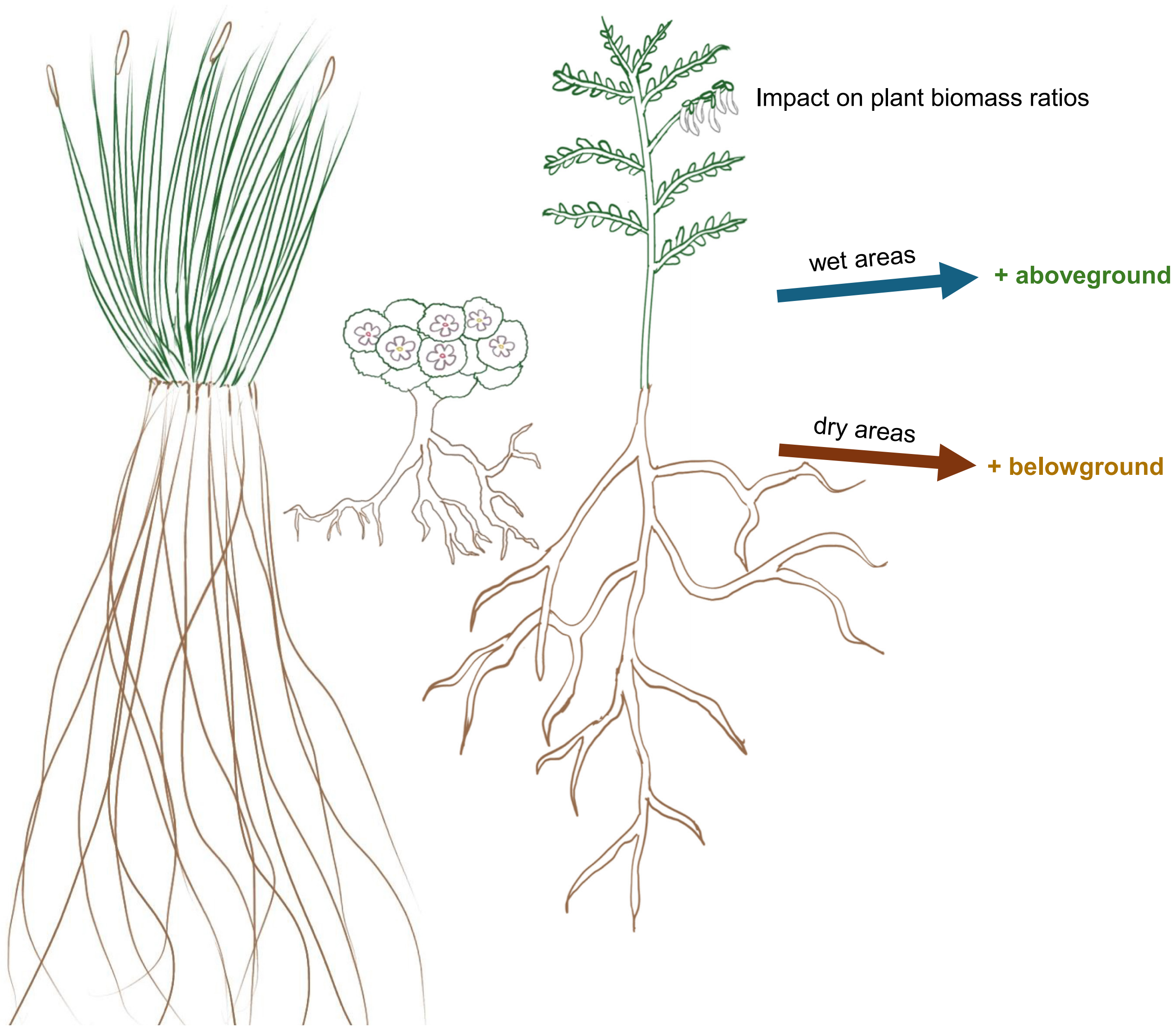

Fig. 1. The findings of Yun et al. (8) can be simplified as over the past 27 y in ecosystems with an abundance of soil moisture (wetlands) plants allocated proportionally more resources toward above-ground structures, while in ecosystems with limited soil moisture (meadows and steppes) plants allocated proportionally more resources toward below ground structures. Note in these cold-dominated ecosystems of the Tibetan Plateau approximately two-thirds of the biomass is below ground (illustration by Judy C. Hollister).

Cold regions have vast stores of carbon belowground (1). Conventional wisdom assumes that with warming, this carbon will be released to the atmosphere and contribute toward further climate change (2). Yet, carbon emissions from decomposing stored biomass in the soils may be influenced and offset by living plant biomass (3). There is a growing body of literature that shows that cold dominated ecosystems are greening as a result of increased plant cover (4). Warming experiments in cold dominated ecosystems also show increased plant growth aboveground and subsequent increases in plant cover (5). What

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is less understood, and much more difficult to track, is how plants may be changing their belowground biomass (6, 7). In PNAS, Yun et al. (8) document changes in above and belowground biomass over 27 y across what many call the third pole, the Tibetan Plateau. They found, in wetlands, aboveground biomass increased over time and the increase was strongly linked with regional warming. While in meadows and steppes the changes in biomass varied much more between locations and that belowground biomass increased more than aboveground biomass. They also found that the increased belowground biomass in drier locations oscillated over time and was impacted by temperature and moisture (Fig. 1).

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The strength of the change in the ratio of above to belowground biomass was greater in more recent years as would be expected due to the increasing magnitude of climate change in recent years (9). The increase in belowground biomass at meadows and steppes was greater at the drier locations. Monitoring was done at the plot and species level. The more robust sampling was done by collecting representative individuals of the dominant plant species annually and weighing the above and below ground components. However, they also conducted a more limited sampling scheme where they harvested all the plant species within a plot. The results were consistent across methods.

Monitoring changes in plant growth and cover has become a significant component of global change research (10); however, fewer studies examine below-ground structures (11, 12). It is time-consuming and costly to monitor belowground biomass. Often, researchers assume that changes in belowground biomass either correspond with changes in aboveground biomass or that it follows changes in species composition; for example, an increase in the cover of woody plant would result in more biomass aboveground because woody plants have a higher above to belowground biomass ratio (13). The findings of Yun et al. (8) show that the changes in the ratio of above to belowground biomass were primarily explained by changes within a species and only partially by changes in the abundance of species in the plots. In other words, these long-lived plants changed their allocation of resources toward above-ground biomass where water was plentiful or toward belowground biomass where water was limited. Mechanistic ecosystem models do not generally account for changes in plant allocation strategies within a species. For example, the ecosystem models tested (TEM 5.0, LPJ—GUESS 4.1, Coup Model 4.0, and ORCHIDEE—MICT 8.4.1) did not accurately predict the changes in soil carbon observed due to the changes in above to belowground biomass ratios. These findings highlight the need for ecological monitoring to provide the information necessary to understand the interactions of multiple factors (14). Climate is complex and species may respond to a large variety of factors (15, 16). We do not fully understand the impacts of climate change on ecosystems, even in cold-dominated ecosystems where most experts agree that cold temperatures are a major constraint on growth. Therefore, in order to better understand how ecosystems will respond to climate change, and other factors, we need detailed long-term observations (17, 18).

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