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Net ecosystem CO_2 exchange of an invasive plant infestation: new insights on the effects of phenology and management practices on structure and functioning

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The net ecosystem carbon dioxide (CO_2) exchange (F_C) of invasive plant infestations has been subject of few studies only. Perennial pepperweed (*Lepidium latifolium* L.) is an aggressive invasive plant with severe economic and environmental consequences for infested ecosystems. A characteristic feature of pepperweed's phenological cycle is the dense arrangement of small white flowers during secondary inflorescence. Little is known about how pepperweed flowering and management practices such as mowing affect canopy structure and canopy photosynthesis (F_A) and autotrophic respiration (F_{AR}) and thus ecosystem respiration (F_{ER}; F_C=F_{ER}-F_A with F_{ER}=F_{AR}+heterotrophic respiration [F_{HR}]). To examine these effects we analyzed three years (2007-2010) of CO_2 flux measurements made with eddy covariance, supporting environmental measurements and near-surface remote sensing data (canopy-scale reflectance, digital camera imagery) from a pepperweed-infested pasture in California's Sacramento-San Joaquin River Delta. The measurements cover three meteorologically similar summers (1 May – 30 September) that slightly differed in terms of land use practices. In 2007-2010, the site was subjected to year-round grazing by beef cattle, and in 2008, the site was additionally mowed in mid-May during flowering. We described structural changes in canopy development through seasonal changes in surface roughness for momentum transfer (z_{0m}). Weekly soil CO_2 efflux ($\approx F_{HR}$) estimates from static chamber measurements made over bare soil were used to separate F_{ER} into F_{AR} and F_{HR}. We identified the onset of pepperweed's key phenological phases (i.e., germination, early vegetative growth, flowering, seed maturation, senescence, dormancy) through the integrated analysis of albedo of photosynthetically active radiation (PAR), a broad-band green normalized difference vegetation index, and a digital camera-based color index. We used non-linear mixed-effects model analysis to investigate the combined effects of measurement year and flowering/ mowing on the variable parameters of the non-linear responses of F_A to light and F_{AR} to air temperature.

We address two specific questions with our research. First, how do year-round grazing and spring mowing affect the timing (i.e., onset) of pepperweed's key phenological phases? Second, we focus on pepperweed flowering, the spectrally most notable phenological phase. Thus we ask does the onset of flowering trigger changes in structural canopy development (i.e., z_{0m}) and functioning (i.e., F_A; F_{AR})?

Over the summers (1 May – 30 September) of 2007 and 2009 the site was either almost neutral with respect to CO_2 (-26 g C m^{-2} $period^{-1}$ in 2007) or a moderate net CO_2 source (89 g C m^{-2} $period^{-1}$ in 2009). In contrast, the pepperweed infestation acted as a net CO_2 sink (-162 g C m^{-2} $period^{-1}$) over the summer of 2008 when the site was mowed once in May during flowering to reduce the reproductive success of pepperweed. Preliminary results show that year-round grazing inhibited the accumulation of dead stalks causing earlier pepperweed green-up. The onset of flowering had no substantial impact on z_0m. In contrast, the onset of flowering significantly reduced maximum photosynthetic capacity compared to non-flowering pepperweed, resulting in reduced photosynthetic CO_2 uptake. Similarly, F_{AR} was slightly reduced in response to flowering, most likely due to the due to the close coupling of growth respiration to F_A. In contrast, mowing early during flowering prevented the decrease in

photosynthetic CO_2 uptake and the associated decrease in F_{AR} due to immediate pepperweed regrowth. Our study highlights the impact of invasive plants' unique ecophysiological features and applied management practices on net ecosystem CO_2 exchange of infested ecosystems.