CHAPTER 5

CONCLUSION

5.1 Overview

Numerous papers published in the last two decades show evidence of variation in $\delta^{15}N$ values of vegetation and soils collected in areas impacted by the deposition of anthropogenic nitrogen pollution (Ammann et al. 1999, Jung et al. 1997, Pearson 2000). The amount of ^{15}N enrichment or depletion, however, was varied between studies. There are many possible sources of this variation including difference in soil types, species, and spatial and temporal sampling schemes (Selles et al. 1986, Pearson 2000). By controlling some of the variables known to contribute to differences in nitrogen isotope ratios, this study attempted to provide evidence that ephemeral atmospheric NO_x pollution signals can be recorded permanently in vegetation using the $\delta^{15}N$ values of leaves and stems *Bromus tectorum* and associated soils. The complimentary analysis of $\delta^{13}C$ values of leaves and stems *Bromus tectorum* and the surrounding atmospheric CO_2 provided further support for the idea that air pollution is taken up during daylight hours for the life of the plant and recorded in its isotope values. The atmospheric CO_2 concentration and carbon isotope data for samples collected in Salt Lake Valley and Skull Valley were used to help explain the difference in average $\delta^{13}C$ value of leaves and stems *Bromus tectorum* between valleys. Since variation in $\delta^{13}C$ values of leaves and stems *Bromus tectorum* was consistent with the variation in $\delta^{13}CO_2$, and both CO_2 and NO_2 are taken up through the stomata, it is likely that the differences in $\delta^{15}N$ values of leaves and stems *Bromus tectorum* between valleys are caused by differences in $\delta^{15}N$ values of atmospheric NO_2. Not only will this information help advance the use of nitrogen isotopes as indicators of urban nitrogen pollution, it will help researchers to better understand the nitrogen isotope discrimination in plants and soils exposed to different nitrogen sources.

5.2 Results

The results presented in Chapter 2 showed that nitrogen isotope values of soils and vegetation could be used as indicators of atmospheric nitrogen pollution. The complex soil nitrogen transformations and associated nitrogen isotopic fractionations were assumed constant at all urban and rural sites used in this study because of the similarity in soil type and climate in the two valleys. The collection of only one plant species, *Bromus tectorum,* at all sites further reduced the variation in nitrogen isotope fractionation associated with physiological processes such as nitrogen uptake via roots. Therefore, the differences in $\delta^{15}N$ values of atmospheric nitrogen associated with nitrogen pollution concentration was the only factor large enough to account for the overall differences in *Bromus tectorum* and soil $\delta^{15}N$ values measured in Salt Lake Valley and Skull Valley. Nitrogen isotopic values of air samples collected around each valley need to be measured to verify the findings presented in this study. Overall, the idea that differences in nitrogen isotopic values of source nitrogen are recorded and integrated over time in $\delta^{15}N$ values of exposed vegetation and soils means there is a future for the use of nitrogen isotopes as tracers of nitrogen pollution in urban systems.

The results presented in Chapter 3 indicated seasonal variation in $\delta^{15}N$ values of vegetation collected in urban areas. Assuming the $\delta^{15}N$ values of the leaves and stems of *Bromus tectorum* reflect the nitrogen isotope values of the NO_2 taken up through the stomates, the seasonal change in $\delta^{15}N$ values in samples collected in the Salt Lake Valley could indicate seasonal changes in atmospheric $[NO_2]/[NO_x]$ (Fryer et al. 1993, Ammann et al. 1999). Because Skull Valley is assumed to have a very low level of nitrogen air pollution, the lack of seasonal variation in the $\delta^{15}N$ values of leaves and stems of *Bromus tectorum* sampled there is consistent with the idea of urban nitrogen air pollution influencing the $\delta^{15}N$ values of vegetation. Air samples need to be collected around the Salt Lake and Skull Valleys and analyzed for seasonal variation in nitrogen isotope ratios and $[NO_2]/[NO_x]$ to better understand the relationship between $\delta^{15}N$ values of plants and atmospheric nitrogen and what role changes in $[NO_2]/[NO_x]$ plays in these values.

The results discussed in Chapter 4 showed that the carbon isotope values of source atmospheric CO_2 are recorded and integrated over time in the $\delta^{13}C$ values of exposed vegetation. The results also suggested the possibility of combining the nitrogen and carbon isotopic analysis of vegetation to better understand the relationship between urban air pollution and isotopic values of plant material. A significant relationship between the carbon and nitrogen isotope values of *Bromus tectorum* leaves and stems collected in Salt Lake Valley was reported in this study. The $\delta^{13}C$ values of CO_2 samples collected around the Salt Lake Valley and Skull Valley were shown to follow the same pattern of urban carbon isotope depletion measured in the leaves and stems of *Bromus tectorum*. Because nitrogen isotope values of NO_2, samples were not available for this study, we can cautiously use these two relationships to make assumptions about the cause of nitrogen isotope depletion measured in urban *Bromus tectorum* leaves and stems. Since vehicular pollution is the main source of both atmospheric CO_2 and NO_2, the more negative $\delta^{13}C$ values of CO_2 samples and *Bromus tectorum* leaves and stems supports the idea that the difference between the urban and rural $\delta^{15}N$ values of leaves and stems *Bromus tectorum* is a result of the nitrogen isotope values of the source NO_2.

5.3 Future Research

Future research in this area should include direct measurements of the nitrogen isotope ratios in urban and rural NO_2, which was not possible during this study. Direct measurements of clay content for each soil sample would provide more accurate information about the correlation between clay content and nitrogen isotope value. I hope others are able to use the information presented in this thesis to gain further understanding of the complex interactions between anthropogenic and natural factors in urban systems.

5.4 Literature Cited

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