4-20-2015

Using Age as a Predictor of Chemotypes for Low Sagebrush (*Artemisia Arbuscula*): Can Age Help Us Manage Sage-Grouse Foraging Habitat?

Andrea Gibbons

Marcella Fremgen

Jack Connelly

Jennifer S. Forbey

Using Age as a Predictor of Chemotypes for Low Sagebrush (*Artemisia Arbuscula*): Can Age Help Us Manage Sage-Grouse Foraging Habitat?

Abstract

The defensive chemistry of plants limit intake by herbivores. In addition, the spatial and temporal variation of plant chemicals constrains habitat use by herbivores. As such, management of herbivores requires that we properly conserve and manage for the most palatable chemical profiles of plants, or chemotypes. However, management of palatable plants requires that we first identify parameters that influence chemotypes. We hypothesized that the age of a plant is one parameter that influences chemotypes and could be managed. To test this hypothesis, we counted the annual ring growth to determine age and used gas chromatography to determine chemotypes of small (tall) and medium (15cm-30cm tall) low sagebrush (*Artemisia arbuscula*). We focused on low sagebrush as it is a preferred food source for greater sage-grouse (*Centrocercus urophasianus*) at our study site. In addition, we tested whether the circumference at the base of the plant is correlated with annual ring growth. Correlating age and circumference may yield a simple, nonintrusive method to estimate the age of sagebrush in the field without counting annual rings. Understanding how age influences palatability of plants is an important factor in assessing and managing grouse habitat. Using a parameter like age, which may be simple to assess in field, to manage sage-steppe habitats could save time and money. We expect if the younger plants are more palatable, reseeding and replanting could be effective methods to make restored habitats more ideal for foraging grouse. Alternatively, if older plants are more palatable the consequences of mowing and herbicide could dramatically outweigh any potential benefits.

Keywords

habitat, threatened wildlife, sagebrush, plant chemistry

Using age as a predictor of chemotypes for low sagebrush (*Artemisia arbuscula*): Can age help us manage sage-grouse foraging habitat?

Andrea Gibbons+, Marcella R. Fremgen+, John W. Connelly*, Jennifer S. Forbey+

+ Department of Biological Sciences, Boise State University, Boise, ID 83725
*Idaho Department of Fish and Game, Blackfoot, ID 83221

Background

- There is a great need to identify parameters that contribute to habitat use by threatened wildlife
- Concentration of coumarins (selected for) and monoterpenes (selected against) in sagebrush influence diet quality and therefore habitat use by Greater Sage-grouse (*Centrocercus urophasianus*)[1] – a species being considered for endangered status
- Our goal is to identify how disturbance changes plant chemistry and therefore diet selection and habitat use by sage-grouse:
  - ✧ Browsing by herbivores may increase monoterpenes in sagebrush[2]
  - ✧ Increasing temperatures may increase chemicals in sagebrush[3]
  - ✧ New research: Does the age of plants influence chemistry of sagebrush?

Figure 1. A Greater Sage-grouse (*Centrocercus urophasianus*) hen taking cover in a low sagebrush (*Artemisia arbuscula*) at our study site on Jim Sage Mountain in southeastern Idaho.

Hypothesis

- We hypothesize circumference can predict annual growth by sagebrush (age).
- We hypothesize higher concentrations of coumarins and lower concentrations of monoterpenes in younger plants.

Methods

Predicting age of sagebrush

- Radio-telemetry was used to flush birds from foraging patches
- Even numbers of browsed and non-browsed low sagebrush (*Artemisia arbuscula*) were selected for analysis
- Age was determined by counting annual growth rings from cut sagebrush
- Circumference was measured around the base of each shrub

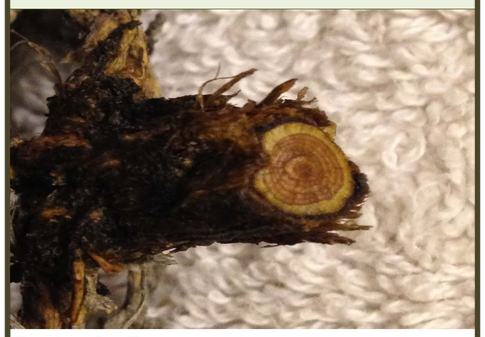

Figure 2. Example of a sagebrush plant that was used to compare annual growth rings (age) and the circumference. This plant has 7 annual growth rings.

Measuring chemicals in sagebrush

- Total monoterpenes were measured using gas chromatography.
- Total coumarins were quantified using a spectrometer and a scopoletin fluorescence assay.

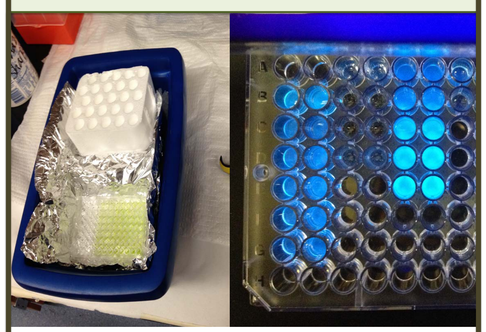

Figure 3. Example of a scopoletin fluorescence assay.

Statistics

- Regression analyses were used to determined relationships between age and circumference, monoterpenes and coumarins (JMP Pro 10, SAS Institute, Cary, NC).

Results

Age can be predicted from circumference (Fig. 4)

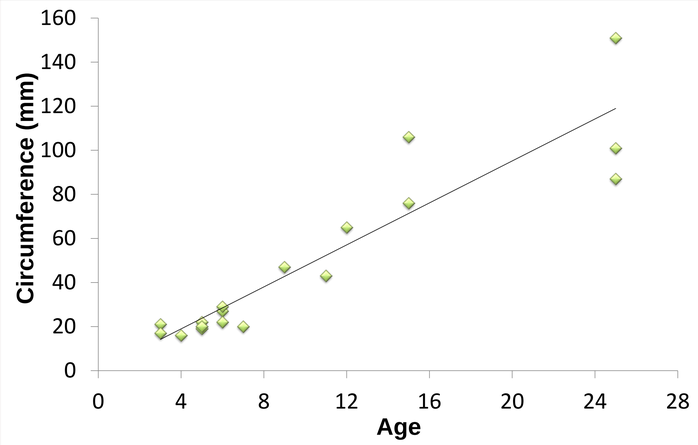

Figure 4. Annual growth rings (age) are strongly correlated with circumference of low sagebrush plants (R^2=0.84676, p-value<0.0001). The formula for the regression line is used to estimate ages for plants with circumference measures.

Total monoterpenes were not significantly influenced by the plant's age (Fig. 5)

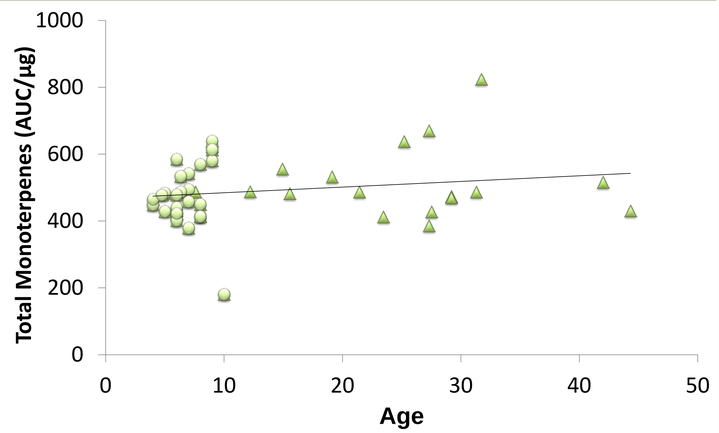

Figure 5. Total monoterpenes (AUC/µg dry weight), a group of plant secondary metabolites, were measured using gas chromatography. There was no correlation between age and total monoterpene concentration (R^2=0.034776, p-value=0.2255). The circles represent exact ages and the triangles represent samples that are age estimates using the formula for the regression line shown in Fig. 3.

Total coumarins showed no significant correlation to age (Fig. 6)

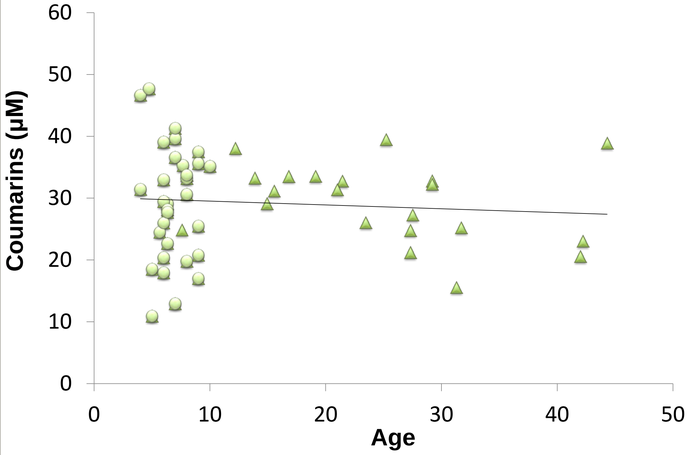

Figure 6. Coumarins, a general measure of palatability, were measured using a scopoletin fluorescence assay. There was no correlation between age and total coumarin concentration (R^2=0.006871, p-value=0.5591). The circles represent exact ages and the triangles represent samples that are age estimates using the formula for the regression line shown in Fig. 3.

Among the small (<15cm tall) plants coumarins were not influenced by exact age (Fig. 7)

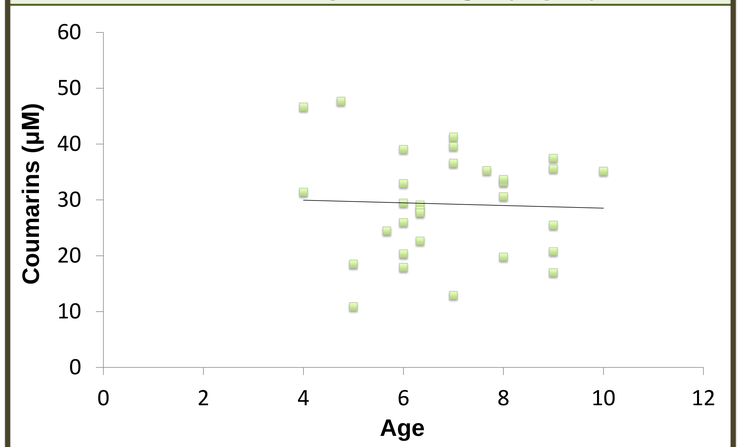

Figure 7. Coumarins, a general measure of palatability, were measured using a scopoletin fluorescence assay. Comparing this graph to Figure 6. shows the comparison between using just annual growth rings (R^2=0.00157), and including the estimates from the formula (R^2=0.00687). A t-test showed there was no significant difference between the age/coumarin correlation that included estimates versus the ones that only used exact age (p=0.9971).

Discussion

Aging sagebrush

- Measuring circumference is a non-destructive approach to determine age of low sagebrush within a habitat (Fig. 4)
- This approach needs to be validated in other habitats for other species of sagebrush
- Ageing sagebrush could be used to determine reestablishment of sagebrush after fire or other disturbances

Chemistry and age

- Total monoterpenes and coumarins are correlated with age in low sagebrush within a habitat (Fig. 5, Fig. 6)
- Other factors may be stronger influences of plant chemistry within age: Habitat quality, plant density, water accessibility[4]
- Concentration of individual coumarin or monoterpene compounds, rather than total concentrations, could be related to age
- Age could influence protein content which can predict diet selection[5]

References:

1: Forbey, J.S., Wiggins, N.L., Graham, G.F., Connelly, J.W. (2013) Hungry grouse in a warming world: emerging risks from plant chemical defense and climate change. *Wildlife Biology*, 19: 374-381.

2: Shiojiri, K., Karban, R., Ishizaki, S. (2011) Plant age, seasonality, and plant communication in sagebrush, *Journal of Plant Interactions*, 6:2-3, 85-88.

3: Revermann, R., Schmid, H., Zbinden, N., Spaar, R., Schroder, B. (2012) Habitat at the mountain tops: How long can rock ptarmigan (*Lagopus muta*) survive rapid climate change in the Swiss Alps? A multi-scale approach. *Journal of Ornithology*, 153(3): 891-905.

4: Jones, J. (2011) Habitat selection studies in Avian Ecology: A critical review. *The Auk*, 118(2): 557-562.

5: Frye, G.G., J.W. Connelly, D.D. Musil, J.S. Forbey. (2013) Phytochemistry predicts habitat selection by an avian herbivore at multiple spatial scales. *Ecology*. 94(2): 308-314.

Acknowledgements:

- Bureau of Land Management #L09AC16253
- National Science Foundation DEB-1146194 and IOS-1258217
- National Institutes of Health Idaho INBRE Program (P20 GM103408)
- Idaho Science Talent Expansion Project, NSF 0856815
- Special thanks to those who helped me with fieldwork: J. Forbey, M. Fremgen, C. Merriman, J. Pena, and C. Ellis.
- Additional thanks to K. Graski and M. Fremgen for training on the gas chromatogram and the coumarin fluorescence assay.