

DIE-OFF OF UTAH JUNIPER NATURAL BRIDGES NATIONAL MONUMENT

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♦ INTRODUCTION

The pinyon-juniper woodland is a wide spread vegetation type in the southwestern United States that is estimated to cover from 30 to 40 million hectares. The pinyon-juniper vegetation provides a source of fuel, building materials, charcoal, pine nuts, christmas trees and folk medicines. About 80% of the acreage is grazed by livestock and wildlife. In Utah, this ecosystem is a large component (62,705 km² or 28.6%) of the vegetation. Particularly in the Utah National Parks, the pinyon-juniper woodlands valued for their watershed, aesthetic and recreational values.

Over the past several years extensive foliar damage to Utah juniper (*Juniperus osterosperma* (Torr.) Little) has been observed in the Natural Bridges National Monument. The characteristic pattern is for the distal foliage to become chlorotic and die. Mortality progresses along twigs until whole branches or even the entire tree dies. Reports of similar foliar damage has been reported in Canyonlands National Park, Arches National Park, Mesa Verde National Park, Colorado National Monument, areas near Cedar City in southwestern Utah and in eastern Nevada, which would indicate that the foliar damage is a widespread problem. The cause for the foliar damage is unknown. The loss of juniper trees in the national parks in southern Utah would have a dramatic ecological impact and would

be an aesthetic blight in the parks. The purpose of this investigation is to determine the cause of the die-off of Utah junipers and suggest management options concerning the juniper die-off problem.

♦ STUDY AREA

The Natural Bridges area was made a national monument in 1908 and covers about 26 square kilometers of area. Seven transects of juniper trees were established in the Natural Bridges National Monument to follow the changes in the die-off problem over time.

♦ BASIC APPROACH

The basic approach to determining the cause of Utah juniper die-off is to consider possible causes and then obtain evidence for or against the hypothesis. After the cause of juniper die-off has been determined, then management options will be evaluated.

1. Determining the extent of the Utah juniper die-off problem in Natural Bridges National Monument.

Seven reference transects were established in Natural Bridges National Monument to determine the extent of the die-off problem and to permit

observation of specific trees over time. The soil and plant tissue samples were collected and analyzed for elements. In order to try to isolate possible pathogens of juniper die-off, isolations were made from trees showing juniper die-off symptoms.

Transects were made at Natural Bridges National Monument in die-off stands located in different environmental conditions such as ridges, washes, flood plains, etc. At each site, 40 Utah juniper trees were selected by the quarter method (Phillips 1959). Each tree was measured for height, trunk diameter, signs and symptoms of diseases, insect damage, nonparasitic injury, die-off symptoms, vigor and percent of decadence.

Nitrogen was determined by the Kjeldahl procedure using sulfuric acid digestion and the concentrations of the following minerals: K, Ca Mg, Na, and Fe will be determined by using nitric-perchloric acid digestion and atomic absorption spectroscopy. Total chlorophyll of leaf tissue were extracted and quantified by the dimethyl sulfoxide method of Hiscox and Israelstam (1979).

Soil samples were taken from each of the sites. The soils were dried, ground and analyzed for mineral composition using the Technicon Auto Analyzer and the Atomic Absorption Analyzer. Soil pH, composition and type were determined on the soils from the different sites. Soil moisture was determined by taking soil samples in moisture sealed containers at the three locations at each site.

The data obtained from the site analyses were analyzed by statistical methods using Statview II.

2. Hypothesis one: Nonpathogenic factors are the cause of Utah juniper die-off.

The correlation between mineral content of the foliage and soil composition in relation to the symptom levels and the environmental locations, should give some indication of the possible deficiency of some elements such as iron or the possible toxicity of other elements such as sodium. Of particular interest were the iron content of the soils and the foliage, since the die-off symptoms appear to be similar to iron deficiency.

Particular attention was paid to the sodium content of the soil and to the foliar tissue of Utah juniper, since in an earlier study (Bunderson et al.

1986) there was a positive correlation between needle blight and high soil salinity.

3. Hypothesis two: Pathogenic agents (viruses, mycoplasma, bacteria, fungi, mistletoe, and insects) are the cause of Utah juniper die-off.

Few studies have been made on the diseases of Utah juniper. The juniper rusts (Peterson 1967) have been surveyed. The presence of diseases of Utah juniper on 17 sites were surveyed by Bunderson et al. (1986). The level of mistletoe infection on juniper on the south rim of the Grand Canyon was determined by Hreha and Weber (1979). The presence of bacteria, fungi, mistletoe and insects were evaluated as part of the disease survey on the transects at the different reference sites.

Isolation of organisms (bacteria, mycoplasma and fungi) were made using standard isolation procedures. Samples of twig and root tissue were fixed in 3.5% glutaraldehyde (in 0.1 M phosphate buffer, pH 7.3) for 2 hrs, washed overnight in fresh buffer and postfixed for 2 hrs in 4% aqueous osmium tetroxide. They were dehydrated for 15 min each in a acetone series of 30, 50, and 70% and then transferred to saturated uranyl acetate in 70% acetone and stained for 1 hr. After staining, the specimens were washed in 70% acetone for 3 hrs dehydrated in 90 and 100% acetone, infiltrated overnight in a eponacetone (1:1) mixture and embedded in epon. The thin sections were cut on a Porter-Blum ultramicrotome using a diamond knife and examined in a Phillips 400 electron microscope.

Plant tissue were prepared by a similar method to look for viruses using the electron microscope.

The presence of insects were recorded during the reading of the transects. A few insects were collected. The tree trunks along the transects were observed for possible borers that could be causing damage to the junipers.

4. Hypothesis three: A combination of drought, higher salinity and temperature stress are the cause of Utah juniper die-off.

The southwestern part of Utah has been experiencing a severe drought over the past several years. As drought occurs, salinity tends to move up to the upper layers of the soil. Since Utah juniper is

salt sensitive, it is possible that these combinations could be contributing to the die-off problem. At the same time, endomycorrhiza and ectomycorrhiza have been reported to be present on Utah juniper (Reinsvold and Reeves 1986, Klopatek and Klopatek 1987). The mycorrhiza increases the water absorption and mineral uptake capacity of Utah juniper. If the mycorrhiza on the juniper roots are decreasing, it could result in decreased water and mineral uptake and this could be an important aspect in the die-off problem. VA mycorrhiza on roots from Utah juniper have previously been observed (Weber et al. unpublished data). Soil and fine roots from the Utah junipers growing at the different sites were collected and the amount of VA mycorrhiza is being determined using the methods of Schenck (1982).

◆ RESULTS AND DISCUSSION

1. The extent of the Utah juniper die-off in Natural Bridges National Monument. Table 1 shows a summary of transect ratings. A completely healthy tree was not observed in any of the transects.
2. Hypothesis one: Simple correlations were made with tip dieback, leaf blight and senescence and the soil factors. High correlations between these factors were not observed. Similar correlations were made with the elements in the plant tissue, and no high r^2 values were obtained.
3. Hypothesis two: No pathogens were isolated from the leaves. High correlation of juniper die-off and elements in the leaves were not observed. Electron microscopy analysis indicated considerable modification in the diseased cells and the presence of crystals. It is not known at this time if the crystals are made up of calcium oxalate or viruses.
4. Hypothesis three: No strong correlation between soil moisture, soil salinity and juniper die-off was observed.

◆ CONCLUSIONS

After 6 months of study, information on the extent of the juniper die-off and the elements in the soil and in plant tissue has been obtained. No high

correlations have been found between juniper die-off and soil and plant factors. The causal agent of juniper die-off is not clear at this time.

◆ LITERATURE CITED

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Table 1. Average disease evaluation for the trees in the Juniper Die-Off transects in the Natural Bridges National Monument.

Transect Number	Needle Blight tree rating*	Senescence tree rating	Tip-Dieback tree rating	Rust Galls no. per tree	Fusiform Rust tree rating	Witches Broom Rust Rating	Wood rot tree rating	Foliage fungi tree rating	Mistle toe tree rating	Insect Bores tree rating	Insect 'Burr' galls no. per tree	Insect 'Pear galls' no. per tree
J-1	1.6	2.5	0.98	0.35	0.08	0.00	0.00	0.03	0.10	0.13	0.23	0.00
J-2	1.5	1.9	0.63	1.13	0.23	0.03	0.00	0.00	0.00	0.05	0.30	0.03
J-3	1.6	2.3	1.28	0.78	0.50	0.00	0.00	0.00	0.08	0.05	0.45	0.10
J-4	1.2	2.6	0.88	1.10	0.60	0.00	0.00	0.00	0.05	0.00	0.25	0.10
J-5	1.1	2.6	0.78	1.48	0.05	0.08	0.00	0.00	0.00	0.13	1.00	0.03
J-6	1.0	2.6	0.75	0.68	1.20	0.05	0.00	0.00	0.10	0.00	1.35	0.15
J-7	1.1	2.2	0.73	0.53	0.40	0.00	0.00	0.03	0.00	0.00	0.90	0.05
Total	1.3	2.4	0.86	0.86	0.44	0.02	0.00	0.01	0.05	0.05	0.64	0.06

*ratings show percent of tree affected: 0-0%; 1 = 1-20%; 2 = 21-40%; 3 = 41-60%; 4 = 61-80%; 5 = 81-100%; 6 = dead (no foliage)