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Landform, soil, and plant relationships to nitrate accumulation, Central Nevada

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ABSTRACT

Nitrate (NO_3^{-1}) accumulates in Haplocambids and Torrifluvents in inset fan and fan skirt positions in central Nevada. The soils store as much as 17,600 kg of NO_3^{-1} N ha^{-1} within the upper 208 cm. This paper provides an explanation. These Holocene soils receive NO_3^{-1} N from mineralization of organic matter and other NO_3^{-1} N sources including snowmelt. The NO_3^{-1} is delivered to soils in the first part of snowmelt in run-off from the higher surfaces. The last part of the melt and the run-off, when sufficient, serve to move the NO_3^{-1} out of the root zone. Winter fat *(Krascheninnikovia lanata)*, the most valuable winter grazing plant in the Great Basin, is the common plant on NO_3^{-1} N rich soils. The soils are loamy or sandy and lack horizons restricting water penetration or biological denitrification zones. Hence, some NO_3^{-1} is free to leach deeply past plant roots. Playas, wet floodplains, deeply gullied inset fans and well-developed soils accumulate little NO_3^{-1} except where the latter soils are capped by desert pavements and rarely, if ever become saturated with water. Soils with argillic or petrocalcic horizons or duripans on summits of alluvial fan remnants loose NO_3^{-1} through denitrification, or incorporate it in plants, commonly accumulating less than 50 kg of NO_3^{-1} N ha^{-1}. These soils however do accumulate salt as shown by their shadscale saltbush *Atriplex confertifolia*, bud sagebrush *Picrothamnus desertorum*, and four-wing saltbush *Atriplex conescens* shrub cover.

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1. Introduction

The accumulation of large amounts of nitrate (NO_3^{-1}) in desert soils again gains attention (Graham, et al., 2008; Walvoord et al., 2003; Jackson et al., 2004; Walvoord et al., 2004). Soil scientists as early as 1906 reported accumulation of NO_3^{-1} in soils of the Great Basin area of the western conterminous United States (Viets and Hageman, 1971). Soil accumulation of NO_3^{-1}, not geological accumulation (Boyce et al., 1976; Mansfield and Boardman, 1932), may also be inferred from the work of Gale (1912) near Lovelock and Gerlach, NV. Mansfield and Boardman (1932) reviewed reports of geologic NO_3^{-1} accumulations in 23 states. The NO_3^{-1} was mostly in caves, caliche, and playas. Nitrate accumulates in soils of both hot (Ericksen, 1983) and cold deserts (Claridge and Campbell, 1968; Cameron et al., 1971). In Nevada the Fang Soils have accumulated as much as 17,600 kg/ha (Soil Conservation Service, 1970; Nelson et al., 1973).

NO_3^{-1} occurs in the arid parts of the southwestern United States in soils that have desert varnish and desert pavement (Nettleton et al., 1989; Graham et al., 2008) and accumulate eolian dust (Nettleton et al., 1978). Nitrate in uncultivated deep loess deposits in semiarid areas of Nebraska occurs in concentrations of as much as 87 ppm between depths of 6 to 34 m (Boyce et al., 1976). Walvoord et al. (2003) points out that this reservoir of bioavailable nitrogen has been previously overlooked in studies of global nitrogen distribution. Jackson et al. (2004) found the accumulation of nitrate in Chihuahuan Desert cores is an order of magnitude less than the ~10^4 kg of nitrogen per hectare reported by Walvoord et al. (2003). Both Walvoord et al. (2003) and Jackson et al. (2004) however agree that desert subsoil nitrate NO_3^{-1} inventories are spatially highly variable and need additional survey to reduce uncertainty in global explorations.

Other sources of the NO_3^{-1} besides dust have been reported. Mueller (1968) believed the NO_3^{-1} in the North Chilean Desert came from Andes drainage waters. He also considered rainfall following electrical discharge in the atmosphere and the action of nitrifying bacteria on organic matter to be possible sources. Ericksen (1983) believed that most NO_3^{-1} deposits in the Atacama Desert of northern Chile formed by fixation of atmospheric nitrogen by microorganisms in playa lakes and associated moist soils. The NO_3^{-1} would have accumulated when these lakes evaporated to dryness. Present annual rainfall in that desert is about 1–2 mm. Winds later could have spread part of this NO_3^{-1} to soils as dust in the nearby hilly terrain.

Wilson and House (1965) estimated that auroral activity and other geophysical phenomena in the upper atmosphere contributed as much NO_3^{-1} as 0.005 kg ha^{-1} $year^{-1}$. Claridge and Campbell (1968) showed that the NO_3^{-1} in Antarctica originated in snowfall and became concentrated as the snow sublimed. Mayewski et al. (1986) found that the NO_3^{-1} concentration in the South Greenland ice core has doubled since about 1950. Snyder and Wullstein (1973) studied the role of desert cryptogams in nitrogen fixation and concluded that lichen blue-green phycobionts, free-living blue-green algae and

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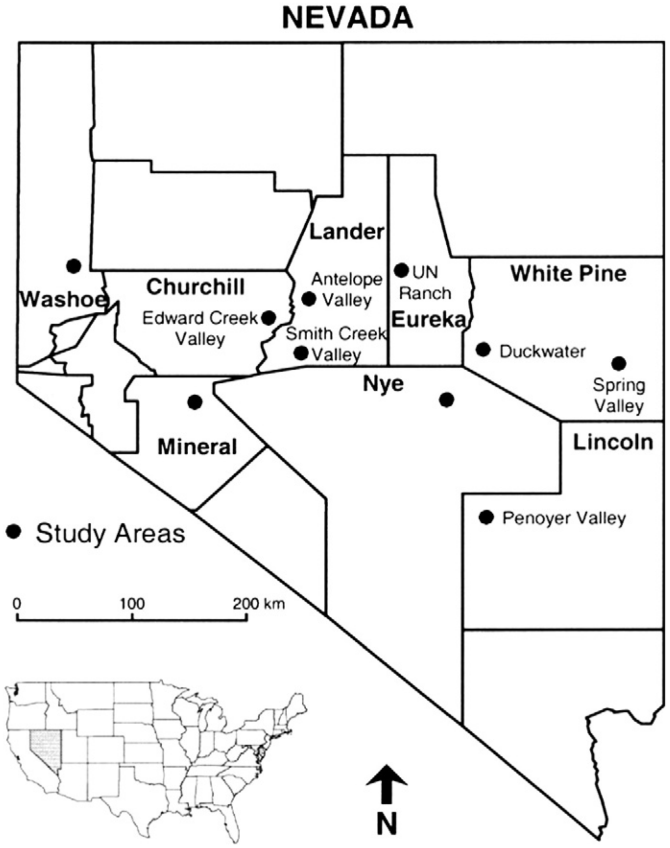

Fig. 1. Location of sampling areas and counties in Nevada in which they occur.

Azotobacter-like organisms were involved, but that total annual nitrogen fixation among desert cryptograms is probably small and related to seasonal moisture. In this paper we investigate the relationship of NO_3^{-1} accumulation in Central Nevada to landform, morphology of the soils, and kind of vegetation supported.

2. Soils and methods

We sampled 34 pedons in 8 counties of central Nevada (Fig. 1). The soils are in the Basin and Range Province of the western United States in frigid and mesic soil temperature families and have xeric or torric moisture regimes in which more than half of the precipitation comes as snow. We use landform (physiographic position) terms defined by Peterson (1981) and Schoeneberger and Wysocki (1998) and analytical methods as described and coded by the Soil Survey Laboratory Staff (1996). Saturated pastes (SP) were prepared and electrical conductivity (EC) determined by method 8A3 and NO_3^{-1} by methods 6M1c and 6K1c. Cations and anions were checked for chemical balance and analysis repeated when they did not. Statistics and graphics were developed using Statgraphics Plus Version 3 For Windows (Manugistics, Inc, 1997)[1]. A bulk density of 1.47 g cm^{-3} was assumed in calculating kg of NO_3^{-1} N ha^{-1} for each pedon. The soils are listed by Soil Taxonomy classes (Soil Survey Staff, 2006).

3. Results and discussion

Electrical conductivity (EC), nitrate (NO_3^{-1}), and nitrate nitrogen (NO_3^{-1} N) data for the water extracted from saturated paste for three of the soils and how the total NO_3^{-1} N was calculated are in Tables 1–3. Nitrate nitrogen, sampling depth, root distribution, landform, and great soil groups are listed in Table 4. Complete soil data and some of the descriptions are available on compact disk (Benham, 1997). The capacity of the soils to retain water between field capacity and the wilting percentage ranges from 2.79 to 33.36 cm for those we analyzed (Table 5).

Table 1
Nitrate and salt data for a Typic Haplocalcid (S81NV011-002), Eureka County, NV, sampled on an inset alluvial fan[a].

Sample no.	Horizon	Depth cm	Water extracted from saturated paste		
			EC mmhos/cm	NO_3^{-1} g/1	NO_3^{-1}–N kg/ha/horizon
82231	Al	0–10	0.45	0.02	2.1
82232	Bw1	10–30	0.41	–	–
82233	Bw2	30–69	0.44	–	–
82234	Bk1	69–91	9.03	2.98	940.8
82235	Bk2	91–127	10.99	4.20	2141.7
82236	Bk3	127–152	12.40	4.50	1707.0

[a] kg NO_3^{-1}–N/ha/152 cm soil depth = 4791.6.

Table 2
Nitrate and salt data for a Typic Torrifluvent (S59NV17-38), Penoyer Valley, Lincoln County, NV, sampled on a shallowly and historically-gullied inset fan[a].

Sample no.	Horizon	Depth cm	Water extracted from saturated paste		
			EC mmhos/cm	NO_3^{-1} g/1	NO_3^{-1}–N kg/ha/horizon
59834	C1	0–8	0.8	0.12	6.2
59835	C2	8–20	0.5	0.06	4.2
59836	C3	20–33	0.6	0.01	0.6
59837	C4	33–51	0.4	0.04	58.6
59838	Cs	51–109	1.2	0.20	118.4
59839	C6	109–132	2.6	0.46	90.4
59840	C7	132–163	4.7	1.62	456.3
59841	2C8	163–178	6.1	2.36	305.0
59842	3C9	178–198	3.8	1.50	212.1

[a] kg NO_3^{-1}–N/ha/198-cm soil depth = 1251.8.

Although it seems likely that there is more than one source of the NO_3^{-1} N in these soils, herein we propose that mineralization of organic matter accounts for most of the NO_3^{-1} N accumulated. The Fang series (S59NV 17-38 of Table 2 is representative) for example produces 392 kg of dry-weight vegetation/ha/year (350 lb./Ac/year, see Table 3 in Rooke et al., 1968). If we make the following assumptions: (i) an average organic matter production, no increase in soil organic matter content, no loss of N through run-off, or gaseous loss through denitrification, (ii) plants with a protein content of 10%, a low estimate, and (iii) protein has an N content of 16%, then the 1251.8 kg/ha of NO_3^{-1} N stored in the Fang pedon will be added in about 200 years. (1251.8 kg/ha of NO_3^{-1} N/392 kg/ha/year/0.10/0.16) (Table VIII, McCreary, 1931 and Bidwell and Wooten, 1925*)*. We consider the Fang soil to be Holocene in age and assumed the time available to be 10 kyr.

More NO_3^{-1} N needs to become available than the vegetation utilizes for any to accumulate below the rooting zone. The pedon descriptions show that roots reach and determine the upper zone of NO_3^{-1} accumulation (Table 4). Three ways NO_3^{-1} N could leach below

Table 3
Nitrate and salt data for a Xeric Petrocalcid (S77NV033-001), White Pine County, NV, on the summit of an erosion fan-piedmont remnant[a].

Sample no.	Horizon	Depth cm	Water extracted from saturated paste		
			EC mmhos/cm	NO_3^{-1} g/1	NO_3^{-1}–N kg/ha/horizon
78P707	A	0–8	1.41	0.37	29.3
78P708	Bw1	8–23	0.81	0.04	7.3
78P709	Bw2	23–33	0.64	0.01	1.0
78P710	2Bk	33–46	0.61	0.01	1.1
78P711	2Bkm	46–56	1.04	0.01	0.7

[a] kg NO_3^{-1}–N/ha/soil depth = 39.4.

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[1] Use of trade names does not represent an endorsement of products, but is for information purposes only.

Table 4
Pedon number, NO_3^{-1} N content, sampling depth for nitrate, rooting depth, geomorphic position, and great soil group.

Pedon no.[a]	NO_3^{-1} N kg ha^{-1}	Sampling depth cm	Rooting[b] depth cm	Landform	Great soil group[c]
Group 1. Inset alluvial fans and fan skirts with well-drained, loamy or sandy soils, without restrictive layers. Vegetative cover is mostly winterfat, black sagebrush, four-wing saltbush, and galleta[d].					
S77NV-033-2	7645.7	56–208	152	Inset alluvial fan	Typic Haplocambid
S80NV-033-1[e]	5375.2	0–190	N.D.[f]	Inset alluvial fan	Xeric Haplocambid
S80NV-033-2	4240.5	70–190	N.D.[f]	Inset alluvial fan	Xeric Haplocambid
S80NV-033-3[e]	2.7	0–70	N.D.[f]	Inset alluvial fan	Xeric Torriorthent
S80NV-033-4[e]	1582.9	0–220	N.D.[f]	Inset alluvial fan	Xeric Haplocambid
S80NV-033-5[e]	7415.2	70–220	N.D.[f]	Inset alluvial fan	Xeric Haplocambid
S80NV-033-6[e]	15859.5	0–220	N.D.[f]	Inset alluvial fan	Typic Haplocambid
S80NV-033-7[e]	2137.0	70–170	N.D.[f]	Inset alluvial fan	Typic Haplocambid skirt
S80NV-021-1[e]	15.5	40–90	N.D.[f]	Inset alluvial fan, historically-gullied	Xeric Haplocalcid
S81NV011-002	4791.6	69–152	152	Inset alluvial fan	Typic Haplocalcid
S77NV-033-3	6102.4	68–235	152	Alluvial fan skirt	Typic Haplocambid
S77NV-015-2	5510.3	60–205	135	Alluvial fan skirt	Typic Haplocambid
S80NV-001-2[e]	2659.1	40–160	89	Alluvial fan skirt	Typic Haplocambid
S81NV023-030	9.5	0–152	107	Alluvial fan skirt	Typic Torripsamment
S80NV-001-1[e]	509.4	40–120	N.D.[f]	Alluvial fan skirt historically-gullied	Aridic Argixeroll
S59NV017-37	4193.1	0–163	N.D.[f]	Inset fan, historically-gullied	Typic Torrifluvent
S59NV017-38	1251.8	0–198	N.D.[f]	Alluvial fan historically-gullied	Typic Torrifluvent
Group 2. Bypassed alluvial fan and piedmont positions with soils that do not receive run-on from higher surfaces. Vegetative cover is mostly shadscale saltbush, four-wing saltbush, galleta, bud sagebrush, black sagebrush, Truckee rabbitbrush, big sagebrush, winterfat, and others[d].					
S59NV-017-34	7.4	0–168	N.D.[f]	Alluvial fan	Durinodic Natrargid
59NV-017-42	15.3	0–178	N.D.[f]	Alluvial fan remnant	Typic Natridurid
S77NV-033-4	4.7	20–127	40	Alluvial fan remnant	Xeric Argidurid
S77NV-033-1	39.4	0–56	46	Old alluvial fan, summit	Xeric Petrocalcid
S81NV001-001	0.0	163	61	Inset alluvial fan that has been	Xeric gullied Haplocalcid
S81NV033-050	31.5	46–122	46	Inset fan remnant, slightly higher than S77NV033-003 site and separated by shallow channel	Xeric Calciargid
S81NV015-001	0.0	157	79	Alluvial fan summit	Typic Natrargid
S81NV011-001	386.9	0–157	66	Alluvial fan remnant, summit	Typic Haplocalcid
S81NV023-031	79.5	0–152	152	Alluvial fan piedmont	Typic Haplocalcid
Group 3. Playas, basins, and associated positions occupied by Aquisalids, Torriorthents, or Haplocalcids. Vegetative cover, some have none, others have black sagebrush, black greasewood, and suaeda[d].					
S81NV031-001	0.0	61	0	Playa	Typic Aquisalid
S81NV031-002	0.0	61	0	Island within playa	Typic Aquisalid
S81NV031-003	0.0	61	0	Near edge of playa	Typic Aquisalid
S81NV031-004	511.7	30–61	0	Dunes on edge of playa	Typic Torriorthent
S81NV033-023	3144.9	10–163	153	Fan in basin, summit	Xeric Haplocalcid
S81NV001-002	3830.1	0–152	152	Flood plain within alluvial flat	Typic Torrifluvent
S77NV-015-1	182.4	76–140	99	Lacustrine bar	Typic Haplocambid
S80NV-011-1	107.7	147	N.D.[f]	Lagoon Typic	Haplocambid

[a] The data for the soils are listed by these pedon numbers on the CD for the laboratory characterization data (Benham, 1997).

[b] Depth where roots decrease to a few in number.

[c] Classification system (Soil Survey Staff, 2006).

[d] Scientific names of the plants follow in alphabetical order: big sagebrush, *Artimisia tridentata*; black greasewood, *Sarcobatus vermiculatus*; black sagebrush, *Artemisia nova*; bud sagebrush, *Picrothamnus desertorum*; four-wing saltbush, *Atriplex canescens*; galleta, *Pleuraphis jamesii*; seepweed, *Suaeda*; shadscale saltbush, *Atriplex confertifolia*; Truckee rabbitbrush, *Chrysothamnus humilis*; and winterfat, *Kraschenínnikovia lanata.*

[e] Auger samples. Other sites were sampled in backhoe pits.

[f] Rooting depth not determined.

Table 5
Soil water retention difference (WRD) to depths of 2 m, or to a root limiting horizon, for selected soils[a].

Soil survey number	Soil taxonomy family	Total WRD[b] cm
S77NV33-1	Xeric Petrocalcid, loamy–skeletal, carbonatic, mesic, shallow	5.25
S77NV33-2	Typic Haplocambid, coarse–silty, mixed, mesic	17.16
S77NV33-3	Typic Haplocambid, coarse–loamy, mixed, mesic	12.40
S77NV33-4	Xeric Argidurid, loamy, mixed, mesic, shallow	2.79
S80NV11-1	Typic Haplocambid, coarse–silty, mixed, mesic	33.36
S77NV15-1	Typic Haplocambid, coarse–loamy, mixed, mesic	22.03
S77NV15-2	Typic Haplocambid, coarse–loamy, mixed, mesic	22.76

[a] Water available for leaching the profile (monthly sum of precipitation minus potential evapotranspiration) is assumed to be the same as for Ely, White Pine County, Nevada, 7.50 cm.

[b] WRD (water retention difference) is water retained at tensions between 33 kPa and 1500 kPa.

our sampling depths are from years of above average precipitation, extreme years, or excessive run-on.

We considered the climatic data for Ely to best fit these Nevada soils. That station shows 7.50 cm of water to be available for profile leaching in an average year (Table 5). The 7.50 cm received in an average year then likely would not completely wet most of the soils below the depth of roots and not to more than 2 m even if it all came as one extreme event. In this area, however, we have observed run-off to be common during snowmelt and could account for the deeper leaching in adjacent downslope areas.

3.1. Relationship of NO_3^{-1} accumulation to landform

The soils in inset alluvial fan and fan skirt positions accumulate the most NO_3^{-1} N followed by those in gullied inset fan and fan summit positions (Fig. 2, Table 4). Of the three groups of landforms, the inset alluvial fans and fan skirts (Fig 2) and gullied inset fans receive run-on

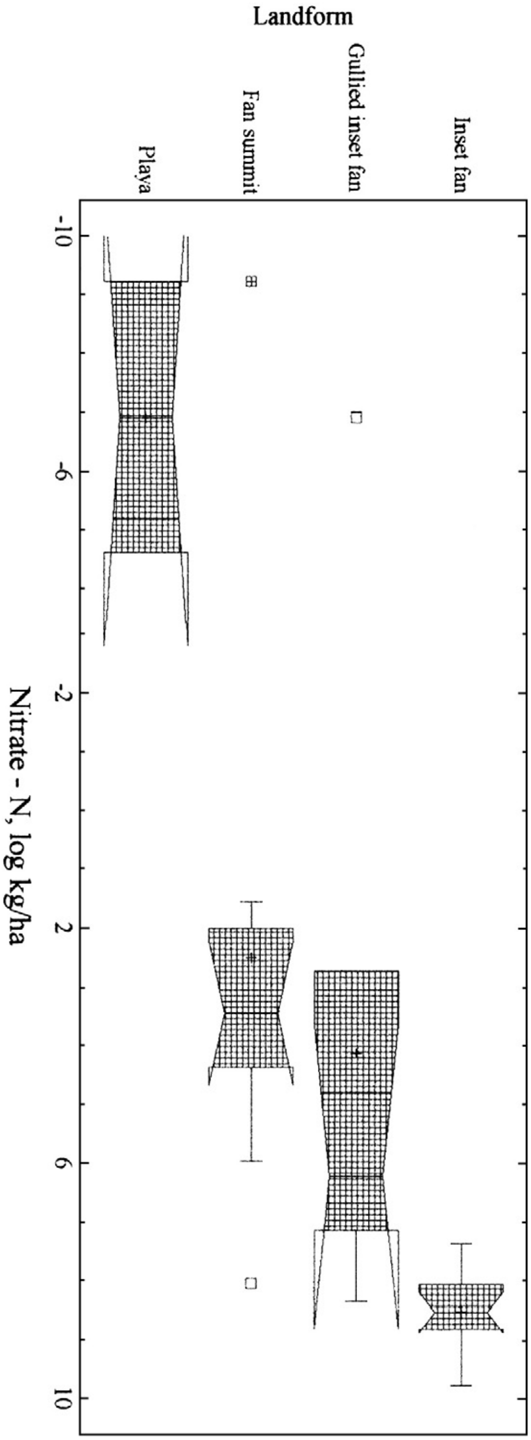

Fig. 2. Box-and-whisker plot of the $\log_{10}$ of the nitrate-N content of the soils in the three landscape positions. The notch represents the median value for the soils in each position.

water. Dissection of the latter apparently resulted in some loss of NO_3^{-1} N. Without run-on none of the soils receive enough water through precipitation to undergo leaching except the shallow soils like S77 NV 33-3 and 4 (Table 5). Run-off likely also occurs from the soils with duripans, vesicular horizons, and desert pavement.

3.2. Relationship of NO_3^{-1} accumulation to soil morphology

Soils with genetic horizons such as duripans and petrocalcic horizons accumulate very little NO_3^{-1} N (note the Typic Natridurid, Xeric Argidurid, and the Xeric Petrocalcid, Table 4). Even the soils with natric and argillic horizons accumulate very little NO_3^{-1} N (note the Aridic Argixeroll, Durinodic Natrargid, and Typic Natrargid, Table 4). These results agree with those of Pratt et al. (1972) who found that in 30-m profiles of a long-term fertility trial with citrus that clayey horizons over sands averaged a 52% loss by denitrification. In their study the textural discontinuities occurred within the first meter.

Most of the other soils are coarse–loamy or coarse–silty and lack horizons that restrict water penetration as inferred from their taxonomic classes (Table 4) and laboratory data available from the National Soil Survey Center (Benham, 1997). One soil, a Torripsamment (S81NV023-030), has accumulated very little NO_3^{-1} within a depth of about 150 cm although it is in position to receive run-on. It is sandy with a low water holding capacity so that the NO_3^{-1} may have leached to a greater depth than observed in the more uniform medium or coarse-textured soils. Another soil (S77NV015-001) is in a lagoon on an offshore bar and has accumulated only small amounts of NO_3^{-1}. It may also be more leached because run-on exceeded the capacity of the soil to hold water. Haplocalcids on summits of alluvial fans contain much more NO_3^{-1} N than do the soils with the more strongly developed genetic horizons. This suggests that some NO_3^{-1} N has been lost from the more strongly developed soils through biological denitrification since some of these soils have restrictive horizons and would lose little through leaching or lateral subsurface flow above restrictive layers. All of these soils are described as well-drained and have pHs of neutral or higher. However, upon flooding of neutral soils, van Breemen and Brinkman (1978) suggest that after oxygen, NO_3^{-1} is the first to be lost through reduction followed by manganese oxides and then iron oxides.

The Xeric Haplocalcid (S80NV-021-001), Aridic Argixeroll (S80NV-001-001), and the Typic Torrifluvents (S59NV-017-037 and 038) have been gullied in historical time (Table 4). Aquisalids in the playa are saturated frequently enough that they accumulate no NO_3^{-1} N. Presumably any NO_3^{-1} brought in by the water from the higher landscape would be lost through biological denitrification. The dark grayish brown to light olive brown colors (2.5 YR 4/2, 5/2, and 5/4) of these soils show that some Fe is in the ferrous state (Benham, 1997). The NO_3^{-1} would have been reduced and lost before the Fe.

3.3. Relationship of NO_3^{-1} accumulation and the water added through run-on to kind of vegetation

Winterfat (*Krascheninnikovia lanata*) occurs on the soils of Group 1 landforms (Fig. 3, Table 4). It is a desirable browse for sheep, palatable and nutritious (Holmgren, 1975). Protein content is high (McCreary, 1931). Like other desert shrubs the productivity of winterfat is enhanced by run-on water (Schlesinger and Jones, 1984). It has a deep taproot (Dayton and Associates, 1937, B75–B76) that reaches the soils' deep-NO_3^{-1} and water storage zone. We found the plant to be more common on the soils on Group 1 landforms, but it also occurs on soils on alluvial fan remnants and summits (Fig. 4). We measured significant NO_3^{-1} N in all of the soils where winterfat occurs. Some of the other plants of the Goosefoot family, unlike winterfat, accumulate toxic amounts of KNO_3 (Dayton, 1960, p. 85).

3.4. Importance of Snowmelt to NO_3^{-1} accumulation in the soils and sediments of Central Nevada

Snow is a source of NO_3^{-1} in at least some parts of the world (Junge, 1958; Rogers and Feth, 1959; Wilson and House, 1965; Claridge and Campbell, 1968; Parker and Zeller, 1980; and Mayewski et al., 1986). Snowfall in central Nevada likely also contains NO_3^{-1}. Johannessen and Hendriksen (1978) found that 50–80% of the pollutant load in snow is released with the first 30% of the meltwater.

The very first meltwater may contain 5 times the concentration of pollutants in the snow pack. This early release would allow more of

Fig. 3. Inset fan landscape showing a dominance of winterfat (*Krascheninnikovia lanata*) in the level foreground. The slightly higher, and older, alluvial fan remnants marked here and there by juniper divide the foreground from the mountains in the background. The mountains are the source of the alluvial fan sediments.

the NO_3^{-1} to be moved by the later part of the snowmelt past the root zone of the plants. There it could accumulate as long as infiltration did not exceed deep percolation and oxidizing conditions existed. Run-off waters would contain more of the NO_3^{-1} also. Inset fans and fan skirts that receive this NO_3^{-1} charged run-off water then could accumulate large amounts of the NO_3^{-1} N.

Snowfall is an important part of the precipitation in central Nevada. Any NO_3^{-1} from other sources such as dust (Peterson, 1977), organic matter decomposition, rainfall from thunderstorms occurring at higher elevation (Junge, 1958), or desert cryptograms (Snyder and Wullstein, 1973; Ericksen, 1983) would also be moved to some depth in the soils that receive run-on. Other sources of water such as pluvials of the Pleistocene are not possible for most of these soils, especially those in inset fan positions. Their close relationship to historically gullying suggests that these are Holocene fans and so would neither have received more water nor have supported more productive vegetation than at present (Morrison, 1965).

3.5. Environmental relationships

Soils with the most NO_3^{-1} in central Nevada are the well-drained, uniformly-textured ones in inset fan and fan skirt positions that periodically receive run-on water. Those soils that do not receive run-on water or have layers restricting water movement mostly do not accumulate NO_3^{-1}. Argids and Natrargids with desert pavements are an exception. Although these soils have horizons that restrict water movement, some accumulate NO_3^{-1} in their surface horizons (Nettleton et al., 1989; Graham et al., 2008). Rarely, if ever, do soils with desert pavements become saturated with water for long periods. Possible sources of the NO_3^{-1} in these soils with desert pavements are the nitrogen fixed by microorganisms and plants and to a lesser extent thunderstorm activity, snowmelt, and dust.

The NO_3^{-1} N in snow is released with the first snowmelt. We anticipate that the first part of the snowmelt will be leached to greater depth in the soils because it is released at a time when temperatures

Fig. 4. Two vehicles are on the historically-gullied inset alluvial fan in the foreground. A gully marked by big sagebrush (*Artemisia tridentata*) crosses the figure from left to right. An alluvial fan and mountains are in the background.

are low and water use is small. As the snow continues to melt and spring rains come, the run-on of lower NO_3^{-1} content water forces the higher NO_3^{-1} content water deeper into the soil and beyond the reach of most plants.

Run-off from the surrounding watershed brings the rest of the NO_3^{-1} to the lower part of the landscape. The NO_3^{-1} remaining in the higher parts of the landscape is used by the plants or is leached out of the soils along with most of the salt. In playa and flood plain landscape positions with high water tables reducing conditions may prevent accumulation of NO_3^{-1}. Soils in inset fan landscape positions receive enough run-on water to move the NO_3^{-1} below most plant roots, but not out of the profiles. In the other soils in lower landscape positions that do not receive run-on, there is rarely enough water to remove the NO_3^{-1} or salt from the soil and so most of the NO_3^{-1} from eolian dust, snowmelt, etc., is used by the vegetation.

The soils in inset fans of Holocene age in Central Nevada have accumulated NO_3^{-1} N at a maximum rate of about 1.8 kg ha^{-1} year^{-1}. This rate is based on the 17,600 kg ha^{-1} accumulated in the Fang soil which is on a Holocene terrace (≤10,000 year.). This is a rate of about 1/5th to 1/7th that measured (10–14 kg ha^{-1} year^{-1}) for Iowa soils (Tabatabai and Laflen, 1976). The annual precipitation in the area studied in Nevada is about 1/3rd that in Iowa, 25–30 cm yr^{-1} as compared to 81–86 cm yr^{-1}, suggesting differences in sources of NO_3^{-1} N other than electrical storms. The maximum NO_3^{-1} N stored in the central Nevada soils is nearly equal to that Mielke and Ellis (1976) measured below an abandoned feed lot in Nebraska (18,200 kg ha^{-1}) and much more than that below an active upland feedlot (1840 kg ha^{-1}), or corn cropland (1100 kg ha^{-1}). Mielke and Ellis were aware that, before use by modern man, soils in Nebraska, like the ones we analyzed in Central Nevada, contained significant amounts of NO_3^{-1} N. Our study will make future users of the Nevada soils more aware of native levels of NO_3^{-1} N.

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