Grazing Potential Index (GPI) and Surface Water Quality in the State of Oregon:
I. Likelihood of animal pathogenic presence using enterococci

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Introduction

Livestock grazing is a widespread and persistent ecological stressor in the western United States. Livestock impact surface water quality by introducing nutrients and bacteria, and by damaging stream banks or removing vegetation cover leading to increased sediment loads and temperatures. The objective of this study is to test the viability of grazing potential index (GPI) (Heggem et al. 2004) to predict spatial distribution and concentration of animal born bacteria (enterococci). GPI is an index that uses Geographic Information Systems (GIS) to identify locations likely to support grazing. It is based on distance to water, forage availability and land ownership.
Further analyses are underway to investigate spatial distribution of livestock and its relationship to landscape metrics (e.g., percent riparian cover, natural cover, etc.) and surface water nitrogen and phosphorous loadings.

Study Area Description

Oregon state encompasses 251,415 km^2 in surface area with a wide range in elevation and vegetation cover from the coast on the west to the dryland in the east (Figure 1). Elevations range from the sea level at the coast to 3,426 m (11,100 ft) at Mount Hood. Climate data for the state of Oregon spanning the last 100 years, indicates wet/dry cycles of 20-30 years. Dry periods were noted in the years from 1920 through 1945 and from 1975 through 1994. A wet cycle appears to have begun in 1994.

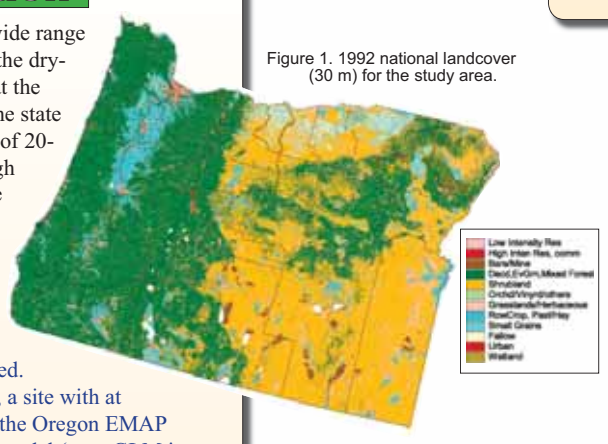

Figure 1. 1992 national landcover (30 m) for the study area.

Water Quality Data: Environmental Monitoring and Assessment Program (EMAP) water data were obtained for the years 1990 through 1994 to coincide with the 1992 remote sensing data (National Land Cover data; NLCD). Only water quality data for the growing season (June – September) were used. To ensure adequate coverage of temporal and spatial water data, a site with at least two years of measurements (n = 197) were extracted from the Oregon EMAP project and used for the analyses of enterococci. General linear model (proc GLM in SAS) and ArcView were used for analyses and presentations of results.

Enterococci: Recently, EPA (1986) recommended using enterococci bacteria to indicate the presence of human and/or animal fecal materials. Water is safe for drinking when a single sample contains no more than 104 colony-forming units (cfu) per 100 ml or when the geometric mean of multiple samples (minimum time interval of 24 hours) is less than 35 cfu/100 ml for freshwater. From the 197 sample sites, 25% (49 sites) exceeded the standard geometric mean (35 cfu/100 ml, Figure 2). These sites were further investigated to identify trends over time (increasing/decreasing). Increasing or decreasing enterococci concentration at a site may represent the impact of livestock presence or absence in the area. A total of 35 sites exhibited a positive or negative trend; only 13 sites had a significant positive trend and one site had a significant negative trend (Figure 2).

The relationships of enterococci and water temperature, dissolved oxygen, organic nitrogen, total nitrate, total nitrite, total phosphate, and dissolved phosphate were studied in sites where the overall geometric mean of the enterococci was higher than 35. The relationships for a few of the sites are presented in Table 1.

Figure 3 shows the GPI (2003) map and enterococci sites in the Johnson Creek South at Glenbrook River Mile 1.1. Although the geometric mean for the enterococci concentration is high (840 cfu/100 ml), the trend of enterococci over time is decreasing significantly. In spite of a positive trend (not significant) in temperature and nitrogen compounds, the significant positive trend in the dissolved oxygen may indicate improving conditions at this site. This site is within a low GPI area. Red and orange dots indicate sites with a geometric mean of enterococci more than 35 cfu/100 ml located mostly within areas of high GPI (Figure 3).

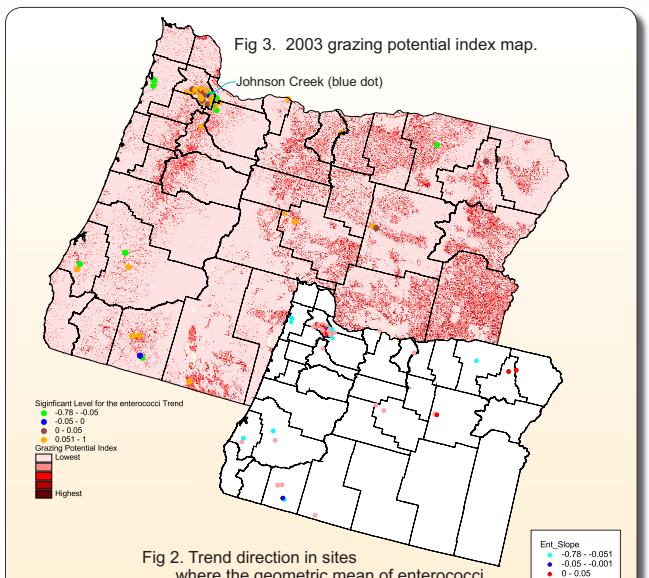

Fig 3. 2003 grazing potential index map.
Johnson Creek (blue dot)

Fig 2. Trend direction in sites where the geometric mean of enterococci concentration is highter than 35 cfu/100 ml.

Table 1. Overall geometric mean of the enterococci concentration (cfu/100 m), temporal trend for the eneterococci, and direction of relationships between enterococci and other surface water measurements for selected sites.

STN	STNNAME	Pred_LC	Ent_Trend	GeoMean	TempC	O2_dix_%	TotNO3	TotNO2	NH3NH4_Mod	NO2NO3_Mod	O_N	PhosTot	PhosDisOrtho
4920000	Wallowa_River_@_Minam	Shrubland	0.03	44.65	-	-*			+	+	+	-	+
4922596	Grande_Ronde_River_@_HWY_82_(North_Elgin)	Shrubland	0.02	45.71	+	-			+	+	+*	+*	-
4922131	Tualatin_River_@_Rood_Road	Pasture/hay	0.04	58.39	-	-			+*	-	-	-	-
27191588	Tualatin_River_@_Sprindrift_Road	Pasture/hay	0.02	74.78	+	+	-	-	-	-	-	-	-*
4941158	John_Day_River_US_Dayville	Pasture/hay	0.01	94.98	-	-			+	+	+	+	+*
4922150	Beaverton_Creek_@_219th_(Orenco)	Forest	0.02	122.87	-	-			+	-	+	-	-
4922139	Fanno_Creek_@_Bonita_Road_(Tigard)	High Intensity Residential	0.01	136.19	-	-			+*	-	+	+	+
3820005	Rock_Creek_@_Pacific_Highway	Grassland	0.00	171.78	+	-	+*	+	+	+*	-	-	+
3815520	Dairy_Creek_@_HWY_8	Pasture/hay	0.04	185.56	+	-	+	+	+	+	-	+	+
3822002	Butternut_CK_@_River_Road_RM_0.2	Orchd/vin	0.01	242.68	+	-	+	+	-	+	-*	-*	+
3820015	Rock_Creek_@_HWY_8_Bridge	Pasture/hay	0.04	285.16	+	-	-	+	-	-	-	+	+
3813001	Weston_Creek_@_Highway_216	Orchd/vin	0.01	289.40	+	-	-	+	-	-	+	+	+
3811018	Wicks_Creek_@_HWY_219	Pasture/hay	0.04	295.47	-	-	+	+	+	+	+	+	+
3806035	Carpenter_Cwk_US_OGF_(RM_3.5)		0.03	539.20	+	-	-	-	+	-	-	-	-
3827011	Johnson_CK_South_@_Glenbrook_RM_1.1	Low Intensity Residential	-0.02	840.59	+	+*	+	+	+	+	+	-	-

Discussion

We presented a simple method as a means to validate the GPI by synchronizing the likelihood of livestock presence from the GPI map with that of high values of enterococci concentrations in surface water (Figure 3).

Enterococci data were used to accomplish one of our objectives; that is to examine the temporal trend in enterococci in an effort to link the behavior with that of the human and/or livestock. This method may be useful as a targeting tool to identify priority areas for implementation of Best Management Practices (BMP) to prevent or reduce the runoff and transportation of animal waste to surface water as a means for improving/preserving the quality of surface water in the western part of the USA.

Acknowledgments

We are very grateful to Tony Selle, Scott Augustine and Peter Leinenbach for their input and discussions.

Reference

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