Catena 116 (2014) 142–148

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

The effect of windthrow disturbances on biochemical and chemical soil properties in the northern mountainous forests of Iran

Yahya Kooch [a,*], Seyed Mohsen Hosseini [a], Pavel Samonil [b], Seyed Mohammad Hojjati [c]

[a] Department of Forestry, Faculty of Natural Resources & Marine Sciences, Tarbiat Modares University, 46417-76489, Noor, Mazandaran, Iran
[b] Department of Forest Ecology, The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Lidicka 25/27, 657 20 Brno, Czech Republic
[c] Department of Forestry, University of Natural Resources and Agriculture Sciences of Sari, Mazandaran, Iran

ARTICLE INFO

Article history:
Received 20 April 2013
Accepted 3 January 2014

Keywords:
Pit and mound
Soil chemistry
Microbial respiration
Nitrogen mineralization
Disturbances
Iran

ABSTRACT

Land degradation as a result of wind (aeolian processes) is one of the most significant causes of soil loss in northern Iran. In order to gain a broader understanding of the specific effects of aeolian disturbance on soils in this region, research was conducted to evaluate soil microbial respiration and nitrogen mineralization in places where differences in microtopography occur due to the uprooting of trees by windthrow events, thereby causing variations in microtopography hereby referred to as “pit–mound positions”.

A twenty-hectare study site situated within the Tarbiat Modares University Experimental Forest Station located in the Mazandaran province of northern Iran was chosen for this research, with thirty-four uprooted trees selected for detailed study. A classification of five microsites was developed to distinguish differences in microtopography in the immediate vicinity of these uprooted trees: mound top, mound wall, pit bottom, pit wall and closed canopy. Soil was sampled in the 0–15, 15–30 and 30–45 cm depths at all microsites using a core soil sampler with an 81 cm^2 cross section. Soil reaction, organic carbon, total nitrogen, carbon-to-nitrogen ratio, moisture, abundance and biomass of earthworms, soil microbial respiration and net N mineralization for all samples were measured in the laboratory.

Statistical comparisons revealed that the highest soil microbial respiration and net N-mineralization occurred in pit bottoms. Mound tops showed the lowest levels of soil microbial respiration and net N mineralization. Measurements of soil microbial respiration and net N mineralization were shown to decrease in relation to increased soil depth, with significant differences depending on soil depth. Indications of aeolian processes indicate that windthrow events create different microsites, thereby influencing the specific micro-scale soil characteristics. These micro-scale characteristics should be taken into account when performing forest soils surveys and to inform forest management practices.

1. Introduction

Iranian Caspian forests, also called Hyrcanian or Northern forests, cover about 1.9 million ha, and are located on the coast of the Caspian Sea and the northern slopes of the Alborz Mountain range, from sea level to 2800 m in altitude. These forests grow as a thin strip (800 km long and 20–70 km wide), and are the most valuable forests in Iran from the standpoint of commercial land use and revenue, being the only forests where industrial harvesting occurs. These forests have been divided into 98 watersheds and each watershed has been divided into several districts (Lohmander and Mohammadi Limaei, 2008). The Hyrcanian forests are one of the last remnants of natural deciduous forests in the world (Sagheb Talebi, 2000). Natural biomechanical disturbances are key factors in forest dynamics, with wind disturbances predominating in temperate forests including in the forests of northern Iran (Kooch, 2012).

Tree-uprooting dynamics results in typical pit–mound microtopography, with unique microclimate conditions within pits and on mounds. These conditions are entirely different from flat, currently undisturbed places. Mounds are typically warmer and drier in comparison to pits, where colder and wetter conditions occur with concentrated water flow from storm events as well as thicker snow cover in the winter (e.g. Beatty, 1984; Beatty and Sholes, 1988; Beatty and Stone, 1986; Bowers, 1987; Clinton and Baker, 2000; Kabrick et al., 1997; Meyers and McSweeney, 1995; Schaetzl et al., 1990; Veneman et al., 1984). These unique conditions are the result of microtopographical forms, but are not the cause of these forms. Similar ecological conditions have been found in some convex and concave relief forms of undefined origin (Dwyer and Merriam, 1981), or in mounds caused by ground gophers (Simkin and Michener, 2004).

Despite the generally accepted ecological principles within pit and mound features in terms of the presence of microclimates, soil formation processes differ regionally within particular microsites (Samonil

* Corresponding author. Tel.: +98 122 6253101 (3), +98 9112932313 (mobile); fax: +98 122 6253499.
E-mail addresses: yahya.kooch@yahoo.com, yahya.kooch@modares.ac.ir (Y. Kooch).

0341-8162/$ – see front matter © 2014 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.catena.2014.01.002

et al., 2010a, 2010b; Schaetzl et al., 1989). Tree uprooting dynamics also influence soil variability through spatial scales (e.g. Samonil et al., 2011). On the other hand, less-frequent soil disturbances have been shown to have considerable effects on soil-formation processes in managed forests (e.g. Samonil et al., 2010b). In addition, the role of tree-uprooting dynamics in tree regeneration seems to be regionally specific (e.g. Kooch et al., 2008; Samonil et al., 2009, 2011; Sebkova et al., 2012). Soil formation is a complex process dependent not only on climate conditions but also on geology, geomorphology, pit–mound longevity and forest type (e.g. Schaetzl and Anderson, 2005).

The majority of studies on soil formation within pit–mounds originate from regions of Podzols (Ives et al., 1972; Armson and Fessenden, 1973; Shubayeva and Karpachevskiy, 1983; Veneman et al., 1984; Schaetzl, 1986; Schaetzl et al., 1990, review in Samonil et al., 2010a). Soil scientists have observed advanced soil-leaching within pits as well as a more gradual soil-leaching process occurring within mounds. However, rare studies from the region of Cambisols have shown different ways in which soil evolution occurs (Samonil et al., 2010a, 2010b; Skvorcova et al., 1983). No studies from either Arabic countries (review Samonil et al., 2010a) or Iran have pointed to microtopography as being the most significant factor in terms of soil formation (Kooch, 2012). Moreover, the majority of research has evaluated only selected soil chemical properties, biochemical properties having been studied only within a few disturbed microsites (Kooch, 2012).

These former studies suggest that there should be differences in chemical and biochemical properties between pit and mound microsites in northern Iran (Samonil et al., 2008a, 2008b), as well as demonstrating differences in chemical composition and variations between communities of decomposers between microsites in the Cambisol region. However, these studies did not measure biochemical properties or the occurrence of soil fauna. Despite repeated windthrow occurrences in different parts of the forests in northern Iran, no study has previously investigated windthrow effects on soil dynamics. In addition, information about the soil biota, especially soil bioindicators, on windthrow-affected areas is lacking. Therefore, the aim of this research is to evaluate the variation of soil microbial respiration and nitrogen mineralization (as the most commonly used soil bio-indicators, Nielsen and Winding, 2002) in response to changes in soil chemistry resulting from uprooted trees localized in pit–mound positions in northern Iran. In particular, this study seeks to answer the following questions: (1) How do windthrows change the soil chemistry in the Hyrcanian forest? (2) How do the windthrows affect soil microbial respiration? (3) How do windthrows change soil nitrogen mineralization?

2. Materials and methods

2.1. Site characteristics and the history of windthrow events

This research took place in the Tarbiat Modares University Experimental Forest Station (TMUEFS) located in a temperate forest of the Mazandaran province in the north of Iran, between 36° 31′ 56″ N and 36° 32′ 11″ N latitudes and 51° 47′ 49″ E and 51° 47′ 56″ E longitudes (Fig. 1). The parent material is limestone and dolomite limestone, which belong to the upper Jurassic and lower cretaceous periods. The soil type is forest brown with suitable penetration and biological activities, and texture consisting of silty clay loam (Kooch, 2012). The mean annual temperature, rainfall and relative humidity were 10.5 °C, 858 mm and 75.2%, respectively. The climate is classified as humid based on the Do Marten Method. This study was conducted on a 20 ha area of the forest reserve that is managed but relatively undisturbed. Forests are dominated by *Fagus orientalis* Lipsky and *Carpinus betulus* L.; slope has an inclination of 60–70% with northeast exposure of 546–648 m a.s.l. The presence of uprooted roots in the study area suggests rooting restrictions in this heavy soil (Kooch, 2012).

In December 2005, forest stands in the TMUEFS were seriously damaged by northern winds over a large area. Only 2 months later

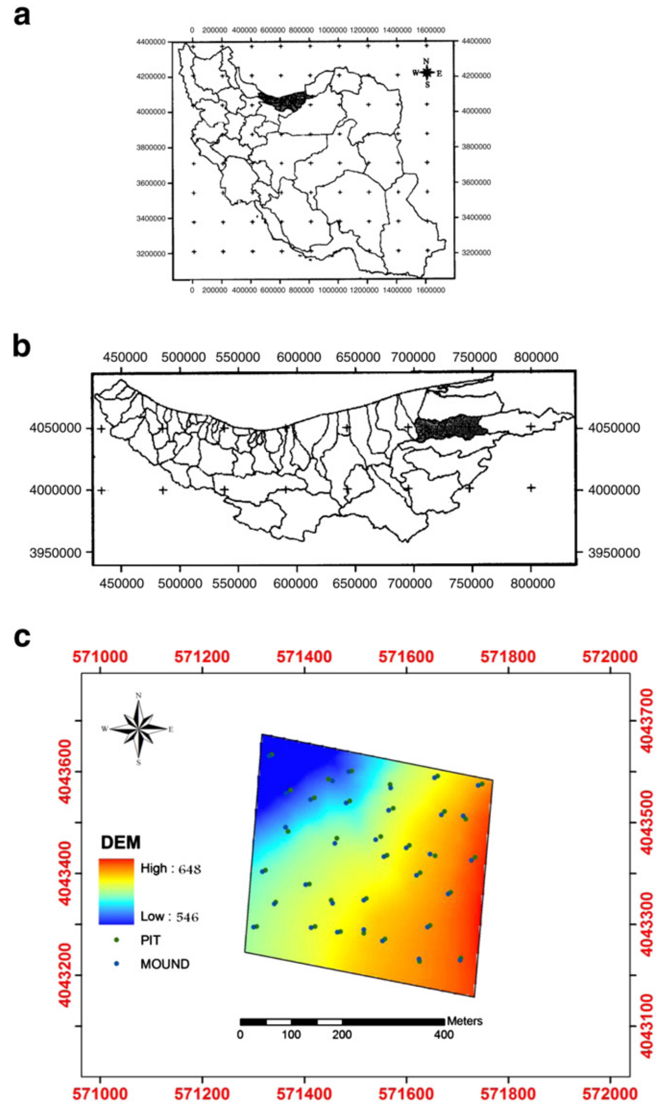

Fig. 1. Location of uprooted trees in the study area (c), Mazandaran province (b) in Iran (a) (legend not to scale).

(February 2006), another high-wind event occurred within part of this area. These events offered an ideal opportunity to study and monitor the uprooted tree locations. Fallen trees were not extracted from all disturbed areas in the forest reserve, and windthrow debris was left on site in part of the affected area to study the natural biogeochemical cycles in such ecosystems. The plots had already been incorporated into a network of long-term ecological research as well as in an experimental platform for ecological research for systematic assessments and monitoring of the conditions in forest ecosystems after windthrows. Different microsites created by tree falls on the research plots and resulting changes in abiotic and biotic environments were expected to be reflected in soil features.

2.2. Soil sampling and data processing

Thirty-four uprooted trees with typical pit–mound features were selected within the 20 ha area of the TMUEFS (Table 1). In 2009 (i.e. approximately 3 years after the windthrows), the bottoms of the evaluated pits were at least 0.3 m below the soil surface and the mound tops at least 0.3 m above the soil surface. Five specific microsites were distinguished within these pit–mounds: mound top, mound wall, pit bottom, pit wall and closed canopy. Individual microsites were sampled