Manuscript - Think Note

On the difference between "exclosures" and "enclosures" in ecology and the environment

Raf Aerts[a]*, Jan Nyssen[b] and Mitiku Haile[c]

[a]Division Forest, Nature and Landscape, Katholieke Universiteit Leuven, Celestijnenlaan 200E-2411, BE-3001 Leuven, Belgium
[b]Department of Geography, Ghent University, Krijgslaan 281-S8, BE-9000 Gent, Belgium
[c]Land Resources and Environmental Protection Department, Mekelle University, P.O.Box 231, Mekelle, Ethiopia
*Corresponding author: raf.aerts@ees.kuleuven.be (R. Aerts)

Rehabilitation of degraded land in arid and semiarid environments often involves excluding livestock from degraded sites, creating what are usually but unfortunately not consistently, called *"exclosures"* (e.g. Mekuria et al., 2007). Their main objective is to allow native vegetation to regenerate as a means of providing fodder and woody biomass, to reduce soil erosion and to increase rain water infiltration. We are concerned that some of the alternative names for this practice that are reported in the international literature, including *"closed area", "area closure"* and *"enclosure"* (e.g. Mengistu et al., 2005), may lead to confusion and misunderstanding, especially when these are used as synonyms (as in Girmay et al., 2008). Here we aim to illustrate the difference between exclosures and enclosures using recent ecological and environmental literature and provide guidance for their proper use.

Enclosure is "*the action of surrounding or marking off land with a fence or boundary, or the action of thus converting pieces of common land into private property*" (Oxford English Dictionary, 2008). Enclosure appeared in England and Wales in the thirteenth century, and took place throughout the medieval and modern periods as a means to end certain traditional land use rights in shared land, such as livestock grazing. In a broader sense, enclosures are "enclosed" areas: "*areas surrounded by walls, objects or* [other] *structures*" (Cambridge Dictionary, 2008). Exclosures are "*areas from which unwanted animals, etc., are excluded*" (Oxford English Dictionary, 2008). Exclosures and enclosures are related terms, but can not be used as synonyms. The word enclosure comes from latin *in* "in" and *claudere*, "closing, confinding, restricting": keeping objects, usually animals, inside a given area. Exclosure, a more recent word, was later formed

as an analogy to enclosure, and has the opposite meaning: keeping things (animals) out.

In experimental research, enclosures are units or plots in which living beings are confined, for instance to reveal competitive relationships between different animal species (Manor and Saltz, 2008) or to create a controlled environment for plant pollination studies (Jauker and Wolters, 2008). Enclosures are a powerful tool in aquatic community studies, where they are used to manipulate environmental conditions or communities in ponds (e.g. Cottennie and De Meester, 2004; Louette et al., 2006). Except for etymology, ecological enclosures have nothing in common with the socioeconomic term 'enclosure', defined as "*increasing commodification and individualization of access to land and water, [...] with increasing disadvantage for the poor*" (Woodhouse, 2003).

Experimental exclosures (*sensu* Wagg, 1964) have been widely used as treatments to exclude (or statistically control for) the effects of predators, large herbivores, livestock, small mammals or birds on the species richness and recruitment in plant communities (Fraser and Madson, 2008; Jacobs and Naiman, 2008; Levick and Rogers, 2008; Negussie et al., 2008; Olofsson et al., 2008; Shitzer et al., 2008), on the abundance of other animals (Isaksson et al., 2007; Torre et al., 2007; Aerts et al., 2008; Huntzinger et al., 2008) and on processes such as sediment deposition, litter production, soil carbon sequestration and woody plant invasions (Descheemaeker et al., 2006a; 2006b; Pei et al., 2008; Shrestha and Stahl, 2008; Yanoff and Muldavin, 2008).

Typical examples of exclosures feature fences that prevent animals from entering, and it is possible to only exclude targeted species from the fenced area while allowing other animals to move freely (Vercauteren et al., 2007). Fencing off areas in this way is a common practice in forest management throughout the world because high tree seedling mortality is often related to high browsing pressure by large or small herbivores (Tremblay et al., 2007; Coop and Givnish, 2008). Exclosures are also known traditionally by pastoralist and agropastoralist communities, such as the Gogo and Maasai in Tanzania, the Himba in Namibia, and the Borana in Ethiopia. These communities set aside some of their grazing land during the rainy season so that it can be grazed during the dry season. These temporary grazing exclosures, where recovery of palatable species is the primary goal, are more appropriately called (traditional) (communal) feed, fodder or forage reserves (Müller et al., 2007; Tefera et al., 2007; Mwilawa et al., 2008).

The term "*closed area*" is primarily used in marine and freshwater biology where it usually refers to areas where fishing is forbidden or suspended (e.g. Hunter et al., 2006; Moustakas et al., 2006; Salas et

al., 2007). "*Protected area*" has a similar, but broader meaning, and usually refers to more formal conservation areas (e.g. Grech and Marsh, 2008; Jachmann, 2008; Linkie et al., 2008). Nevertheless, in a well-defined context both can be used as a synonym for exclosure - i.e. closed to cattle (Tilahun et al., 2007) and protected by guards and bylaws against grazing and cutting (Aerts et al. 2004; 2006; Mekuria et al., 2007). Similarly, "*area closure*" (Chadhokar, 1992; Aerts et al., 2004) can be used for describing the act of establishing an exclosure, but not as a synonym for it.

Thus areas where, for management or research purpose, certain animals are excluded or biomass harvesting is controlled, should never be described as enclosures but as exclosures. For reasons of uniformity, clarity and increased indexing performance, we strongly recommend the terminology 'exclosure' for any area or activity that involves excluding unwanted species or practices from (degraded) sites.

The authors wish to thank Katrien Descheemaeker, Jean Poesen, Bart Muys and Jozef Deckers for earlier discussions on the subject in Ethiopia, Canagasaby Devendra for providing useful insights from the livestock perspective and Bob O'Hara at Nature Network for commenting on an earlier online draft. RA is a Postdoctoral Fellow of the K.U.Leuven Research Fund and the Research Foundation - Flanders (FWO).

References

Aerts, R., Lerouge, F., November, E., Lens, L., Hermy, M., Muys, B., 2008. Land rehabilitation and the conservation of birds in a degraded Afromontane landscape in northern Ethiopia. Biodivers Conserv 17, 53-69.

Aerts, R., November, E., Van der Borght, I., Behailu, M., Hermy, M., Muys, B., 2006. Effects of pioneer shrubs on the recruitment of the fleshy-fruited tree *Olea europaea* ssp. *cuspidata* in Afromontane savanna. Appl Veg Sci 9, 117-126.

Aerts, R., Wagendorp, T., November, E., Behailu, M., Deckers, J., Muys, B., 2004. Ecosystem thermal buffer capacity as an indicator of the restoration status of protected areas in the northern Ethiopian highlands. Restor Ecol 12, 586-596.

Chadhokar, P.A. 1992. Area closure for soil conservation in Ethiopia: potential and dangers, in: Hurni, H., Tato, K. (Eds.), Erosion, conservation and small-scale farming, a reviewed selection of papers presented at the 6th International Soil Conservation Conference held in Ethiopia and Kenya, 6-18 November 1989,Geographica Bernensia 2, Bern, pp. 329-333.

Coop, J.D., Givnish, T.J., 2008. Constraints on tree seedling establishment in montane grasslands of the Valles Caldera, New Mexico. Ecology 89, 1101-1111.

Cottenie, K., De Meester, L., 2004. Metacommunity structure: synergy of biotic interactions as selective agents and dispersal as fuel. Ecology 85, 114-119.

Descheemaeker, K., Nyssen, J., Rossi, J., Poesen, J., Haile, M., Raes, D., Muys, B., Moeyersons, J., Deckers, S., 2006a. Sediment deposition and pedogenesis in exclosures in the Tigray highlands, Ethiopia. Geoderma 132, 291-314.

Descheemaeker, K., Muys, B., Nyssen, J., Poesen, J., Raes, D., Mitiku Haile and Deckers, J., 2006b. Litter production and organic matter accumulation in exclosures of the Tigray highlands, Ethiopia. Forest Ecology and Management, 233(1): 21-35.

Fraser, L.H., Madson, E.B., 2008. The Interacting effects of herbivore exclosures and seed addition in a wet meadow. Oikos 117, 1057-1063 .

Girmay, G., Singh, B.R., Mitiku, H., Borresen, T., Lal, R., 2008. Carbon stocks in Ethiopian soils in relation to land use and soil management. Land Degrad & Develop 19, 351-367.

Grech, A., Marsh, H., 2008. Rapid assessment of risks to a mobile marine mammal in an ecosystem-scale marine protected area. Conserv Biol 22, 711-720.

Hunter, E., Berry, F., Buckley, A.A., Stewart, C., Metcalfe, J.D., 2006. Seasonal migration of Thornback rays and implications for closure management. J Appl Ecol 43, 710-720.

Huntzinger, M., Karban, R., Cushman, H., 2008. Negative effects of vertebrate herbivores on invertebrates in a coastal dune community. Ecology 89, 1972-1980.

Isaksson, D., Wallander, J., Larsson, M., 2007. Managing predation on ground-nesting birds: the effectiveness of nest exclosures. Biol Conserv 136, 136-142.

Jachmann, H., 2008. Illegal wildlife use and protected area management in Ghana. Biol Conserv 141, 1906-1918.

Jacobs, S.M., Naiman, R.J., 2008. Large African herbivores decrease herbaceous plant biomass while increasing plant species richness in a semi-arid savanna toposequence. J Arid Environ 72, 889-901.

Jauker, F., Wolters, V., 2008. Hover flies are efficient pollinators of Oilseed rape. Oecologia 156, 819-823.

Levick, S., Rogers, K., 2008. Patch and species specific responses of savanna woody vegetation to browser exclusion. Biol Conserv 141, 489-498.

Linkie, M., Smith, R.J., Zhu, Y., Martyr, D.J., Suedmeyer, B. , Pramono, J., Leader-Williams, N., 2008. Evaluating biodiversity conservation around a large Sumatran protected area. Conserv Biol 22, 683-690.

Louette, G., Vander Elst, M., De Meester, L., 2006. Establishment success in young cladoceran communities: an experimental test. Limnol Oceanogr 51, 1021-1030.

Manor, R., Saltz, D., 2008. Conservation implications of competition between generalist and specialist rodents in Mediterranean afforested landscape. Biodivers Conserv 17, 2513-2523.

Mekuria, W., Veldkamp, E., Haile, M., Nyssen, J., Muys, B., Gebrehiwot, K., 2007. Effectiveness of exclosures to restore degraded soils as a result of overgrazing in Tigray, Ethiopia. J Arid Environ 69, 270-284.

Mengistu, T., Teketay, D., Hulten, H., Yemshaw, Y., 2005. The role of enclosures in the recovery of woody vegetation in degraded dryland hillsides of Central and Northern Ethiopia. J Arid Environ 60, 259-281.

Moustakas, A., Silvert, W., Dimitromanolakis, A., 2006. A spatially explicit learning model of migratory fish and fishers for evaluating closed areas. Ecol Model 192, 245-258.

Müller, B., Linstadter, A., Frank, K., Bollig, M., Wissel, C. , 2007. Learning from local knowledge: modeling the pastoral-nomadic range management of the Himba, Namibia. Ecol Applic 17, 1857-1875.

Mwilawa, A.J., Komwihangilo, D.M., Kusekwa, M.L., 2008. Conservation of forage resources for increasing livestock production in traditional forage reserves in Tanzania. Afr J Ecol 46, 85-89.

Negussie, A., Aerts, R., Gebrehiwot, K., Muys, B., 2008. Seedling mortality causes recruitment limitation of *Boswellia papyrifera* in northern Ethiopia. J Arid Environ 72, 378-383.

Olofsson, J., De Mazancourt, C., Crawley, M.J., 2008. Spatial heterogeneity and plant species richness at different spatial scales under rabbit grazing. Oecologia 156, 825-834.

Pei, S.F., Fu, H., Wan, C.G., 2008. Changes in soil properties and vegetation following exclosure and grazing in degraded Alxa desert steppe of Inner Mongolia, China. Agric Ecosyst Environ 124, 33-39.

Salas, S., Chuenpagdee, R., Seijo, J.C., Charles, A., 2007. Challenges in the assessment and management of small-scale risheries in Latin America and the Caribbean. Fisheries Research 87, 5-16.

Shitzer, D., Noy-Meir, I., Milchunas, D.G., 2008. The role of geologic grazing refuges in structuring Mediterranean grassland plant communities. Plant Ecol 198, 135-147.

Shrestha, G., Stahl, P.D., 2008. Carbon accumulation and storage in semi-arid Sagebrush steppe: effects of long-term grazing exclusion. Agric Ecosyst Environ 125, 173-181.

Tefera, S., Snyman, H.A., Smit, G.N., 2007. Rangeland dynamics of Southern Ethiopia: (2). Assessment of woody vegetation structure in relation to land use and distance from water in semi-arid Borana rangelands. Journal of Environmental Management 85, 443-452.

Tilahun, M., Olschewski, R., Kleinn, C., Gebrehiwot, K., 2007. Economic analysis of closing degraded *Boswellia papyrifera* dry forest from human

interventions - a study from Tigray, northern Ethiopia. For Pol Econ 9, 996-1005.

Torre, I., Diaz, M., Martinez-Padilla, J., Bonal, R., Vinuela, J., Fargallo, J.A., 2007. Cattle grazing, raptor abundance and small mammal communities in Mediterranean grasslands. Basic Appl Ecol 8, 565-575.

Tremblay, J.P., Huot, J., Potvin, F., 2007. Density-related effects of deer browsing on the regeneration dynamics of boreal forests. J Appl Ecol 44, 552-562.

Vercauteren, K.C., Seward, N.W., Lavelle, M.J., Fischer, J.W., Phillips, G.E., 2007. A fence design for excluding Elk without impeding other wildlife. Rangeland Ecol Managem 60, 529-532.

Wagg, J.W.B., 1964. Design of small mammal exclosures for forest-seeding studies. Ecology 45, 199-200.

Woodhouse, P., 2003. African enclosures: a default mode of development. World Development 31, 1705-1720.

Yanoff, S., Muldavin, E., 2008. Grassland-shrubland transformation and grazing: a century-scale view of a northern Chihuahuan desert grassland. J Arid Environ 72, 1594-1605.

Web references

Cambridge Dictionary, 2008. "Enclosure". URL:http://dictionary.cambridge.org/define.asp?key=25515&dict=CALD. Accessed: 2008-09-12. (Archived by WebCite® at http://www.webcitation.org/5amU31k3P)

Oxford English Dictionary, 2008. "Enclosure" URL:http://dictionary.oed.com/cgi/entry/50074713?single=1&query_type=word&queryword=enclosure&first=1&max_to_show=10. Accessed: 2008-09-05. (Archived by WebCite® at http://www.webcitation.org/5abwDLTTK); "Exclosure" URL:http://dictionary.oed.com/cgi/entry/50079638?single=1&query_type=word&queryword=exclosure&first=1&max_to_show=10. Accessed: 2008-09-11. (Archived by WebCite® at http://www.webcitation.org/5akyFIjEJ)