Journal of Arid Environments 66 (2006) 751–763

Journal of Arid Environments

www.elsevier.com/locate/jnlabr/yjare

Assessing desertification

S.R. Verón*, J.M. Paruelo, M. Oesterheld

Laboratorio de Análisis Regional y Teledetección, IFEVA-Cátedra de Ecología, Facultad de Agronomía, Universidad de Buenos Aires and CONICET, Av. San Martín 4453, C1417DSE, Buenos Aires, Argentina

Received 11 April 2005; received in revised form 12 September 2005; accepted 31 January 2006
Available online 5 April 2006

Abstract

It is widely recognized that desertification is a serious threat to arid and semiarid environments—which cover 40% of the global land surface and are populated by approximately 1 billion humans. Given the potential relevance of this problem, it is surprising that there is no consensus on the proper way to assess the desertification status of a piece of land. During the last 70 years, conflicting definitions have produced both different assessment methodologies and divergent estimates. Contrary to conceptual issues on desertification, assessment methodologies have not been reviewed comprehensively. Here, we critically review the most common methodologies to assess desertification, and describe their principal consequences on scientific and social arenas.

We show that desertification assessment has shifted from simple appraisals of the interannual movement of desert boundaries to complex multivariate field surveys, to practical methodologies based on indicators of ecosystem functioning, such as rain use efficiency. Although often regarded as an evidence of stagnation and failure, these methodologies reflect the progress that desertification ecology has experienced. Future challenges for properly assessing desertification are (1) the lack of reference situations against which actual desertification could be compared, and (2) the difficulties that appear when desertification operates through structural rather than functional ecosystem changes.

The coexistence of conflicting definitions and divergent estimates negatively affects societal perception, leading to scepticism and, ultimately, to a delay of eventual solutions. Societies must recognize the progress desertification ecology has made, leave behind concepts that no longer represent current knowledge, grasp the opportunity to better assess the extent and intensity of the problem, and, for the time being, realize that assessing desertification is an unsolved issue.

Keywords: Desertification; Methodology; Precipitation marginal response; Quantification; Rain use efficiency

*Corresponding author. Tel.: +54 11 4524 8070; fax: +54 11 4514 8730.
E-mail addresses: veron@ifeva.edu.ar (S.R. Verón), paruelo@ifeva.edu.ar (J.M. Paruelo), oesterheld@ifeva.edu.ar (M. Oesterheld).

doi:10.1016/j.jaridenv.2006.01.021

1. Introduction

Arid and semiarid environments cover more than 40% of the global land surface (Deichmann and Eklundh, 1991) and provide habitat to more than 1 billion humans (UNSO Office to Combat Desertification and Drought, 1997; Reynolds and Stafford Smith, 2002). Rural people in these regions ultimately depend on the effective use of natural resources (Reynolds, 2001). However, it is widely recognized that these lands are prone to desertification—the most accepted definition up to date states that desertification is land degradation at arid, semiarid and dry subhumid areas resulting from various factors, including climatic variations and human activities (UN (United Nations), 1994; Reynolds and Stafford Smith, 2002)—a serious threat to the environment, and human welfare (Mainguet, 1994; Williams and Balling, 1996; Reynolds and Stafford Smith, 2002).

Given the potential relevance of desertification, it is surprising that there is no consensus on the proper way to assess it. Since Stebbing's pioneer works (Stebbing, 1935, 1938), a variety of estimates have been published and subsequently criticized. Some studies provided catastrophic perspectives on both the rate of advance of desert lines and the area affected by desertification (Lamprey, 1975; UNEP, 1984). Others, in contrast, questioned the methodology employed by previous studies and found no evidence for extensive desertification (e.g. Helldén, 1988, 1991; Tucker et al., 1991; Nicholson et al., 1998; Prince et al., 1998). New research (Huenneke et al., 2002; Verón et al., 2005) has, however, also called into question these studies, as a result of methodological or conceptual problems, illustrating that desertification assessment remains controversial. The failure to achieve an accurate inventory of desertification is evident from the United Nations Convention to Combat Desertification (UNCCD, 2000) recent statement: "To date, although a great deal of data on land resources are available, it has not been possible to get a clear picture of the status of land degradation at regional or national levels".

The lack of precise, agreed estimates of the extent of desertification opens the door to misusing the concept. For instance, figures portraying a dramatic image of desertification have proved very popular among politicians seeking to attract international funds (Thomas, 1997). A recent review of most important newspaper headlines (Reynolds and Stafford Smith, 2002) (Table 1) showed the radical treatment that the issue of desertification was given in the popular press. Even the scientific use of estimates is questionable: peer-reviewed articles routinely report that 70% of all drylands are affected by desertification, a figure based on a heavily questioned report issued by the UNEP in 1992 (Reynolds and Stafford Smith, 2002).

Despite the situation described above, we are not aware of any synthesis of the most important methodologies to quantitatively assess desertification. Traditionally, the issue of desertification assessment has been approached from a site-specific perspective (e.g. Prince et al., 1998; Runnstrom, 2000; Diouf and Lambin, 2001; Collado et al., 2002; Holm et al., 2003; Wessels et al., 2004). General views, through reviews or book chapters, dealt with the concepts, definitions, causes, consequences and processes involved in the phenomenon of desertification, but have not tackled the problem of assessment in a comprehensive way (e.g. Graetz, 1991; Le Houérou, 1996, 2002; Williams and Balling, 1996; Hillel and Rosenzweig, 2002; Reynolds and Stafford Smith, 2002). As a consequence, it has been difficult to understand the advances and limitations of desertification studies because the link between what is understood by desertification and how it is measured has been obscured. In fact, we believe that much of the confusion surrounding the spatial extent of

Table 1
Desertification assessments and their impact in Popular Press

UNCOD (1977). "Area threatened at least moderately by desertification within the drylands 3.97 billion hectares or 75.1% of the total drylands, excluding hyper-arid deserts. Population in areas recently undergoing severe desertification: 78.5 million. Annual rate of land degradation (in arid and semiarid areas only) in million hectares: 5.825."

Headline	Source	Date
World's Deserts Grow by 14 Million Acres	New York Times	Aug. 28, 1977
Plan For 'Green Belt' Near Sahara Revived	New York Times	Sep. 7, 1977
Man and Environment-An Unending Battle	The Washington Post	Sep. 9, 1977
Greedy Sahara Devours Land Along Its Border	New York Times	Sep. 15, 1980

UNEP (1984). "Land degraded to desert-like conditions continued at 6 million hectares annually, and land reduced to zero or negative net economic productivity was showing an increase (from 20 to 21 million hectares annually). Rural populations in areas severely affected by desertification numbered 135 million".

Headline	Source	Date
Droughts, Deserts and Death	Nassau Guardian	May 13, 1985
Spread of Deserts Seen as a Catastrophe Underlying Famine	New York Times	Jan. 8, 1985
Continuing Threat: Senegalese President Makes Drought Plea Staff Writer	Washington Post	Oct. 26, 1985
Desert Encroachment Is Predicted in China	New York Times	Sep. 15, 1985

UNEP (1991). "A comparison of total estimates for the areas affected by desertification shows an increase from 3.475 million hectares in 1984 to 3.592 million hectares in 1991, that is 117 million hectares or 3.4%. This increase in figures falls within the range of +10% accuracy and thus should not be considered as a proven change. The conclusion again is that the situation remains the same and very unsatisfactory."

Headline	Source	Date
The Ebb and Flow of the Sahara	New York Times	July 23, 1991
Sahara Discovered to be in Retreat	The Washington Post	July 21, 1991
Threat of Encroaching Deserts May be More Myth than Fact	New York Times	Jan. 18, 1994
Man-made Desert	National Geographic	May 1998
Sahara Jumps Mediterranean into Europe	Guardian of London	Dec. 20, 2000
The Arid Expansion	Guardian of London	Jan. 11, 2001
China's Growing Deserts Are Suffocating Korea	New York Times	April 14, 2002

Source: Reynolds and Stafford Smith (2002) and search by the authors.

desertification would be reduced if estimates were interpreted according to the conceptual and methodological framework under which they were produced. For example, the widespread quotations of deserts expanding at 6 km a year or that 70% of all drylands are affected by desertification are meaningless unless they are circumscribed to a specific meaning of desertification or to a particular method to measure its magnitude. Thus, unawareness of the problems of assessing desertification is more serious than the lack of a single definition or a single assessment methodology.

The ongoing debate about the very nature of desertification does not necessarily imply that there should not be consensus on the methods to assess desertification status. In general, the debate upon the nature of desertification is centred on issues such as its causes, consequences, if it is reversible or not, the relative importance of socioeconomic or meteorological aspects, etc. On the contrary, in our opinion a methodology to assess desertification impact should quantify its effects independently of other issues. Thus, we here critically review the most common methodologies to assess desertification and describe their principal consequences on scientific and social arenas. We then analyse future challenges, and highlight some issues that need to be better understood before we can rightly assess desertification. We recognize that the phenomenon of desertification is a highly dynamic process that includes both biophysical and socioeconomic factors (Reynolds and Stafford Smith, 2002). However, the land can hardly be said to be desertified until the symptoms appear in the biophysical system (Prince, 2002). Thus, we will focus on the biophysical aspects of desertification deliberately excluding socio-economic processes and drivers.

2. Desert-edge displacement

In 1975, Hugh Lamprey attempted to quantify the rate of advance of the Sahara by comparing the location of the southern margin at two different times: 1958, according to a vegetation map produced by Harrison and Jackson (1958), and 1975, according to aerial and terrestrial surveys conducted by Lamprey (1975) (Fig. 1). During this 17 year period, he observed a 90–100 km displacement, thus concluding that desert edges were encroaching at ca. 5.5 km per year. This figure, together with the severe droughts of the 1960–1970s in Africa, prompted many, a posteriori ineffective, anti-desertification actions. Institutional recommendations comprised planting "green belts" around the Sahara (UNCOD), prohibition of goats, destocking of herds, prohibition of tree cutting or grass burning, and the enforcement of soil conservation programs (Batterbury and Warren, 2001).

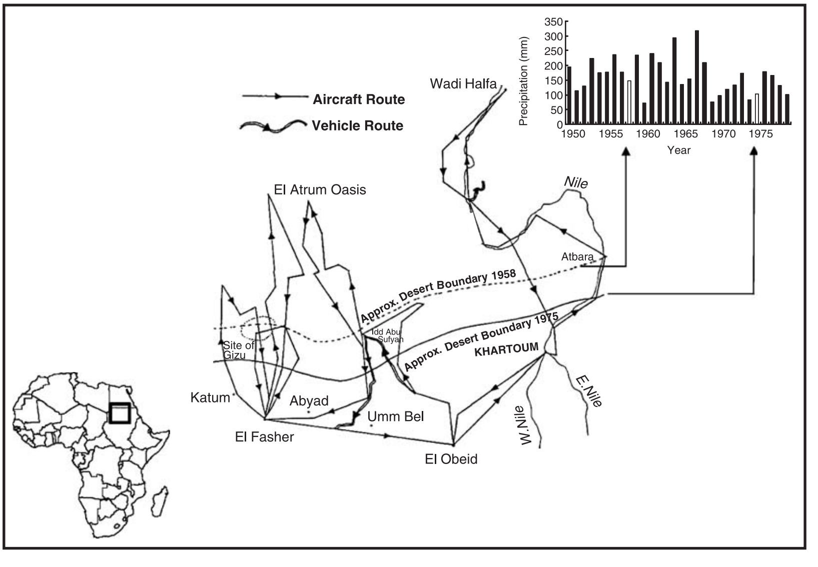

Fig. 1. The survey route taken by aircraft and vehicle in 1975 by Lamprey. Dotted and plain horizontal lines indicate the position of the desert boundary in 1958 and 1975, respectively. Upper right inset: Khartoum annual precipitation (in mm) from 1950 to 1980. Precipitation from years 1958 and 1975 appear in white. Taken from Lamprey (1975) and FAO/UN (2000).

Although we now know that Lamprey's approximation was mistaken, it represented the application of the prevailing paradigm of desertification. This paradigm was based on observations of European foresters working in West Africa during the early years of the 20th century (e.g. Stebbing, 1935, 1938; Aubréville, 1949). Their original interpretation of desertification is clearly suggested in Aubreville's (1949) statement: "These are real deserts that are being born today, under our eyes, in the regions where the annual rainfall is from 700 to 1500 mm". Desertification was regarded as the creation of deserts by humans. It was assumed as a state, characterized by physiognomic features typical of deserts (e.g. sand dunes, scarce open thorny vegetation, etc.), rather than as a process. It was believed to spread from desert cores by means of "sand invasions" and, in general, these changes were considered irreversible. Interestingly, this perception of desertification remained almost unchanged until Lamprey's years (Mainguet, 1994).

Lamprey's conclusion received substantial criticism contending that it ignored the fundamental role of climate variability. Helldén (1991) and Tucker et al. (1991) showed through a combination of field work and satellite remote sensing that desert boundaries were very dynamic, their locations being tightly linked to annual rainfall. In fact, a detailed rainfall analysis showed that Lamprey's assessment was, actually, a comparison between a wet year (1958) preceded by a series of wet years, and a dry year (1975) preceded by a series of dry years (see inset of Fig. 1). These and other findings (Helldén, 1984; Olsson, 1985; Ahlcrona, 1988) challenged earlier tenets of desertification and led to the abandonment of the initial simplistic paradigm of desertification (Thomas, 1997).

3. Field-data matrixes, cryptic indexes

Boosted by the Sahelian tragedy, desertification studies diversified. However, a new paradigm did not arise immediately and a rather long transition, characterized by lack of consensus and debate, followed. Issues such as the process or state nature of desertification, its reversibility, and the relative importance of human vs. climatic causes were subjected to intense arguments. Glantz and Orlovsky's (1983) popular review of more than 100 definitions of desertification speaks by itself of the vagueness and uncertainty that reigned during the 1980s.

Translated into assessment attempts, this conceptual ambiguity yielded multidimensional methodologies that, based on a number of field data on vegetation and soil, resulted in an index of desertification for each site surveyed. International institutions like FAO or UNEP promoted the monitoring of desertification with these methodologies. For example, the FAO/UNEP (1984) method was summarized by a matrix whose rows were quantitative and qualitative variables of vegetation and soil. The columns were classes of degree of desertification (slight, moderate, etc.). The elements of the matrix were, in the case of quantitative variables, the range of values of each variable corresponding to each degree of desertification status (Table 2). In the case of qualitative variables, there were verbal descriptions instead of values. Individual sites whose desertification status needed to be determined were visited and actual values or descriptions were recorded. The elements of the matrix were then integrated in an unexplained way into a single index that summarized the desertification status of a site into one out of four classes: slight, moderate, severe, and very severe (Table 1). The most well-known result produced by this approach was the estimation that 70% of all drylands were affected by desertification (UNEP, 1992).

Table 2
FAO's matrix. Example of the criteria for the evaluation of desertification status proposed by FAO/UNEP (1984)

Variable	Class limits			
	Slight	Moderate	Severe	Very severe
Plant cover				
Perennial plant cover	>50	50–20	20–5	<5
Grassland condition (%)	>75	50–75	20–50	<25
Actual productivity (% potential)	85–100	65–85	25–65	<25
Water erosion				
Surface status (% area)	Gravel and stones <10	Stones and boulders 10–25	Boulders and rocks 25–50	Boulders and rock outcrops >50
Type of erosion[a]				
Exposed subsoil (% area)	<10	10–25	25–50	>50
Gully area (%)	<10	10–25	25–50	>50
Soil thickness (cm)	>90	90–50	50–10	<10
Soil loss (%)				
Original soil depth <1 m	25	25–50	50–75	>75
Original soil depth >1 m	30	30–60	60–90	>90
Actual productivity (% potential)	85–100	65–85	25–65	<25
Wind erosion[b]				
Area covered by hummocks (%)	<5	5–15	15–30	>30
Surface gravel percent cover	<15	15–30	30–50	>50
Salinization				
Morphology[c]				
Soil electrical conductivity (mmhos/cm)	<4	4–8	8–16	>16
Exchangeable sodium (%)	<5	5–20	20–45	>45
Crop yield (% potential)	85–100	65–85	20–65	>45
Affected areas (%)	<5	5–20	20–50	>50

[a]Slight: slight to moderate in sheets and rills. Moderate: moderate to severe in sheet and rills. Severe: severe in sheet, rill and gully. Very severe: very severe in sheets, rills, and gully.
[b]It includes a number of same characteristics used for water erosion.
[c]Slight: no salts. Moderate: salt spots. Severe: salt spots and philaments. Very severe: crystalline efflorescences and salt crusts.

Both FAO (1984) and UNEP's (1992) methodologies have logical and practical problems. Within the logical problems, the most relevant is likely the number of implicit assumptions underlying the matrix. For example, it assumes that 40% of perennial plant cover is equivalent to a 75% decline in plant production. In a similar way, a system with 10% of the area with exposed subsoil (slight desertification) and 25 cm of soil thickness (severe desertification) is made equivalent to a system with 15% of the area with exposed subsoil and 70 cm of soil thickness (moderate desertification). The reasons for these and the other multiple assumptions imbedded in a 16×4 matrix are at least unclear. Another major avenue of criticism has been the subjective nature of their data as most variables were not measured but estimated by "informed opinion" (Agnew and Warren, 1993). Regarding the practical problems, the methodology was labour-intensive, which posed serious limitations to the frequency and/or the extent of assessments.

Although large amounts of resources were invested to inventory desertification with this approach during the 1980s and early 1990s, these did not translate into a significant increase in our knowledge of desertification status. According to the United Nations, these global assessments served to reveal insufficient basic knowledge of the desertification process (UNCED (United Nations Conference on Environment and Development), 1992). In retrospective, methodologies that rely heavily on soil variables, such as FAO and UNEP's look more like an autopsy than a preventive diagnostic: once soil is lost, the chances of preventing further desertification and the economic feasibility of restoration are almost nil (Milton et al., 1994). Overall, the methodology served to institutionalize desertification as a fact, downplaying the intense debate that was still taking place within scientific circles.

4. Rain use efficiency

The need to develop a practical, objective methodology based on indicators which were applicable and readily interpretable across different regions was an important lesson from the 1980s and early 1990s attempts. Prince et al. (1998) and Nicholson et al. (1998) tried to fulfil this requirement, and assessed the desertification status of the Sahel region by means of the rain use efficiency (RUE).

The RUE, the ratio between annual aboveground primary production (the rate of aerial biomass accumulation by plants, ANPP) and annual precipitation, was first suggested as a useful indicator of ecosystem productivity by Le Houérou in 1984. Le Houérou's (1984) underlying assumption was that different plant traits, favoured by natural selection, and community structure (e.g. soil cover, plant biomass) account for the spatial variation in soils or climate leading to a convergence in the limiting resource use efficiency. Departures from the average RUE would, thus, constitute the result of human management.

The application of the RUE concept to the assessment of desertification was not investigated until many years later when Prince et al. (1998) sharpened its rationale. These authors argued that desertification decreased the proportion of precipitation that was diverted to infiltration and transpiration largely due to increases in run-off or evaporation. Prince et al. (1998) and Nicholson et al. (1998) articles concluded that there was not enough evidence to indicate extensive Sahelian desertification as neither ANPP nor RUE decreased with time.

RUE-based approaches offered an attractive solution to the problem of desertification assessment. The availability of both rainfall data and remotely sensed estimates of ANPP at adequate temporal and spatial scales ensured its applicability to regional assessments. In addition, by considering RUE instead of soil variables, this methodology had more chances to provide anticipatory value as it allowed remedial actions to be taken before severe soil degradation occurs. Finally, the use of RUE was consistent with the most authoritative definition of desertification (Reynolds and Stafford Smith, 2002)—"Land degradation in arid, semiarid and dry subhumid areas resulting from various factors, including climate variations and human activities" (UN (United Nations), 1994)—as ANPP has been proved to be a good estimator of ecosystem functioning (McNaughton et al., 1989) and, thus, of land degradation.

Prince et al. (1998) and Nicholson et al. (1998) were particularly influential not only because of their novel results, but also because they questioned the Sahel story, considered the embodiment of desertification. Their results were extensively reported in scientific and popular media with provocative titles such as "The Sahara is not marching southward" (Kerr, 1998), and the methodology they used was afterwards applied in Australia (Holm et al., 2003), South Africa (O'Connor et al., 2001), and Senegal (Diouf and Lambin, 2001). Additionally, they incorporated remote sensing data into the analysis allowing for a complete coverage of large areas.

5. Future challenges

In spite of the advantages that the RUE-based methodology represents, its use in desertification assessment is often limited by two issues that have not received enough attention so far:

1. *Lack of a reference situation*: Desertification is a matter of knowing how things were or should have been, compared to how they are today. Without a reference condition to which the current condition could be compared, conclusions may be misleading. Thus, changes in RUE in one site alone will be sufficient indicators of desertification only if there are reasons to assume that the reference situations do not change. This assumption is not robust in nature: RUE may increase in a desertifying land, as a consequence of, for example, atmospheric CO_2 rising, while RUE of the reference situation may increase at a higher rate. Thus, reference situations must be taken into account, as it is the case of areas comparable to nearby National Parks or protected areas (Garbulsky and Paruelo, 2004; Paruelo et al., 2005), or may be at least modelled, as shown by Boer and Puigdefabregas (2003) who modelled potential vegetation functioning for semiarid areas in Spain from monthly climate records and satellite imagery.

2. *Desertification may not necessarily imply a reduction in ANPP*: Some cases of desertification do not lead to a decline in ANPP, which would turn RUE in a poor indicator. In one of the most studied desertification cases, i.e. the Jornada Experimental Range at the Chihuahuan desert of New Mexico, USA, the displacement of grasslands by desert scrub, an extreme case of desertification, only resulted in minor decreases in average aboveground production (Huenneke et al., 2002). Moreover, interannual variation of production was lower in the shrubland than in the original *Bouteloua eripoda* grasslands. These results are consistent with a widespread model of desertification which proposes that the replacement of grasslands by shrublands leads to an increase in the spatial and temporal heterogeneity of soil resources and, eventually, to a decrease in overall resources as water or nutrients are lost from bare intershrub patches (Schlesinger et al., 1990). However, the slight differences between grassland and shrubland mean ANPP found by Huenneke et al. (2002) suggests that there might be a considerable lag between the onset of desertification and its effects upon ANPP. As a consequence, a methodology based only on mean ANPP—or a series of annual values of RUE—may not suffice to assess desertification.

Fig. 2a provides a schematic representation of how desertification proceeds in these cases in the context of the relationship between ANPP and PPT. The desertified system shows a lower interannual variability of ANPP than the reference situation, but both types of system have the same average ANPP, as in Huenneke et al. (2002). Similar averages but different variability implies that the slope of the relationship between annual ANPP and annual PPT should differ between systems: it is steeper for the reference situation than for the desertified situation. Thus, this form of desertification—such as the conversion of semiarid grasslands into shrub-dominated systems, which has been reported over extensive

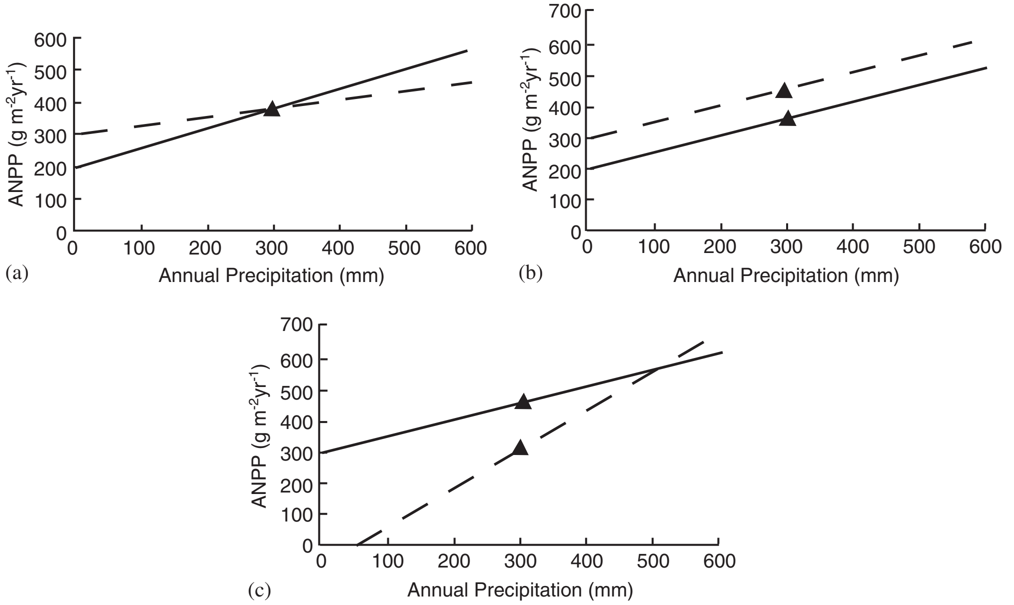

Fig. 2. Scenarios described to illustrate how the combine use of average ANPP ($ANPP_{mean}$) and PMR (i.e. the response of PPNA to interannual changes in PPT assessed by the slope of the relationship between annual PPNA and annual PPT) may help to quantify the impact of desertification. Reference and actual sites are depicted by a solid and broken line, respectively. In (a), there is no difference between actual and potential $ANPP_{mean}$ but reference PMR is higher than actual PMR. This example of desertification is expected to occur when herbaceous vegetation is replaced by woody vegetation. In (b), no difference in PMR can be found, though $ANPP_{mean}$ is different. This would be the case when desertification involves an increase of bare soil surface area without plant functional type replacements. Finally, in situation (c) both $ANPP_{mean}$ and PMR are different suggesting that desertification has proceeded mainly through an increase in bare soil surface cover and a replacement of perennial by annual herbaceous vegetation.

areas of North America and Africa (Huenneke et al., 2002)—would not be captured neither by RUE calculated from average ANPP and PPT values (RUE_{avg}) nor by temporal series of annual RUE.

Interestingly, the model suggests that a potential, yet unproven, way to assess desertification in these cases is to use the slope of the relationship between annual ANPP and annual PPT, which describes the sensitivity of ANPP to changes in PPT (i.e. Precipitation Marginal Response, PMR, Verón et al. (2005) (Fig. 2)). PMR will depend on the ability to maximize resources acquisition (Lambers et al., 1998), which is achieved by plant traits such as a high relative growth rate (RGR, the rate of dry weight increase per unit of biomass), high tissue turnover rate, and high specific root length (root length per unit of root mass). Apparently, plant functional types involved in the structural replacement associated to desertification—i.e. perennial, herbaceous vegetation, woody vegetation, and annual herbs—provide a range of plant traits that would translate into changes in PMR. Thus, for example, the decrease of PMR in Fig. 2a corresponds to the increase of woody plants (characterized by low growth rates, perennial habit, low photosynthetic rate, etc.) over perennial herbaceous vegetation (Fig. 2b) (Grime, 1977). In addition, physiological trade-offs between rapid growth that maximize resource acquisition vs. resource conservation through reductions in tissue turnover (Grime, 1977) would serve as an alternative explanation for the lack of changes in average ANPP in desertification cases as the one reported by Huenneke et al. (2002). In the long term, the disadvantages that less responsible plant functional types—i.e. shrubs—obtain on wet years compared to more responsible plant functional types would be compensated by a better performance during dry years resulting from the conservative use of scarce water.

Eventually, PMR should always be used in conjunction with average ANPP or average RUE (if precipitation from the reference and actual sites differs) to assess a wider range of desertification possibilities. Taking Fig. 2 as an schematic representation of possible scenarios of desertification, the combined use of PMR and average ANPP—or RUE_{avg}—would allow to identify desertification in cases where only plant functional type composition varies and ANPP remains constant (Fig. 2a), when total resources, and thus ANPP, decrease without plant functional type replacements (Fig. 2b) or, finally, when both total resources decrease and plant functional type composition also changes (in the case of Fig. 2c, a change towards higher abundance of fast growers). As happens with other methodologies, the number of years required to calculate the PMR and RUE_{avg} or $ANPP_{avg}$ limits the utility of this approach. Hopefully, this limitation is in part ameliorated by the availability of long-term remotely sensed data. These allow the calculation of surrogates of productivity for almost any area in the world for a period of, in some cases, up to 25 years.

Although up to date Pickup (1996), O'Connor et al. (2001) and Paruelo et al. (2005) have provided empirical evidence to support our hypothesis, the degree to which specific shifts in plant functional types alter the PMR remains to be experimentally explored before concluding that combining PMR, average RUE, or average ANPP may be used for desertification assessment. Further research should address the changes of a suite of ecosystem characteristics, such as evaporation, transpiration, drainage, and vegetation functional types' biomass production per unit of basal cover along a gradient of desertification before a robust and operative desertification assessment tool is to be accepted by the scientific community and then taken to the political and social areas of decision.

6. Conclusions

The different perceptions reviewed here evidence a continuous progress in the study of desertification. From general observations spuriously correlated with weather changes, to painstaking and likely *post-mortem*, descriptions of soils and vegetation, to unifying indicators of ecosystem functioning, science has refined its ability to monitor desertification.

Neither scientists nor the general public have kept up with all these changes. Even today, the scientific literature has plenty of desertification assessments based on FAO–UNEP criteria, and public opinion spans through all levels of concern, clinching to scientific evidence in various ways. There are no reasons to believe that desertification ecology faces harder challenges than other disciplines (e.g. the definition of invasive species in invasion ecology, or of endangered species in conservation ecology). The exceptional growth of remote sensing tools and the extraordinary development of ecosystem ecology during the last two decades represent a unique opportunity to properly assess desertification all over the arid and semiarid world at virtually any reasonable spatial scale (Asner et al., 2003).

The coexistence of conflicting definitions and divergent estimates negatively affects societal perception, leading to scepticism and, ultimately, to a delay of eventual solutions. We hope that this review assists, for the first time, to fasten estimates to its conceptual framework and its temporal applicability, and suggests prospective avenues for future assessments. Independently of the exact definition of desertification, most people agree that it is an important, urgent environmental problem. Societies must recognize the progress desertification ecology has made, leave behind concepts that no longer represent current knowledge, grasp the opportunity to better assess the extent and intensity of the problem, and, for the time being, realize that assessing desertification is an unsolved issue.

Acknowledgements

Our work is supported by CONICET, UBA, ANPCyT and FONTAGRO. SRV has a doctoral fellowship from CONICET. Lucas Borrás and Andrew Warren provided valuable help to get key bibliography.

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