

A brief summary of a third of a century: Nahal Yael in retrospect, with some ideas for the future of catchment research

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Abstract The research history, scientific achievements and environmental impact of the Nahal Yael Research Watershed in the Negev Desert are reviewed and evaluated. While catchment modelling expertise has markedly improved in recent years, rainfall and runoff monitoring systems are under increasing pressure and are declining. It is proposed that some of the scientific effort involved should be shifted to intensive, science-oriented, long-term research catchment studies whose results have the potential to guide modellers with real world processes, beyond concentrating on numbers alone.

Key words catchments and modelling; research policy; catchment research philosophy; hydroscience, geomorphology and catchment research; Nahal Yael; Negev Desert hydrology; streamgauging network priorities

In 1964 a combination of novice scientific enthusiasm, an intellectually rewarding post-doctoral experience, a supportive university department, and some money derived from United States sales of surplus butter, led to the establishment of the small but heavily instrumented research catchment of Nahal Yael in the southern Negev Desert (Gerson & Inbar, 1974; Schick, 1974). Spurred by the then new wave in geomorphology epitomized by the classic *Fluvial Processes in Geomorphology* (Leopold *et al.*, 1964) in general, and by the Vigil Network concept in particular, it blended well into the yearning of physical geographers for more precision and numbers. From then on the Nahal Yael operation continued uninterrupted. Research emphasis changed according to need and fashion and connections with applied research interests were established. Export of ideas to nearby and more distant venues occurred interchangeably with import of new techniques, which enabled previously unexplored research avenues. After a third of a century, the time may be ripe for an attempt to evaluate this continuing effort, to ponder its scientific and educational yield, and perhaps to provide some advice based on the Nahal Yael experience.

During its first years, Nahal Yael provided a set of observations on which a better understanding of the effects of wind and topography on storm rainfall distribution and the spottiness of desert rainfall was based (Sharon, 1972). Concurrently, the first floods monitored in this hyperarid environment supplied some of the earliest measured data on the rates of generation and extinction of these sudden and powerful phenomena (Schick, 1970). From the beginning, attention focused on bed load as the prime share of the sediment transported, with identification of the mode of transport in pulses (Lekach & Schick, 1983). An early sediment budget (Schick, 1977) was superseded two decades later by a more accurate one, based on detailed analyses of flood deposits

in the 100% trap-efficiency dam constructed at the outlet (Schick & Lekach, 1993). The small size of Nahal Yael led to exploratory attempts at transferring the knowledge gained southward into the Sinai (Yair & Lavee, 1976), to large catchments in the Sinai (Schick, 1979), and to the Central Negev further north. Two cardinal aspects governing desert hydrogeomorphology were emphasized: the high magnitude low frequency events and flood transmission losses. Incidental observations on the distribution of acacia trees on some alluvial fans off the coast of the Gulf of Aqaba led to a study which confirmed the controlling role of surface floodwaters on the growth and mortality of these trees (BenDavid-Novak & Schick, 1997). From ruminations on the origin of 1 m large imbricated boulders in the mid-reaches of tiny Nahal Yael, two ideas grew. The first developed into a full-scale study of palaeofloods in the Negev (Greenbaum *et al.*, 2000). This provided, *inter alia*, the first well documented series of 28 megafloods in a large hyperarid catchment anywhere, covering the last 2000 years, and with palaeoclimatic implications. The second developed from the observation that over one half of the flood events in Nahal Yael remained internal, with not a single drop exiting the catchment. It provided the impetus for a simulated flood experiment released by an artificial dam breach, enabling many flood parameters to be observed by pre-stationed observers (Schick *et al.*, 1996). Parallel with this experiment, a process study of transmission losses was set up in the large catchment of Nahal Zin, starting with channel bed infiltration tests (Kuells *et al.*, 1995). The full-scale study employs, among other methods, time domain reflectometry for real time monitoring of the in-channel infiltration process (Schwartz, in preparation). Understanding catchment processes on the basis of radar-derived rainfall coverage and detailed terrain-based studies, such as a coverage of miniplot infiltration tests for all terrain types of the central and southern Negev Desert (Greenbaum *et al.*, 1998), enabled us to take a significant step into hydrological modelling based on real world distributed information without resort to “calibration” (Lange *et al.*, 1999).

More recent developments stemming from Nahal Yael feature the discovery of the “red layer”, the nickname for the fluvio-pedogenic layer (FPU), a distinctive indurated sedimentary boundary underlying continuously, at a depth of several decimetres, the channel bed surface (Lekach *et al.*, 1998). The FPU, still under study by diverse laboratory methods at numerous desert field sites on active channel beds and terraces, is likely to develop into an indicator of maximum scour and associated hydroclimatic conditions during the period since its formation. Another incursion into the Quaternary geomorphological development of Nahal Yael has been recently provided by a study employing cosmogenic dating methods. This provides a new insight into the climatic geomorphic history of Nahal Yael (Bull & Schick, 1979) and offers a 20 000 year long quantitative control on the 30 year long sediment yield rate derived from contemporary measurements (Clapp, 2000).

Flooding as a hazard specific to desert settlements was one rationale for the Nahal Yael operation from its very beginning. Evaluations on flood magnitudes and protection needs in the southern Negev were continuously supplied to the authorities involved (Schick *et al.*, 1999), but it is only in recent years that the knowledge accumulated has resulted in the formulation of a different concept for flood protection on small urbanizing alluvial fans in general (Grodek *et al.*, 2000).

The first years of Nahal Yael were devoted entirely to establishment and maintenance of a catchment with a variety of measurements. Much effort and expense were spent to fulfil this aim, and many students were involved to overcome the adverse logistics. The research climate at that time was amenable to such an operation, even though technically measuring rainfall and runoff were in the hands of central authorities. Over the years scores of students as well as overseas volunteers worked in Nahal Yael, some of them associated with EARTHWATCH. While spending immeasurable hours driving there and doing chores in the field, conversations generated ideas and these provided the motivation to do the desired research, often in other areas. This seminal effect of Nahal Yael may be more important scientifically than the research papers coming out of Nahal Yael *per se*.

Can we draw any lessons from the Nahal Yael story? A proposal to a science foundation today to establish and operate a research catchment for research and educational purposes would probably be regarded as anachronistic: the period required would much exceed the customary three years, the objective of the research would be regarded as too general and too fuzzy, and the main motivation—to study what is really going on there, without limitation of time and pressure to use innovative (and expensive) techniques—as insufficient. On the other hand, the structure of large governmental bodies, despite their occasionally important help, is not designed to accommodate adequately such extensive long term efforts.

The scientific output of Nahal Yael is intertwined with a continuing association of researchers and students marked, over longer periods, by carrying out seemingly menial tasks of mapping, sampling, surveying, servicing instruments, or digging trenches. Much of what has been learned would not be with us today, had not this seemingly loose routine been the order of most of our field days. This attitude of apparent low efficiency was more than balanced by the indirect beneficial effect gained from educational visitors in field camps and courses. The framework encouraged participants and visitors to embark on their own ideas, often resulting in valuable scientific reward.

I conclude from the Nahal Yael experience that research achievements in geomorphology are greatly facilitated by the establishment and maintenance of long-term study areas. Such areas, which, for obvious reasons, will mostly be in the form of catchments, provide a stable focus for scientific and educational activities on whose basis research ideas and novel concepts are likely to flower. While an association with national agencies in that context may be beneficial, most likely such a setup will best be led by a university department, or a group of departments.

Sadly, the current research funding system is not geared to enable such a development. Not only the limited period of research usually granted, but also the utmost specificity demanded today by stringent reviewers, preclude the success of grant proposals featuring a loose, open-ended agenda intertwined with only generally defined educational objectives. In a way similar to heavy equipment funding and establishment of specific high cost laboratories, I advocate the opening of a possibility to establish and maintain a combined research-educational long-term field base devoted to the terrain and water sciences in the wide sense. Such a venture has the potential to provide research opportunities not available to individual scientists, and to draw students into the environmental earth sciences within a programme of working in

the field instead of only in front of computer screens. Recently, two US Geological Survey scientists have surveyed the fate of long-term stream gauging stations and concluded that, if the present trend continues, the prospect of preserving these important data collectors is bleak (Lanfear & Hirsch, 1999). Monitoring changes on the earth surface and also trying to understand them from the point of view of preserving our environment is a task which blends organically with the ideas proposed here.

A vast majority of monitored catchments in the world comprise no more than a few rain and stream gauging stations. Their data provide the numerical base for often very elaborate hydrological models. Only very few of the monitored catchments include in their work programme a compatible, site specific effort aimed at unravelling the attributes of the terrain processes which govern the hydrological output. And of these few, only a handful are truly interdisciplinary in approach and span a period long enough to be relevant for a real world hydrological and geomorphological analysis. Hydrological modelling, powerful as it now is, would not lose its capability to create proxy data or provide hydrological estimates, if based on, say, only one half of the existing monitoring stations. The effort freed by such a shift of priorities, if invested in long-term catchment research ventures, would much more adequately advance our understanding of real world catchment processes. Instead of just more numbers, we need more knowledge.

REFERENCES

- BenDavid-Novak, H. & Schick, A. P. (1997) The response of *Acacia* tree populations on small alluvial fans to changes in the hydrological regime: southern Negev Desert, Israel. *Catena* **29**, 343–351.
- Bull, W. B. & Schick, A. P. (1979) Impact of climatic change on an arid watershed in Nahal Yael, southern Israel. *Quatern. Res.* **11**, 153–171.
- Clapp, E. M., Bierman, P. R., Schick, A. P., Lekach, J. & Caffee, M. (2000) Differing rates of sediment production and sediment yield. *Geology* (in press).
- Gerson, R. & Inbar, M. (1974) Reviews and summaries of Israeli research projects—the field study program of the International Symposium on Present-Day Geomorphic Processes in Arid Environments. *Z. Geomorphol. Suppl. Bd.* **21**, 1–40.
- Greenbaum, N., Margalit, A., Schick, A. P., Sharon, D. & Baker, V. R. (1998) A high magnitude storm and flood in a hyperarid catchment, Nahal Zin, Negev Desert, Israel. *Hydrol. Processes* **12**, 1–23.
- Greenbaum, N., Schick, A. P. & Baker, V. R. (2000) The palaeoflood record of a hyperarid catchment, Nahal Zin, Negev Desert, Israel. *Earth Surf. Processes Landf.* **25**, 1–21.
- Grodek, T., Lekach, J. & Schick, A. P. (2000) Urbanizing alluvial fans as flood-conveying and flood-reducing systems: lessons from the October 1997 Eilat flood. In: *The Hydrology–Geomorphology Interface: Rainfall, Floods, Sedimentation, Land Use* (ed. by M. Hassan, O. Slaymaker & S. Berkowicz) (Proc. Jerusalem Conf., May 1999). IAHS Publ. no. 261 (this volume).
- Kuells, C., Schwarz, U., Leibundgut, Ch. & Schick, A. P. (1995) A channel infiltration study using dye tracers. In: *Application of Tracers in Arid Zone Hydrology* (ed. by E. M. Adar & Ch. Leibundgut) (Proc. Vienna Symp., August 1994), 424–436. IAHS Publ. no. 232.
- Lanfear, K. J. & Hirsch, R. M. (1999) USGS study reveals a decline in long-record streamgages. *EOS, Trans. AGU* **80**(50), 605–607.
- Lange, J., Leibundgut, Ch., Greenbaum, N. & Schick, A. P. (1999) A non-calibrated rainfall–runoff model for large arid catchments. *Wat. Resour. Res.* **35**(7), 2161–2172.
- Lekach, J. & Schick, A. P. (1983) Evidence for transport of bedload in waves: analysis of fluvial sediment samples in a small upland stream channel. *Catena* **10**, 267–280.
- Lekach, J., Amit, R., Grodek, T. & Schick, A. P. (1998) Fluvio-pedogenic processes in an ephemeral stream channel, Nahal Yael, southern Negev, Israel. *Geomorphology* **23**, 353–369.
- Leopold, L. B., Wolman, M. G. & Miller, J. P. (1964) *Fluvial Processes in Geomorphology*. Freeman, San Francisco, USA.
- Sharon, D. (1972) The spottiness of rainfall in a desert area. *J. Hydrol.* **17**, 161–175.
- Schick, A. P. (1970) Desert floods: interim results of observations in the Nahal Yael research watershed, southern Israel, 1965–1970. *Bull. Int. Assoc. Scient. Hydrol.* **96**, 478–493.

- Schick, A. P. (1974) Formation and obliteration of desert stream terraces—a conceptual analysis. *Z. Geomorphol. Suppl. Bd 21*, 88–105.
- Schick, A. P. (1977) A tentative sediment budget for an extremely arid watershed in the Southern Negev. In: *Geomorphology in Arid Regions* (ed. by D. O. Doehring), 139–163. Publications in Geomorphology, State University of New York, Binghamton, New York, USA.
- Schick, A. P. (1979) Fluvial processes and man in arid environments—applications to planning. *GeoJournal* 3, 353–360.
- Schick, A. P. & Lekach, J. (1993) Storage versus input-output accuracy: an evaluation of two ten-year sediment budgets, Nahal Yael, Israel. *Physical Geogr.* 14, 225–236.
- Schick, A. P., Lekach, J., Grodek, T., Lange, J. & Leibundgut, Ch. (1996) An artificial flash flood in a small arid stream channel, Eilat Mountains, Israel. *Suppl. to EOS* 77, 12 Nov. 1996, F259.
- Schick, A. P., Grodek, T. & Wolman, M. G. (1999) Hydrologic processes and geomorphic constraints on urbanization of alluvial fan slopes. *Geomorphology* 31, 325–335.
- Schwartz, U. (in prep.) Transmission losses from floods, Nahal Zin, Negev Desert, Israel. PhD Thesis, Hebrew University of Jerusalem, Israel.
- Yair, A. & Lavee, H. (1976) Runoff generative processes and runoff yield from arid talus mantled slopes. *Earth Surf. Processes* 1, 235–247.