Publication draft for virtual fence hypothesis: -

Draft copy – work in progress!

Animal behaviour – argument for 'virtual boundaries' that dominate movement and wellbeing of all animals created and sustained by conflict

Mike La Grange January 2016 – full draft corrected by Cari Mostert Jan 2017

Fore note: This hypothesis - at present un-researched and unknown to the scientific world – is based on observations from 1970-2016 (46 years) spent directly manipulating wildlife in the role of hunting, capture and translocation, culling, HWC (Human Wildlife Conflict) and intensive breeding management programs.

Much of the related experience has been gained while conducting management operations: Specifically, herding animals from a helicopter - personally flying as well as guiding other pilots – for many years - and putting over 150,000 animals into bomas. I have been fortunate that I was untaught, being thrown into the deep end and forced to swim! This disadvantage meant that I/we (the few semi-experienced operators in the world) pioneered new approaches for capture and translocation of animals; systems, tools and strategies that are now commonly used today.

As may be imagined, capture success was at first dubious, even disastrous and I quickly realised that trial and error was simply not enough! For me, I had to know why efforts failed. I worked through these, understanding how animals behaved and responded while being manipulated - traits hitherto unrecorded, and unknown. I was then able to correct, retest, and evaluate as I went along, constantly improving upon techniques devised. The information gleaned during this process remained with me, unpublished, particularly with respect to virtual understanding although subconsciously, I understood and even acted upon this knowledge. The implications of this were not realised or understood at the time - noticed but unexplained - seen only in the context of the management activity being undertaken. Only recently, reflecting on past experiences collectively, I came to the realisation that virtual boundary principles governed all animal behavioural traits. I had collected enough observations to collate them sufficiently, thereby describing a working, virtual hypothesis that best describes how animals relate to one another and the immediate environment they live in.

I then had the opportunity to apply these principles in a HWC situation in Ward 7 Tsholotsho, Rural District with staggering results, preventing not only access along the stretch of virtual fence protected, but for the whole virtual fence it formed a part of.

It is now time for these observations to be researched scientifically to understand and prescribe long-lasting strategies to enable coexistence between communities and wildlife.

Principles fundamental to manage wildlife for the long term with respect to HWC (Human Wildlife Conflict), population reduction, the capture and translocation of wildlife; management of wildlife in general, examining behavioural traits that maintain herd function, population integrity and home-range spatial distribution, focussing on virtual boundary knowledge and governance within and between same species social groups

Introduction: Currently accepted wildlife management is physical; directly manipulating animals in some way, forcing or moving them - mechanically or chemically - to achieve the desired management goal. These actions more often conflict with researchers and welfare groups, particularly programs dedicated to the welfare and study of the animal; any invasive management action is actively condemned. The leaning is to live with the problem by educating communities to the benefit of the animals while devising methodology to directly protect crops or livestock - without direct impact on the animals themselves. Currently, research studies undertaken are mostly pure research orientated; understanding how the species fits into its environment rather than providing solutions for respective communities. The damage inflicted by the animals tends to be minimised while the efficiency of the practices suggested by these groups is maximised! Regrettably, and possibly because of the widening divide between communities and science, less effort is directed to solving wildlife problems at the crop/livestock interface where conflicts occur. This, ultimately driven by politics, will impact on wildlife found there in the future, fuelling negative perceptions while increasing the risk of poaching to provide local solutions to the problem.

There is another option, often practised without realisation - hotly resisted by many wildlife practitioners, communities and researchers alike – which is the reality of 'virtual boundaries' that naturally exist and function. These 'virtual boundaries' govern social group integrity and spatial distribution that is only just beginning to be described by science; a 'landscape of fear' observed often, but without explanation! It is the realisation that virtual boundaries govern practically all wildlife movement, affecting both daily and seasonal sojourns. Understanding these, it is hypothesised, will better enable communities and wildlife to coexist, separating activities that bring them together in conflict. Exploring these assumptions, understanding the dynamics of virtual boundaries, it is further hypothesised, will prove pivotal to allow animals and communities to function together - yet apart; an answer that would only require direct physical management when absolutely necessary.

The record of field anecdotes and observations discussed here has been recorded over many years while directly managing wildlife. These situations representing many aspects of wildlife management, provided evidence that highlighted the significant change to animal behaviour that ensured - mostly not understood at the time. When considered collectively and scrutinised under new insight they have, I believe, provided the basis for more effective virtual control rather than the direct physical manipulation currently meted out! This paper provides deeper, introspective examination of these observations, realising the virtual reality component playing out and suggesting how these principles may be applied to manage current wildlife challenges. The focus here is more on HWC (Human Wildlife Conflict) challenges, being the most pressing problem facing sub-Saharan Africa today.

The thrust of this paper is to introduce these observations for discussion and suggest research opportunities to scientifically evaluate and quantify them so that the science of virtual boundary dynamics may be realised and be used to manage wildlife and communities holistically

Behavioural indicators of the virtual phenomenon:

- ***Mostly animals/herds live in a stable home-range, resisting change, totally geo-located***:

Throughout my years of capture experience, I'm always amazed just how animals - herds and individual animals - always return to the position I first found them. This phenomenon mostly occurs overnight and even if the animals are scattered, they always come back together by the following day. Driving them over long distances with a helicopter to a distant boma, too far to complete on a single drive, we generally leave them to rest awhile returning later to complete the drive. Depending on diurnal temperature, they may commence moving back but mostly they remain close to the spot left. Left

overnight however, they always return. In 1983, several eland herds, threatening small scale farming practices, were captured and translocated in the Chimanimani Mountains in the Eastern Highlands of Zimbabwe. On most occasions a suitable boma could not be sited where they were located, necessitating them to be driven along a circuitous route - across main roads and fast flowing streams, past inhabited houses, over hills, distances up to ten kilometres - to access the mass boma. Most of these were successfully caught, driven slowly over several hours, breaking off occasionally to refuel and allow them to rest, but in two attempts they failed to enter the boma and returned right back where they started the following day! This observation also holds true for darting operations, where one or more animals are darted and separated from the natal group that always regroup, even when separating juveniles from their mothers. This dynamic is not surprising, as it provides an essential component to animal behaviour, geolocation, ingrained by the stage juveniles are weaned; necessary considering how often in nature animals must become separated from their natal herds by predator activity or some other outside influence.

- Never lost then, animals - by choice - frequent only places they know!
  - Forced out or relocated in some way leaves them anxious and lost where they will endeavour to return to their known home-range:

This phenomenon - most noticed during my years translocating wildlife - is still debated by many wildlife managers, preferring hard release of the animals into their new environment rather than soft release through a specifically managed release boma. Despite the costly purchase of the animals and the capture/translocation exercise, they believe this to be less stressful to the animals. All too often, despite releasing them near water and improvised food (often synthetic in the form of bales and cubes), my observation is that they 'escape' across neighbouring farm fences, requiring further capture to return them once they finally settle. Even on large extensive ranches, e.g. Mwenezi Ranch, I observed direct comparisons (being the same operation) of herds - both buffalo and elephant - released into large electrified release paddocks that later settled well once finally released to the ranch. In comparison, herds hard released (the release bomas filled to capacity at the time, preventing further introduction) never found water - being downwind of it - and patrolled the fortified boundary fence that prevented them from heading back in the direction of capture, some 600km distant.

  - This discovered experiential knowledge is developed and recognised even by neighbouring herds

Animals, newly introduced to a new area, have no knowledge of the whereabouts of where they are and where to find basic requirements. As a result, they immediately search for their old home-range and most often end up patrolling the perimeter fence which often they finally challenge. They display typical lost characteristics, constantly moving, anxious; often patrolling on the side towards the direction they came from. Animals that have been soft released - through a release boma system - demonstrate less of these symptoms, often returning to the safety of the boma for food and water until they become habitualised outside of it. My advice has always been to resist searching for them immediately post release; that provides for more disturbances. Instead, rather patrol the perimeter fence to check for possible break out, while enforcing the position by placing a human scent trail barrier. Once settled though, particularly in smaller intensive game parks, the position of the physical fence becomes imprinted in the mind of animals and is established as a virtual barrier that remains and is respected

even should the physical fence become dilapidated. Once this virtual barrier is established, this imprint takes time to break and enforced eviction to cancel out its presence. I have observed (e.g. Impala in the former Chipinga 'A' hunting area) - now designated Middle Sabi Irrigation Scheme - whole herds subsequently running alongside the now non-existent fence, finally leaping high and long over nothing except the virtual knowledge of its former existence.

- To achieve this requires animals to be fully geo-located always, intimately knowing and interacting with; boundaries with neighbours around them, the whereabouts of basic requirements of food, water, safety refuges, places of danger, access routes, paths and crossing places – in fact any routine practice (both opportunities and avoidance)

Commonly during the drive to the boma, fences, streams and other obstacles must be crossed or circumnavigated. Experience has shown it is better to take the animals to regular crossing places to get them to cross, rather than force them where they traditionally don't cross - the same applies to roads. For this reason, it is important to conduct a pre-survey before committing to a boma site. Where there is no evidence of the animals crossing a fence, it is better not to try and force a situation that often results in refusal and the herd splitting up if pushed too far. On occasion, we have even resorted to opening a farm gate to drive them through where we have noted animals have passed through before

- The virtual knowledge gained provides the basis for routine daily movement and activity, the boundaries of which are conveyed to neighbouring groups, often through active boundary patrolling

In nature, herd males - particularly territorial males - mark their respective boundaries in several ways; urinating and defecating in middens or directly marking vegetation from anal or eye glands or even scratching tree trunks to delineate respective boundaries. These natural occurrences may be replicated virtually to delineate manmade boundaries for a management purpose.

- Although virtual boundaries are also established while respecting a well-managed physical fence, it also occurs where no physical barriers exist, dependent upon changes in risk perception at the interface.

This new phenomenon was discovered, employing the *kuPISA* approach in Ward 7 Tsholotsho, where it was revealed while protecting crop clusters from the general approach of elephant originating from the wildlife area adjacent to Hwange National Park. The park boundary was originally fenced; that is now largely defunct but also represents two completely different land use categories bordering between the PA and communal land. Further in, (± 10km) toward community inhabitation provides a less obvious change - still communal land - but that which separates the wildlife area to the villages and cropped clusters. Although the hunting area in between was managed by 'Campfire,' it was also frequented by the villagers collecting wood and grazing their cattle. Google Earth clearly indicates a myriad of paths to facilitate this, some of which were also used by depredating elephant to access the crops through a core entrance point over a two kilometre stretch we protected, employing the kuPISA approach. Surprisingly, we found at the end of the season that the whole virtual boundary was protected - around 22-km - rather than just the two kilometres we concentrated on, indicating the absence of logic among animals. The elephant conforming to the heightened risk suggested beyond the interface was interpreted for the

whole virtual boundary indicated. This observation remains conjecture for now, requiring scientific verification to establish it as a principle.

- Virtual boundaries thus formed are respected more than physical barriers once established

This significant observation has been borne out often, particularly post farm invasions in the year 2000 in Zimbabwe with regards to the Sikumi Forest Area veterinary fence; e.g. 16 years on, with all vestiges of the fence stolen (removed ten years previously) it is still respected by animals. Eight elephant bulls were satellite collared and a study covering the cropping period Nov 2011 to May 2012, showed conclusively that they all independently respected the boundary north of Mbale community. On a couple of occasions, a few individuals moved out a short distance for a couple of hours before returning during the night. Of significant interest was the fact that virtually all crossed the fence, south of the Main Camp access road to Hwange National Park at different times, accessing the well-known wildlife corridor following Dett vlei. This connects Hwange National Park via the Safari Lodge, to the Lubimbi Gwaai River corridor complex. The place they momentarily exited at Mbale was all at the same spot at the head of a separate re-entrant drainage line to the Gwaai River. Investigation of this, speaking to the older members of the community, confirmed that this route, used to be the corridor linking Gwaai to Hwange that - because of the fence - was redirected to its present position, south of the main Hwange National Park access road where presumably, there was less activity where they finally broke through.

A second incident occurred at The Stanley Livingstone Game Park in Victoria Falls where there were too many elephant bulls that decimated vegetation in the Park, all the large mahogany trees. My capture unit, AWMC, was tasked to remove them to the outside. At first, we removed 400 metres of boundary fence, poles and all, and tried to drive them across, using a helicopter without success. We easily managed to direct all 19 bulls separately to the fence position but they all refused to cross despite repeated attempts to get them to do so. We continued to try to the point they were overheating, regurgitating water, and covering themselves to cool! We had to capture and physically move each one out independently. There was nothing left of the fence except the cut line and there were occasions where we even managed to force them a metre across the precise position of the fence but it was very evident that it still fully existed in the minds of the elephant. Additionally, all the elephant displayed this pattern, both as individuals and collectively, when we joined them to form a group which we also tried to move without success.

- Loss of geo-location disorientates boundary knowledge

Because of this observation, our current management protocol to get animals across an established boundary, now routinely used for plains game species, is to employ the mass plastic boma straddled across the fence. Here, despite the cut line or even poles remaining with fence down, the animals are unable to discern the fence position, having lost indicators of its geo-located position within the plastic walls. Therefore they cross readily without any sign of recognition!

- Home ranges are also places where animals choose to stay when persecuted even though better opportunities may be available elsewhere

This observation became abundantly clear after the country wide farm invasions where people were directed to live in and cultivate new land within private game farms. Fences were taken down, huts built

and animals poached but still the animals remained within the confines of the original park until totally decimated

- Their movements are set seasonally, daily triggered, set not only for each species but that differ marginally from herd to herd

In Chirundu, at the educational centre, an elephant bull returned almost on the same week each year to a solitary fig tree to benefit from its fruit. In fact, so reliable was its visit that the Professional Guide responsible for the centre could set up a photographic blind to film it each year *Dave Winnall pers coms*

- A factor of habituation and experience - *never* deduction - that is basically unknown by the group until experienced or passed on directly in some way

Providing the fundamental difference, I think, between human and animals! Never in all my experience have I observed a single case where an animal has been able to deduce a course of action. Having captured several thousand animals (e.g. employing the drop boma principle) and having baited thousands of baboons, never have they refused entry or deviated from the habituated feeding established unless prior alerted in some way. Provided that the manner of operation exactly mimics the protocol established during the pre-baiting phase, they will enter without hesitation. Any change, even the smallest detail, will engender suspicion where they would rather refrain than enter the trap. Additionally, provided the animals in question are not directly alerted, even although they may observe change from a distance, they will still enter. This is borne out while capturing one herd in full view of another when afterwards, when we have restored the area exactly as it was before, we successfully captured the next within a couple of hours! The same holds true for general capture procedure where we often build the capture boma in full view of the target animals. Provided we camouflage sufficiently, so they are unable to directly detect its presence, they enter without suspicion. Alerted though… is a totally different situation, discussed in detail further in!

Standard 'walk in' traps for both animals and birds capitalises on the fact that once they enter they are unable to find their way out. Rather they endeavour to escape through the side they see through, oblivious of the entrance inside the trap perimeter to escape, which they consistently miss and remain caught. Logic and deduction would quickly render them free!

- Personally, witnessed over years undertaking capture, translocation and population reduction operations - unrecorded by science – is the major behavioural differences that occur between species with respect to the unusual circumstances we force upon them. The knowledge of which has proved vital to perfect the management approach, methodology developed over the years.

When I first embarked on capture, I looked at general principles for all animals, but soon realised just how different each species was. Each species having its own peculiarities, strengths and weaknesses; how they react to certain stimuli, what levels of stress they could manage and what bazaar traits would manifest under stress. To complicate matters, these changes occurred severally during the translocation process, from capture through transportation and finally settling them down. I quickly learned that to

successfully conclude translocation, I had to manage these traits all the time, all different for each species!

- Remarkably this information is consistent for each species wherever they occur in Africa despite distances and geological features that distance them apart

I also realised how consistent these behavioural traits were for each species, pivotal to the success of capture process, each system designed around their unique but different behavioural patterns that if changed even slightly would result in excessive mortalities. An impala in South Africa behaves in the same way as one in Kenya! Their behaviour is fortunately predictable for the species that permits exploitation of it, traits that negate possible logic occurring!

- Home range and particularly territorial boundaries are established and maintained through sustained conflict of some sort

Played out in a constant mind battle between territorial individuals, reminding one another consistently where the boundary is; the boundary following the line of equal resistance formed and demarcated by both parties. During a study of leopard, e.g. two adult male leopards were observed on camera trap walking the line, side by side, each on their side of the boundary, avoiding direct eye contact that would spark an attack. *Chap Masterson pers com*

- These often follow a physical feature such as a vlei, vegetation change or man-made obstacles such as road but not necessarily so, often deliberately marked and identified through urination, defecation or gland secretions

E.g., buffalo herd home range studies in Niassa and Gonerezhou

- In many cases, e.g. sable antelope, the natal herd have their own home range knowledge governed by a senior female while the males are territorial, not necessarily occupying the same geographical home range boundary that they forcibly attempt to keep the natal herd in
- Other species, e.g. baboon troops, don't physically mark boundaries but announce their position to one another, usually from elevated positions that they respect for the day

On Thetford Estates, three baboon females were collared from respective natal troops and their home range movement established for each. Once established, the dominant males from each troop were systematically removed, one every ten days over a four month period to observe if and how home range boundary delineation might alter. Interestingly it didn't, the boundaries remaining intact in the same relative position to one another, occupying the same high ground. However, the boundaries were not fixed in between, altering as much as one kilometre from week to week, presumably depending on the strength of one troop against the other. We forcibly changed the balance of power regularly, played out over the favoured foraging opportunities in abandoned agricultural land that occurred between them. What was evident were the frequent scuffles that took place in the disputed middle-ground and the vocalising of respective high-ground lookouts was presumably to enforce high-ground, home range

boundary position every three to four days. The suggestion being that it was the senior females in each group that retained the basic home range information that was modified from time to time by dominant male activity, eroded by the balance of power shift we affected every ten days: *personal unpublished field notes*

- Requiring greater understanding of the function and integrity of corridors and paths that provide passage conduits through home ranges routinely used by all herds seemingly without dissent or challenge, often also used by another species

While there is much in scientific literature and observation alluding to the importance of corridors to enable unrestricted movement between protected areas, little is understood on the true dynamics of the virtual knowledge transfer that may be happening. E.g.: Understanding the importance of elephant paths; examining when elephant move along defined paths and when they don't! Observations indicate that at night and early each morning, elephant spread out to take advantage of scattered food while foraging and so digress from paths. Later, as it becomes warmer, they tend to clump and rest. When moving to a new site or to water, they follow defined paths that link to and from where they are going. Considered this way, these paths form a myriad of connecting conduits, mini corridors that the elephant choose to use rather than 'cutting through the bush' forming a new one. It would not be uncommon then, as often observed, that several elephants may use the same paths although heading to different destinations, travelling along these linked 'mini corridors.' It follows that any new path occurs only when connecting to a new point of provision or to avoid a blocked pathway, *possibly even persistent conflict!* These mini corridors coalesce into larger pathways following drainage lines up and over higher ground to access other drainage lines beyond; such as the Nata system crossing over at Boli to the Dett/Gwaai drainage system in Hwange National Park. When sandwiched through more developed areas or changing land use patterns, they become major highways with a lot of movement observed, seemingly going both somewhere and nowhere, mostly linking short distance destinations I think! Bulls however, I would argue, hold the key to the wider knowledge of a greater movement map overlay, being separated from their natal herds at puberty, joining and separating from other bulls as they mature. Bulls are more prone to suddenly undertake long distance sojourns over several months, often because of a major fright or sustained conflict. Through them, it may be argued that possibly major corridors linking protected areas are information or knowledge corridors that elephant will inherently move along when forced, rather than general long distance movement passages.

Critical examination is necessary to determine precisely what constitutes a corridor? What it is and what it is not, as wrongly inferred by general terminology used, examining how elephant move over long distance. Consider that mounting research data consistently reinforces the establishment of smaller defined home ranges within protected areas and in-between, rather than regular, large movement patterns connecting protected areas, thereby masking the true significance of the well-developed paths observed and used by elephant. Clearly there is a lot of controversy around corridors and how they are defined that many take to mean bulk movement of elephant in and out of protected areas, whereas home range studies clearly refute this. Although bulls, as indicated, do so on occasion, moving considerable distances. This understanding seriously challenges the popular concept of *source and sink dynamics,* popularised as the answer for dealing with large elephant populations found in the sub-region.

- Changes in routine behaviour are largely discouraged; the herd/troop leadership determining and enforcing daily direction and herd behaviour that is largely predictable for that group at any one time

While undertaking the control of baboon populations stripping exotic trees in the Eastern Highlands of Zimbabwe and the Mpumalanga province of South Africa, it was observed - after a few years of control - that often-damaging troops occurred immediately adjacent to other troops that did not damage, raising the question why did the non-damaging troops simply not copy those that did? It appeared that either the whole troop were involved or not - not restricted to individuals. Studying Shirley Strum's work following known baboon troops for several years in Tanzania, she relates to an incident of a dispersal male - finally accepted into a troop - that had learned the art of capturing and predating upon young Thomson Gazelle. Previously, the troop had not done this but in the year that followed, the troop successfully caught and ate over 100 fawns, having emulated the dispersal male's behaviour! This recording, along with my observations, indicated to me that the transfer of information between groups occurs in this way, emulating knowledge brought in by a newly accepted, individual dispersal male (or males) rather than copying outside activity. Based on this, I deliberately targeted troops that were damaging while encouraging those that didn't. On the fringe Estates, I succeeded in removing baboon damage completely but not in Estates surrounded by others. I believed I had discovered the transfer mechanism that occurred, which unfortunately was not the trigger which was still ongoing! See further discussion on this

The fact that troops were either damaging or not damaging indicated to me that the dominant males dictated troop activity. Although subordinate males may experiment, largely their activities were frowned upon by the dominant coalition; this often resulted in disciplinary action when they didn't conform. In time, this was achieved through persistent effort of a dispersal male or take-over by another male coalition!

What it also indicated was that herds or troops maintained their own identity resisting change from outside influences until forced upon them.

- Establishing and maintaining a consistent ethos enforced peck order within each herd; this is constantly tested and rearranged upon the removal or weakening of a senior member of one herd

Evidenced often during darting operations hence the axiom, 'tranquilise one, tranquilise all!' Often, when only individuals are tranquilised on capture, once the herd becomes settled, the treated animals are more relaxed - more than untreated herd members - so they less actively enforce their rank position, possibly also becoming less vigilant. This is immediately recognised by the others; the ethos balance subtly changes often resulting in the previous senior individuals being attacked to assert new ranking positions

Observations made after darting operations moving herd bulls, is that they are quickly replaced by others, a phenomenon that surprises operators with the speed at which it happens, mostly overnight! The exact mechanism of this is unclear, but both points enforce the idea that pecking order is ethos driven; riding the fine line that must be constantly asserted and communicated to others, reminding them of ownership, which upon the individual's demise is immediately refilled by another

Science has long documented this phenomenon, particularly in respect to chickens feeding, which often manifests amongst animal herds under manipulation to provide for a management purpose. Although not always obvious under general observation; established within herds and between them is a virtual thread of understanding, a rigorously enforced ranking sequence that affects all the individuals of the species, played out differently for each age and sex class component. It follows that animals don't exist in limbo but ascribe to a well-established society that is immediately juggled and rearranged - in some way but never logically discerned - when herd structure is physically altered.

It is not unreasonable to assume then, that provided brought-on 'calamities' are quickly managed, herd dynamics, home ranges and movement remain stable. Managed quickly, ensures that for most management conditions foisted upon animals, they can swiftly cope and rearrange ethos status, provided they are not relocated that is extricable tied in to geo-location.

- A dynamic, unseen 'status quo scenario' rigorously understood and maintained by all herds of the same species in the same area; rearranged as stated, upon the demise or reassertion of key individual/s.
- Boundary establishment, respect and maintenance are then fear/ethos driven (landscape of fear)!

Science, experience and general observation generally agree that animal movement, home range establishment and herd dynamic boundaries are set by conflict, both real and suggested, that individual members know and respect.

- Juveniles and calves relying more on the senior females of their natal group for direction (information), which they will experience and eventually emulate.

This observation is particularly relevant whilst capturing nursery groups of eland weaners, accompanied by a 'nanny' senior cow that they follow and emulate. Existence of weaner groups seems to be more prevalent among eland, possibly because they don't maintain consistent herd structure, e.g. often grouping in several hundred in the Lowveld areas of Zimbabwe. Being predominantly browsers, home ranges are indistinct and they move considerable distances compared to grazers. Age to adolescence is longer so often weaners and sub-adults temporally separate out, but always accompanied by a senior female that rigorously guards and guides them. Her diligence, responsibility and persistence in this role is phenomenal, often requiring forced separation to effectively capture the weaners under her charge. These traits are immediately apparent whilst driving the group; her consistent efforts to turn into wind to detect dangers ahead, being super alerted, vigorously avoiding anything that spells of danger. The success of the drive often depends on removing her from the weaners despite her obvious reluctance, often directly challenging the helicopter. Separating her out completely strips the weaners of the ability to recognise danger, even wind directly out of the boma, making them comparatively easier to drive. However, afterwards the move ushers in a new set of problems; e.g. in that they have no knowledge of crossing obstacles. Twice this was confirmed during capture; upon reaching the fence, 'the nanny-less' weaners simply pushed against it, unable to cross. In one instance, this required soliciting a kudu that was collected from nearby and 'joined.' The kudu jumped the fence followed effortless by the weaner group and the second time a zebra went beneath, again followed by the weaner group!

- Should they become separated from their natal group outside the herd home range before this occurs they are often rendered lost – possibly natures method to disperse and colonise new territories, hence the need for a specific learning management period when contemplating translocation.

Satellite telemetry, studying buffalo movement throughout the sub-continent, consistently shows that home ranges remain stable and buffalo females remain with their respective groups, though it appears that some females may move between adjacent herds. To understand this dispersal, juvenile females from an established natal buffalo herd were collared along the Limpopo River. This was to establish or refute a hypothesis that it was juvenile females from established buffalo herds that initiated dispersal. In 2014, two collared individuals, 3 months apart, split from their natal herd, separated and crossed the Limpopo River heading north. One encountered the international Mozambican boundary to the East, which it followed up to the main Boli/Chikwarakwara road and railway line that it continued to follow towards rural communities on the western edge of Gonerezhou. Here it turned back south, heading back towards the Limpopo River in the direction it came from. Regrettably, the collar stopped transmitting, terminating further movement information. The other buffalo followed the Bubye River from its confluence with the Limpopo, also heading north until it bumped into communities. Here it turned back, reaching a point where it remained, moving around one spot for a few months until its collar too, stopped transmitting. The question being raised, what initiated this movement, considering the many observations that juveniles, particularly females, stick to their natal group! My hypothesis would argue that something must have dispersed the natal herd - natural or man-made - scattering individuals beyond their known, home range into unknown territory. The knowledge of which was probably unknown to the juveniles that when separated, could not find their way back on their own. Indicated by their movement was that they were lost, moving directly away from the disturbance, bumping up against unfamiliar obstacles and people they shied away from, that then determined new direction. Finally, it was the presence of these communities and the animal's natural homing ability that turned them back in the direction of home. Plainly, more research is essential to understand the dynamics of dispersal.

- It follows therefore, to disperse animals from their home range and known environment requires unexpected major disruption and disturbance. This allows permanent dispersal, but at a cost; their survival, as juveniles, being totally dependent upon herd protection and direction is lost, rendering them susceptible to greater predatory risk!

The incident with the buffalo, related above, shows that despite herds maintaining fixed home ranges, discouraging dispersal and expanded knowledge, there exists a mechanism to achieve this. Major intervention is probably required (in this case) in the form of a sustained carnivore attack by painted dog or lion but at high risk. The question remains, were the two juveniles successful in the dispersal effort or did they succumb to poaching or predator attack, which they would have been more vulnerable to.

During the era of elephant culls, young elephant were caught and translocated to establish founder natal herds - a nucleus - to domesticate elephant (this practice has now ceased in the interest of conservation). Initially, the procedure involved darting the targeted individuals while confused in the heat of the cull. Occasionally, one would escape before it went down. Mostly these were re-caught but

some did get away. Invariably, they would be identified later in subsequent culls; often by the pilot observing the juvenile, on the outside of a herd, obviously not accepted in, continually rebuffed by the older cows of the herd. On two occasions, the animal also bore evidence of recent lion attack, indicating it was no longer afforded full protection from the herd. The method to capture was immediately changed to physical hand capture using ropes, immediately heavily sedating them on constraint. However, these incidents graphically demonstrate how juvenile elephant are reliant upon their respective families and the fact that they are not readily accepted in by others.

A 'herd' of ten juveniles, thus caught, was released back to the wild in Hwange in 2012. The oldest cow of the group was 2, 2 metres at the shoulder, firmly establishing her as a sub-adult cow going into adulthood, a young breeding cow who assumed leadership of the group. She was collared and their progress monitored from the moment of release. Over the next year, they remained separately from others close to the release point < 5km, not far from the main Hwange Victoria Falls road and park boundary. Finally, they joined up with a small cow herd, the matriarch of which assumed control of the 'new' group, evidenced by a change in their daily movement pattern recorded by satellite. Soon afterwards, an elephant was shot in the neighbouring community near the boundary of the park not far from them. This the senior matriarch reacted to, taking the whole group down and spending time near Victoria Falls town, providing an example of the 'coping strategy' principle described in detail later, exhibited by all elephant following a significant fright. Importantly, this reaction to a major fright effectively provided the catalyst for the orphaned members of the new herd to gain knowledge of their wider surrounds! More recent movement data indicates they went as far west as Botswana near Kasane where they were seen a few times. *Roger Parry pers com.*

- Interestingly, science does not seriously consider the virtual boundary dynamic process to be part of dispersal movement, potentially important to the dispersal process; rather considering dispersal as a random trial-and-error directional movement, directly escaping possible conflict that determines where animals go and eventually settle!

Do lion researchers in Hwange National Park really consider virtual corridors and other mechanisms to get lion to disperse…? Obviously, it has to involve direct aggression from the natal group that initiates the movement in some way. Certainly, first time natal dispersers may not follow exactly old remembered trails as they skirt many conflicts of different kinds, including man, and changes to the environment, while avoiding occupied territories, but they do seem to follow a prescribed direction!

Recent research papers describing lion dispersal in Hwange gloss over the possibly of following previous virtual corridors, concentrating only on the immediate physical obstacles lion encounter on a general 'escape' route. They note that obviously they, like all animals, would rather avoid habitation and areas of disturbance. Natal dispersal males, it would seem, instinctively avoid paths that are more likely to result in confrontation, indirectly following the same general route used in the past! *Elliot et al 2014*

What is clear; however, is that most carnivore researchers, are more concerned that carnivores face a dilemma avoiding other land-use categories to achieve efficient dispersal that may well bias their appraisal of the situation! This especially includes hunting, applicable to all animals, which they often incorrectly identify as being detrimental to the carnivores wellbeing. Therefore, the pressure placed on the hunting fraternity and communities to conform, providing conflict of interest detrimental, I believe,

both to the communities living there and in the long-term survival of the animals themselves. Consequently, researchers often are biased in their recommendations for moving forward. Regrettably, the communities have identified this as being only to benefit the lions, rather than to seek solutions for the community enabling the carnivores to coexist with them; principally they are seen to be only concerned with the species in their charge and their survival! See introduction *Personal observations!*

- Probable natural occurrence of nature's dispersal agents at work; predator agents like painted dog that scatter herds often well beyond their respective current boundary knowledge

While herds/troops minimise outside influence and maintain home range, history shows that dispersal does occasionally happen; possibly forced because of major traumatic disruption such as from sustained predator attack, particularly affecting young animals that have limited area knowledge

- Perceived changes to the environment are immediately avoided by animals, a factor that may be used to manage them on a graded scale: little to guide or redirect animals, while too much results in more permanent avoidance, finally advancing to extreme fright resulting in geo loss and confusion.
  - Providing for a graded response to sensory stimulation that provides potential for multiple management opportunities

This is probably one of the more important observations that may be harnessed to capture or repel wildlife. Temporary avoidance is noted with smell or sight detection that becomes permanent with repetition or conflict. Temporary avoidance often occurs approaching the mouth of the boma - particularly when wind direction is erratic or wrong - coming from the boma, alerting the incoming animals to the existence of people ahead, where they refuse entry. If the animals are not forced, waiting until the wind changes, they will re-enter readily thereafter. Should they be caught within the boma, then break out, they will not return to the immediate area even if the boma is removed.

Even when temporally alerted, the response by animals is deft and determined, knowing precisely the direction wind emanates from. This behavioural trait that could be used to divert animals from the usual trail along a path they travel, along into a concealed drop boma for example. It would be necessary to pre-condition the animals immediately beforehand to trigger this response, requiring that they must be pre-alerted somehow!

Note: this observation will provide the focus of the Thetford experiment concept as basically this observation remains unproven at this point

- Fear avoidance is more directed to the place it occurs rather than the source or object providing it; that is then avoided depending on the degree of conflict sustained

During one capture of plains game, while driving animals to a boma using a helicopter, they all became difficult to manage at some point. This worsened over the next few hundred metres until they finally managed to double back, necessitating taking them on a more circuitous route to finally achieve capture. This happened with the next three herds driven and I recognised the pattern evolving was indicating the animals were avoiding something! Later I returned and searched the area on foot to

establish the cause and found an old snare line that had caught a couple of animals in the past that now was avoided. Gary Baldwin, the game manager for Hippo Estates related how he observed repeated avoidance by buffalo of an area where he also found an old snare line. The animals all knew precisely where the snare line was and so avoided it!

Experience in the art of capturing animals, quickly identifies conflict zones that are remembered and avoided by the target herd being driven. I specifically tested this theory after the animals I was attempting to catch broke out of the boma. I took down the boma and re-built it some 500 metres forward and to the side. Driving them again toward this, I decided first to drive them through the previous site - to test their reaction - from which they refused approach, requiring me to take them round to re-position for the new boma, which they readily entered without challenge!

- Herds of the same species each have their own subtle, unique different daily pattern:
  - Could this explain why some herds of the same species remain localised while others migrate, e.g. wildebeest and zebra in Botswana and in East Africa

Various migration routes documented in Africa, particularly those involving zebra and wildebeest, are interesting from a virtual viewpoint: In East Africa in Tanzania, relatively close to one another, is the east/west movement each season from Tarangire National Park into the adjacent Burungwe WMA and the well documented, north/south Tanzania Selous National Park to southern Kenya, the Maasai Mara corridor; all moving along precise routes to take advantage of rainfall patterns and therefore changing food opportunities. There are other migrations over a shorter route in Africa, as well as closer to home, found in Botswana, but what is most interesting is there are other herds of wildebeest and zebra in the same areas that don't migrate at all! Could it be that each herd has specific information, virtually embedded, and triggered seasonally, which they follow? Do some herds having the same pattern that they all follow, while others behave independently, each having their own movement strategy virtually imbedded?

A similar situation has been recorded about elephant in Hwange, where most cow herds occupy single area home ranges. However, there are some that inhabit a home range on the eastern edge of the park then traverse across to the western edge for the remainder of the year. Again, each herd conforming to its own established virtual remembrance dynamic.

- Providing the possibility that animal instinct may be established through repetition of events, certain traits finally become attached to DNA that dispenses the need to be relearned each generation.

This observation is hotly disputed by most scientists that feel that all behaviour for each generation is re-learned for that generation, passed on from parents and herd leadership then added to by experience. This would have to include bird nest design and calls, despite the problem of the cuckoo species that never see their parents, brought up by surrogate parents, that characteristically still call as cuckoos and later still, replace surrogate parent eggs with theirs.

With respect to zebra/wildebeest migration, this may well be the case where these traits in time become so established that they are difficult to change despite changing land use in their path along the

corridor, e.g. the Kwakuchinja corridor along the Tarangire PA or veterinary fences elsewhere, enforcing the possibility this trait too may be DNA entrenched

- The discovery of the pre-alert cue, which may provide for a key management tool for the future!

Conducting an elephant cull once required a long circular walk of approximately 5km to approach the herd from the opposite direction, preventing scent detection from wind blowing directly to them from where we started. The cull commenced once we were fully in position and all the animals were accounted for except one large cow that ran out the back, heading in the direction we approached from. Directed in from an aircraft and running forward to catch up with her, we were dropping further and further behind when suddenly, she turned right back on her heels, running towards us, enabling us to intercept her. Later investigation revealed that she had turned back exactly where she intercepted our walk-in passage.

During routine capture operations, we occasionally experience animals refusing to cross over a road even though ground 'spoor' signs indicated they crossed regularly. Investigating why this occurred always indicated direct invasive human activity from vehicles in the past, mostly hunting from the road. Interestingly, what this occurrence highlighted was that they would happily approach the road and cross it while unsuspecting, once pre-alerted, this action would be linked directly to the human disturbance they previously experienced, and immediately they would not cross!

Trials protecting water-leaks along the railway line from Bulawayo through to Hwange - forming the boundary between Hwange National Park PA and to other Wildlife use areas (including, hunting and tourism) - did seem to suggest interruption of wildlife movement across the entire railway line protected. The movement ceased completely, either side of the central corridor, but then recommenced as natural water supplies dried up when the need to procure water became greater than the risk involved. Within the central corridor, the passage of animals appeared to lessen generally and stop for 10 days, independent of activities either side of it: Regrettably this was not quantified as the research protocol in place was designed to research other unrelated parameters. At the time of the research program, this phenomenon was unknown, nevertheless it clearly demonstrated the remarkable choreographed replication of results along the entire 12 km protected; indicating the possibility of distant communication between respective elephant to provide for a species response to danger across risk change barriers

- Capitalising on the manipulation of the 'alert' sensory cue response:
  - Where when animals are relaxed, they largely ignore potentially dangerous indicators
  - Until alerted - triggered by the pre-alert cue, they then actively avoid them
  - Most recently discovered is if animals become alerted on a virtual boundary, its effect is realised for the whole of that boundary, as indicated both at Sikumi and Tsholotsho virtual boundaries - as described

The full implications of this are not yet fully studied or understood. Seemingly, it provides huge potential to manipulate management opportunities for both capture and HWC to repel animals temporarily or permanently. A major discovery, with huge implications for both HWC and capture for the future, is the finding that this also includes SVBs 'soft' virtual boundaries!

- The most recent discovery of 'soft' virtual fencing and the probability of using this as a management tool
  - This phenomenon revolves around risk perception change that occurs anywhere and for whatever reason. Where there is a risk change from less risk into one greater, it establishes a virtual boundary along the boundary change in the mind of respective animals that is geo-located for the entire length it occurs un-broken. Any change to the perceived level of risk, results in direct avoidance not only where it takes place but for the whole virtual fence established

This new dynamic to the virtual boundary hypothesis is the most recent behavioural trait discovered, too new to be certain of its full implications. This provides new possibilities to enable manipulation of animal movement direction; both to effect capture and repel wild animals for HWC, providing the probable reason for the effective reduction of elephant moving into Ward 7 Tsholotsho in 2016.

- Provides understanding to observations noted for individual herds that indicate virtual recognition of:
  - Places of refuge, deliberately sought out

Frequently observed during capture of waterbuck, buffalo cows with calves and to a less degree, kudu ---- particularly bulls - hiding during the capture process

  - Places where there is least disturbance

Not fully understood but animals finally evicted from established game parks, owing to the land reform program, or those regularly persecuted, often recognise and break into less disrupted game parks that are more stable, contrary to expected behaviour of remaining in established home ranges. This phenomenon is usually associated with extreme disturbance, enforcing the coping strategy hypothesis!

  - Weekend verses week activities on commercial farms as was demonstrated on Thetford Estates

As evidenced studying the movement of satellite collared baboons that moved out to forage in old lands mainly on weekends, holidays and after hours when there was less human activity.

  - Set days and times of routine provision, viz market days Chirundu

On market days, Monday and Friday, despite additional noise and activity, it was observed that elephants visited Chirundu in greater numbers on these two days, every week - concentrated near the vendors, to take advantage of food dumped. What was interesting was that the elephant gathered on these days before the vendors arrived, in anticipation of it!

- Instinctive back to home direction movement when scattered or moved

Displayed by all species upon a hard release; attempting to get back home to known geo-located position.

  - Provides explanation for the operation of the *plastic boma method* for capture and for other semi intensive management purposes, e.g. being the sudden removal of this ability, rendering the animals totally lost and confused that is capitalised on

Routinely used, managing animals across an established fence, both virtual and physical, as previously discussed. Once a boundary becomes 'virtual,' imprinted on the mind of all animals, it is extremely difficult to get them to cross, as discussed severally e.g. elephant at Sikumi and Victoria Falls. Where this becomes imperative for plains game, the plastic mass boma - set at right angles across the fence - is the most appropriate management tool to achieve this. The entrance is set well to the inside, preferably encompassing a path where the animals often frequent. The fence is removed between the two plastic walls; the position of which is no longer recognised, once the animals become trapped owing to geo-located loss, caused by the plastic surrounding them, confusing their previous geo-located knowledge.

- ***I believe that understanding these observations may provide better insight into strange behaviours observed sometimes:***
  - Loss of geo-location and proximity; resulting in frustration, providing a major trigger for bizarre behaviour, such as bark stripping of exotic trees in plantations by baboon

Under close confinement animals in a capture scenario, experiencing elevated anxiety, fear and resultant stress levels often display unusual, destructive behavioural tendencies; attacking one another, both calves and females triggered by the proximity of humans. This however, is not related to geo-location loss - as observed employing the drop boma method for capture where it is only upon loading the animals this behaviour manifests. However, chronic stress amongst wild populations, over the longer term, may play out in other bizarre behaviour demonstrations such as direct tree damage.

  - Problems of bark stripping by baboon and elephant possibly brought on by:
    - Loss of boundary feature recognition masked by intensive silviculture practices in afforested areas especially with respect to baboons

Early in the 90's, baboon damage to exotic trees escalated in afforested plantations in the Eastern Highlands of Zimbabwe. It is suspected that mal-adaption to the constantly changing environment, brought on by constant 'rapid' silvicultural operations may be the driver of the problem. By constantly changing the landscape, the baboons' ability - to geo locate - is suspended, necessary to maintain and communicate home range positions. Effectively, these plantations follow repetitive cycles of thickening up, followed by thinning out. The continuous pruning back and clearing of all substrate vegetation beneath to promote growth, inadvertently completely changes the nature of the landscape. All the trees rapidly grow in height, changing both the profile of individual trees and the landscape as a whole, effectively rendering the baboons lost. As they are unable to define respective home range boundaries, frustration occurs, most often at the troop boundary interface as individual troops 'argue' to establish

recognizable boundaries. Interestingly, this phenomenon is not observed in the many smaller isolated forests, less intensively managed, dotted around the region.

Large scale plantations are found in the Zimbabwe Eastern Highlands and the extension of this high ground following in the Mpumalanga region of South Africa, underscoring the principle problem facing large scale Macro Agriculture in sub-Saharan Africa. This demands ultimately, in order to reduce the drivers that provide the conflict with agriculture, to include re-planning of the respective enterprises to reduce the clumping effect over large, contiguous areas in combination with other exclusion and repellence options.

Interestingly, damage by eland in Chimanimani region of the Eastern Highlands to the same pine species also occurred at the same time in Zimbabwe, strongly indicating similar underlying circumstances at work. Several studies have been launched to determine whether the problem resulted from a food or mineral deficiency but have failed to establish this as the reason for triggering the behavioral change observed.

- Confusing their inability to geo-locate – providing the driver for bark stripping and wanton tree damage

Largely conjecture at this point, requiring research to substantiate and explore other possible reasons for this behaviour…Appears the only fitting hypothesis, repeatedly observed under large scale plantation management that also has been replicated elsewhere outside plantations during pre-baiting exercises to control baboons elsewhere.

- Resulting in frustration that arises from this and …
- Anxiety that follows that is played out by deliberately damaging surrounding vegetation, starting first with selected species, progressing to others

Started slowly at first, involving a single species of pine, which then escalated involving all pine species, finally targeting all exotic species! Initially damage was localised in several ‘hot spots’ both in Zimbabwe and South Africa indicating a universal trigger, spreading from these troops slowly to others (5-6 years), indicating behavioural adoption in some way as discussed. Two principles seem to be happening, the trigger phenomenon, as discussed, is then perpetuated as ‘normal behaviour’ introduced into other troops nearby.

- Similar occurrences being observed around management habituation cages set for lethal baboon control in surrounding Acacia species trees in the Midlands Conservancy, Humane Ranch and on Thetford Estates where 2 or more troops attracted were ‘forced’ into close, spatial proximity to one another, avoided under natural circumstances

During pre-baiting of baboon under ranching conditions, well away from the major afforested Estates referred to above, baboons were attracted from outside their respective home ranges to ‘bait stations’ for control purposes. Their behaviour changed dramatically, often resorting to physical fighting until common agreement in troop ranking was achieved, where afterwards they then tried to stay clear of one another, the dominant troops given preference. To achieve this required that they satellite around

one another, the weaker troop making way for the stronger troops in a 'battle of words'. Observations indicate that while several troops may be attracted to the pre-bait site in this fashion, particularly those established for some time, not all could be feeding at the same time. The troops remained close by, waiting their feeding turn, possibly in some sort of 'peck' order arrangement as discussed, all the while still bickering and fighting. Observations also indicated that dominance ranking achieved was not dependent on numbers but on the strength of the male coalition involved. That, we managed by removing the dominant males to achieve consistent feeding at each bait station! During this time of frenzied activity, tensions remained high, resulting in much anxiety for the respective troops waiting. Often a result is displacement behaviour occurring, ranging from leaf stripping to serious bark stripping, observations also recorded in the wild, depending on the time anxiety continued. This was particularly noticeable amongst the troops waiting longer periods to feed; fuelled by boredom and anxiety, it would appear! Where this condition is temporary, this behaviour ceases as soon as the situation reverts to normality, but over time, it is suspected that the disorder becomes chronic; developing as a negative, learned adaptive behavioural trait that is then passed on! This is the exact condition it seems, which occurs on large intensively managed exotic plantations (as explained) and is extremely difficult to control.

These three independent observations have been recorded, all involving Acacia, Acacia karroo and Acacia sieberiana. In the Midlands District of Zimbabwe, interestingly, bark stripping also occurred a short distance away from the baiting site along an adjacent vlei. All three situations involved bait stations that had three or more troops present, meaning some were outside their respective home ranges. Feeding at different times depended upon troop dominance, as explained, so that two troops had to wait their turn under usually avoided circumstances. They all were totally habituated to the bait offered so instead of foraging elsewhere while waiting, it is hypothesised, they become bored and anxious, turning on the trees they occupied! Interestingly, also recorded in the exotic, afforested plantations was the fact that nobody, in full view, directly watching them had observed the baboons doing it? Rather, the behaviour has been captured on camera trap or seen when hidden from view, strengthening the argument that boredom and frustration maybe companion key drivers of this phenomenon that cease to function once the baboon's attention is re-focussed toward another potential danger!

- Similar behaviour may have triggered the recorded widespread vegetation degradation by elephant in the Sebungwe region observed in Chizarira, Sengwa and the Omay wildlife areas, exasperated by the 'Penduka Ndzou' elephant drive campaign and other land-use management that forced additional elephant too quickly into already occupied home ranges in 1969, promoting geo-location loss, frustration and total vegetation wipe out that remained ongoing after it started in the early 70's.
    - General behavioural destruction that followed thereafter, sustained as a negative habit, passed on further by herds to new areas eventually eradicating all the vegetation targeted – possibly no more than a management error that inadvertently occurred before virtual boundary and geo-location knowledge was understood that then became normal herd behaviour

Conjecture at this point, although there seems to be a correlation observed regarding elephant on Humane Ranch where they were also attracted to the baboon bait site after the food ran out, as they waited for more. Secondly, along the Malilangwe Hippo, heavily fortified, electric boundary fence that effectively cut off their passage onto Hippo Valley Estates, resulted in increased concentrations and accompanying frustration, played out by extensively damaging trees in the area.

- Understanding urban wildlife conflict problems; basically:
  - Habituation experience either discovered and nurtured directly by the herd/troop or imported in; passed on by an 'accepted in', individual/s breaking away and joining another herd or group, as discussed previously
  - Possibly answering the question of why in older towns/cities of Zimbabwe, baboons remain to the outside, unknowing of food opportunities that occur within while in the more recent developing towns, they reside within and compete for improvised food found there. Probably this happened pre-independence by unwittingly disabling food information transfer around the city/town edge by deliberate, whole-troop, lethal control management around the major cities and towns. This removal measure prevented the knowledge from passing out to other troops, further distant. This practice is no longer supported; encouraging habituation, inadvertently crossing the natural human/wildlife avoidance boundary

Underscoring the hypothesis developing; information regarding new food opportunities is at first learned, remembered and passed on through an individual/s experiencing this and then being accepted into another troop. If this information knowledge is terminated in some way, other troops outside don't know or learn of its existence.

On Nyakavanga Estates in Victoria Falls, three baboon troops were removed entirely, the main one frequenting the elephant pens where the baboon were attracted to waste from the tame trained elephant operation located there. The improvised food raided included concentrate elephant cubes, bana grass *Pennisetum purpureum,* and vegetables grown in a small veggie patch. These, the baboon constantly raided and despite shooting individuals, they continued to be an unending problem. In 2007 they were all removed using *Papiol* toxicant and thereafter (at the pens) any new baboon troops seen in the vicinity, particularly males, were targeted and shot. This included males from both natal troops and dispersal males. From the toxicant control to April 2011, eleven individuals were shot and no troops have since established there. In the other two areas however, the hotel and reception sites, new troops repeatedly re-established themselves requiring further lethal control to be undertaken every two years, again removing all and yet still more returned. It seems positive the consistent removal of male scouts at the elephant pens, presumably male dispersal groups, had seriously eroded the knowledge of food existence even though visible from high ground nearby. It appears if new troops don't get information on this food source directly in some way, they remain unaware of its existence. This substantiates the hypothesis that information is not deduced but located and learned experientially. The possible reason why baboons are not a problem in Harare, whereas they are in Chirundu, Kariba and at the Falls is that in Harare, information of food availability within has been severed - as discussed. However, in the smaller centres, the problem is perpetuated by the passing on of knowledge of food opportunities

remaining within. It would be interesting (in a smaller border town) to remove all known knowledge reservoirs while repelling new troops coming in until the food source, knowledge pathway is finally severed.

Experience on two occasions, one involving a commercial farm near Harare and one under rural chieftainship near Victoria Falls, has shown that prompt action - following lethal control - physically chasing away new incursions before they become established, proved successful to prevent baboons re-establishing themselves in the area, finally eroding the information base with time.

More recently in Chirundu it appears that the repeated efforts employing the mhiripiribomba chilligun to stop elephants raiding is finally paying dividends in that towards the end of 2016 there being less incursions now compared to the previous 2 years

- Unwanted habituation is fuelled by poor waste management and general reluctance to manage the resulting conflict

Researchers, Collen and Keith Begg's camp on the Lugenda River, Niassa National Park in Mozambique clearly demonstrated this. Their camp was a virgin camp, established from new and from the start they were careful to properly dispose of all rubbish and put away improvised food.

Along a 50km stretch of the Lugenda River in Mozambique, there are three contrasting baboon depredation patterns as follows:

- The Che-Mambo troops that are deliberately fed, providing much competition between troops. The subsequent infighting often results in death amongst dominant males.
- Colleen and Keith Begg's camp (as noted), which they built and were careful from the start not to leave any food or wastage around. Here, baboon pass through peacefully without damaging or even trying to access storage places despite the camp being open.
- Thirdly, the villages up and down river, where baboons display usual crop raiding tendencies.

These examples underscore the cliché, 'where or what they don't know, they don't go.' principle and the virtual boundary dynamic – (*personal observations*)

- *On the upside, habituation provides a management opportunity* to deliberately habituate animals to food bait to achieve a targeted management goal, e.g. baboon removal or capture, employing the drop boma technique
- Also on the positive side, providing the potential to remove undesirable traits by:
    - Removal of the knowledge base – lethal control
        - Or more acceptable, preventing access sufficiently long enough to modify and lose this knowledge as observed establishing long-term virtual boundaries – *currently unknown how long this may be!*
        - Investigating the possibility for the targeted removal of troop male coalitions and surrounding dispersal males, to remove knowledge

Currently, experience indicates this hypothesis to be correct, the targeted removal of corrupted troops. Can this be achieved realistically, by either/and/or lethally targeting dominant coalition males and other dispersal males also inhabiting the immediate surrounding area is another question? Alternatively,

preventing access long enough so new generations no longer have this knowledge, as described for the older cities and trialled on Nyakavanga Estates.

Observations large flocks of Quelea moving considerable distances, over ten kilometres daily, to take advantage of the concentrated food supply, small irrigated, cereal grain crops provide. The departure from the night roost, a progression of frenzied activity; small flocks take off and land nearby, until the majority of the roost becomes airborne. These, heading in a precise and determined direction, which the other flocks - that do not know - follow, has always begged the question, 'how do they know and learn where to go?' In the late 1980's, researchers Jaegger MM and Bruggers RL 1989, studied the mechanisms played out by flocking, seed eating birds, in particular the red-billed Quelea. They hypothesised that smaller flocks, not yet knowing where to head, follow the mass purposed departure from the roost directly to the food each day, which they then remember and become part of. This choreographed process is developed gradually by initial, small scout flocks, finding the food opportunity separately by chance. Generally, this occurs around the edges of small grain crops that ripen a week or two before the main crop, which these scouts locate and capitalise on. The formation of small roosts, bonded by common purpose, grows as others add to it. Therefore, it follows that by applying a bird repellent employing Mesurol or the pesticide Azodrin to field edges, farmers reported success in preventing the birds largely not finding the crop later. Regrettably, science has been unable to quantify the success of this novel approach

Of the much publicised, garbage-raiding troops at a lodge in Kenya, baboon males of the resident troop and neighbouring PA forest troop were infected by tuberculosis and subsequently died. Most of the senior males succumbed, probably because they aggressively defended their provisioned source, preventing the others that survived from feeding there. This resulted in a skewered population dynamic, providing opportunity for either a new male coalition to take over, the most likely - from my observation - or waiting for the subordinate males within the troop to mature! In any event, troop behaviour altered dramatically, seeming less confrontational toward one another and no longer feeding at the garbage site. Important to observe is change resulted directly from leadership change, both for relationships and for the provisioned food, suggesting that a targeted approach may be appropriate to correct severely habituated situations!

Advanced, GPS assisted, virtual fencing applied against baboons in the cape peninsular area of South Africa will hopefully provide an opportunity to explore the possibly of training (or retraining) troops to remove unacceptable habituated behaviours as demonstrated on a picture poster: Richardson PRK et al 2016 *Virtual Fencing as a New Strategy for Baboon Management.* The principle is to establish a geo fence defending the approach to community property where the baboons are habituated to improvised food. The troop is repelled by employing triggered scare lights and horns, preventing them from crossing to access the respective communities. My experience in this regard however, is that severely habituated individuals may require additional approaches to finally get them to desist.

- The problem macro agriculture creates in respect to food opportunity balance for opportunistic exploitation and the consequences for HWC
  - Natural population balances are terminated, the enhanced provision of food and habitat - favouring a few species - providing new, better opportunities that are quickly learned and capitalised on. These they become habituated to, requiring further 'new' management strategies

to protect the mono crop grown to enforce a 'new' virtual boundary reality
- Removing predation and natural environmental constraints
- Reducing bio diversity generally
- Absence or minimising of seasonal events
- Providing better conditions to sustain large numbers of the problem species
- Provides new opportunities that don't occur naturally in the wild

Hippo Valley is an excellent example of this scenario, providing for modified situations resulting in reducing biodiversity. By growing large areas of sugarcane, under irrigation, the trend is toward a mono culture, agricultural practice. The sugarcane provides improvised, enriched food opportunities for all grazers along with prime cover for buffalo, bushbuck and bushpig. The cut cane is bulked and carted to the mill, spilling out all along the route, spreading waste food further, effectively reducing competition to obtain it. Water is abundant year around and excessive runoff has increased tree growth at the bottom of lands, significantly improving roosting opportunity for baboon. Work opportunities over the estate have been enhanced, requiring high density houses set in compact villages. Unfortunately, sanitation is not as good as intended, so that most of the inhabitants prefer to use the bush to defecate. Small plantations of gum trees are grown to provide poles that also double as baboon roosts. There are many other changes that have proved ideal for baboon and bushpig. By providing all their requirements of food, water, and roosting habitat, reduced home range area requirements are enabled encouraging population growth while eliminating natural constraints that would have normally kept populations in check. Similarly, the Lowveld is too dry to sustain large populations of bushpig, but under this modified irrigated habitat, conditions for them are ideal enabling them to thrive in large numbers. Densities of bushpig surrounding the villages are further boosted, scavenging on faeces in open latrines and baboon roosts situated close-by.

Similar problems also arise in respect to Quelea depredation of cereal grain grown under large hectarage, under irrigation.

- ***Behavioural traits hitherto unknown that may in the future provide pivotal changes to mitigation tools and strategies:***
    - Exploring the recently discovered '*coping strategy*' scientifically described as 'landscape of fear'

Elephant observations while undertaking culls, have demonstrated the sudden mass choreographed movement of them some distance away - more than thirty kilometres -to escape persistent attack. This was recently demonstrated when using the chilligun during sustained field trials in Hwange National Park. Also recorded is long distance movement – more than one hundred kilometres – in the case of individual bulls that received a significant fright (shot at) or from the sustained effort from the Mhiripiribomba chilligun, indicated recently in Chirundu. This unknown principle evolved from virtual understanding, in effect provides the ability for animals to escape and hide from sustained attack. Science recently has been able to quantify this, studying cortisol levels in dung; demonstrating elephant movement that recorded high levels of this stress hormone in areas they were subjected to elevated

stress and then moving to comparatively sheltered areas where stress levels dropped significantly. *Jachowski D S*

This principle needs to be studied further; it may prove to be a major tool to implement against totally habituated individuals defying current repellence options, often ending in the lethal control of the individual.

- Understanding the concept of layered boundary knowledge information separating current virtual boundaries presently enforced, to old ones they replaced
  - As found with the Mozambique/South Africa international boundary in the Limpopo TFCA for example

The South Africa/Mozambique international boundary within the Trans Limpopo TFCA, has been fenced and patrolled for many years, preventing any wildlife from crossing. With the proclamation of the TFCA, the fence was removed to restore movement across the boundary. This did not happen, despite the fact that before the boundary was closed, free movement took place from Kruger following the major tributaries passing down to the Limpopo River, many of which also served as corridors. This was particularly noticeable with elephant, so 50 elephants were caught, fitted with satellite collars and moved fifty kilometres within Limpopo National Park, where they were released. They promptly returned to Kruger as expected, back to known geo-located territory. Within a year, these elephant went back to the place of release, taking approximately 1000 elephants with them, indicating re-established, old movement knowledge. This example illustrates how effective physical boundaries format virtual boundaries that remain in place, despite the removal of the physical one, requiring reboot management to uncouple the virtual reality.

There are many examples how fences form or modify virtual boundaries. A further example of this occurred in Central Kenya, *Patton F J et al 2010,* where a new population of 27 rhinos were introduced into an adjacent fenced area and the adjoining fence removed to allow free access to both sides. Over an 18-month period, no rhino crossed, necessitating translocation of two across to the other side to achieve this

- Problems and advantages of establishing long term boundaries

The examples given above provide clear indication of long term problems resulting from enforced physical fences. This is particularly observed with the placement of veterinary fences and tsetse fences across established corridors, possibly leading to widespread vegetation destruction by elephant in the Sebungwe corridor, as discussed earlier. In Botswana, veterinary fences are reported to have decimated wildebeest herds preventing their movement to water and grazing opportunities. However, it is not only fences that establish physical boundaries but also extensive land-use patterns such as exotic afforestation, the opening of large tracts of land for agriculture and settlement and major roads. In fact any major land-use plan that adversely impacts on wildlife movement by changing natural features.

Advantages of physical fences in contrast, would be the protection of crop clusters, opening connective corridors to access PA's, enabling a compromise between communities and wildlife to coexist, e.g. providing the ability to reboot old ones when required.

- Behavioural changes occurring within a troop/herd either by direct habituation or imported directly in by outside individual/s of the same species:
    - Providing for the observation that should this no longer occur, occupancy knowledge is forever lost, requiring *reboot management, through the relocation of new groups* to repopulate and regain this knowledge!

Observations made in the 1980s made me question why populations of giraffe occurred south of the Runde River, but not north of it in Zimbabwe, despite that - for most of the year - the river is easily crossed. Similarly, why did no giraffe occur east of the Hwange Victoria Falls railway line? I pondered this, considering why this was so, questions that resurfaced as I gained experience, predominantly with respect to virtual boundary dynamic knowledge. Recently, I began to hypothesise that both situations experienced early development by European settlers on one side. Hunting was permitted on their side of the boundary and giraffe and other species were systematically shot out; natural dispersal could no longer cope to recolonise the other side, eroding all knowledge of its existence, sufficiently to terminate dispersal attempts in that direction. Later, I was fortunate to be part of the pioneer group of capture and translocation experts to restock these areas. Now giraffe and other species inhabit both sides and cross over the barrier regularly, probably because the original knowledge of it has effectively been rebooted!

- Behaviour change brought about by natural information transfer mechanisms:
    - Within the group 'per chance' finding new opportunities and habituating to them
    - Introduced by a new individual accepted in a population – dispersal males with respect to baboons, as discussed
    - Change in male or female dominance in respect to antelope
    - Occasional absorption of new females into natal groups – mostly repelled!
    - Examining the importance and function of bachelor male groups as the key source to provide information of a larger area availability to enable wider natural dispersal of the species

I realised this possibility, through capture and translocation of tsessebe antelope, when returning to Central Estates Zimbabwe, to manage an annual offtake. Over five years of capture, it became evident that the areas where tsessebe were removed were not re-colonised, requiring us to find new populations elsewhere each year to capture. As evidenced on Ruby Ranch, another Anglo-American property, were the many bachelor herds of males where we caught every year. On Central Estates, the bachelor groups were non-existent, having being regularly hunted in the belief that these bulls were surplus to breeding requirements. Studying this apparent anomaly, considering possible virtual implications and weighing up how this fitted in with data I had begun to collate on the subject, led me to hypothesise that it was the bachelor males that achieved local dispersal. These bachelor males were constantly forced to the periphery of the larger area occupied by the natal home range and male territories that then enabled them, having this knowledge, to occupy territories further afield, later on

adopting small natal groups breaking away from the more established herds! (part of the proposed RFID study at Thetford Estates)

        - Recognising that herds/troops seldom emulate a neighbouring group, requiring direct association and participation into the group to achieve this behaviour as discussed
    - The recent unexpected discovery providing the possibility that physical reboot management applied to one part of a virtual fence may trigger the same response for the entire virtual fence established along virtual boundaries separating high and low risk interfaces
        - The Tsholotsho experiment: - two kilometres of a corridor/land cluster edge was protected implementing the kuPISA (progressively interrupted staggered approach) approach, following the borehole 27 to Pelendaba road over the 2015-2016 cropping period that stopped elephant intrusion from neighbouring Hwange National Park completely. Interestingly, this result was also reflected for the entire corridor edge from borehole 27 up to and including the Gibixhegu cluster in Ward 1 *(Herald report Thursday the 12th of January 2017)*

Results from the cropping period, Dec to July 2016, were that no elephant penetrated the virtual fence, although an estimated 250-500 elephant moved in and resided within 200 metres of the virtual barriers created, during the months April to May (the main crop growth period). On several occasions, spoor confirmed they approached the barriers but doubled back when they saw/smelt the various interventions placed. This was in stark contrast to the previous season where most crops were ravaged; 150 cropped lands destroyed at an estimated loss of USD 22 000.00, resulting in the shooting of 14 PAC elephants for Ward 7, seven of them within the 2km zone protected. In contrast, this season only three lands were ravaged in Ward 7, inflicting less than USD 1000.00 of damage, none of which were adjacent to the virtual fence protected area and no elephant were shot on PAC for the entire Ward. These facts compared favourably to cultivated lands beyond the virtual boundary, including Ward 3, which indicated similar results for both seasons.

- ***Improvement to current capture technology such as:***
    - Capture boma siting incorporating natural movement indicated by paths

Experienced operators choose the right place to build a capture boma; e.g. placing an impala boma in a thicket, situated off an open area where they instinctively head to seek cover from the hounding helicopter. Google Earth proved a useful tool - prior to aerial survey - when combined with good ground knowledge and experience, to place the boma in the best possible position for capture.

    - Avoidance of repetitive boma placement

Some properties in South Africa showed poorer capture success where the boma was placed in the same spot each year. Despite ground signs indicating that animals frequented the position, upon capture, the animals refused to be driven through it. This observation was particularly evident where capture repeatedly took place at the same time each year. I believe the start of sudden ground and

helicopter related movement triggered previous remembrance of it and ensuing avoidance. Simply by selecting a new boma site, I prevented this re-occurring.

- Boma layout including internal gates, main gate and wings that are species specific

With experience gained, I moved from a standard design to customising the boma for different species to be caught. E.g., for buffalo, instead of gates spread across from wall to wall, the animal was better controlled (once inside) by reducing these to a smaller gap, which they perceived was an escape route. Similarly, ostrich and impala all displayed individual preferences that we could capitalise on by customising boma layout. This exploits animal behaviour, different for each species but consistent for each species.

- Helicopter drive to the boma

Experience consistently reveals that animals of different species drive differently, e.g., compare wildebeest to impala to waterbuck, all behave differently. These traits must be considered and corrective procedures applied for a successful drive to the boma. Each species refutes the conformity that would naturally occur with logic.

- Crossing fences, farm gates and other known crossing places, even using other species to provide a response cue to follow, e.g. showing eland weaner groups being driven during a helicopter drive, how to negotiate a fence, as discussed

Observation showed that animals prefer to go where they know. This is most evident during the drive, particularly as they became more alerted to potential danger ahead. The animals preferred crossing places and routes they knew, places seemingly more dangerous to us - but where reality on the ground did not support this, e.g. entry through farm gates where they were accustomed to crossing.

- Recognising and interpreting subtle herd indicators of potential problems ahead, unnoticed by the untrained eye almost always associated with area knowledge and the pre alert factor!

Only experience provides insight as there are no clear prior indicators (to the untrained eye) displayed by driven animals. They recognise potential dangers, looming ahead while being driven, leaving the pilot befuddled as to what happened when they suddenly all react negatively. With experience these symptoms are recognised; behavior based on perceived virtual knowledge the animals have of the area, knowing unseen problems ahead. The common indicator is slightly more reluctance to move in the required direction, which progressively becomes worse as the obstacle - experiential or physical - is approached. These indicators are seen over the normal reluctance displayed while driving animals against where they would like to proceed. Situations that include crossing fences and rivers and approaching physical barriers, boundaries and other unseen areas of conflict, e.g. snare lines, as previously discussed.

Scent detection, in contrast, maybe recognised and anticipated with experience. Knowing the next course of action as animals approach the boma mouth when they refuse to enter or 'miss' the boma mouth as they instantly move directly away from the scent source?

- Soft release management through release bomas, providing a mini habitat to accustom animals to a new location allowing them time to become geo-located, from which they are passively released

Essential to the wellbeing of all animals and the success of the release process, is the understanding of geolocation and virtual recognition - animals need to know where they are, always! Experience knows there are major hurdles facing introduced animals into unknown territory where they don't recognise anything they see or smell. The science of release bomas provides for this; providing a smaller, artificial soft release situation through mini habitat - a staging post. Animals quickly become geo-located, finding all their needs including safe areas, shelter, food and water before final release into the new area. It is imperative to ensure that view to the outside is totally blanked out, making the animals within totally oblivious to goings-on outside. Further, I suggest initially, certainly for the next week or so, not to enter the boma but to provide all their daily requirements from the outside. I also suggest that attendant staff be housed close by outside, preferably playing music during working hours. The reason is to accustom animals to the fact that they are safe within and that disturbances on the outside do not invade their space. This way, they recognise that the boma centre is not invaded, which they retreat to when they perceive disturbance. I advocate all work be done early morning or late afternoon, giving animals the opportunity to siesta midday, emulating conditions they practice in the wild. Managed in this way, their requirements in nature are replicated. This erodes perception of pending danger, introducing the taming process that calms them down, enabling them to cope with final release. Here, I suggest leaving the gate open and refraining from driving them out. Length of time spent in the release boma is dependent on how wild they should be after release.

  - That includes recognition and habituation to concentrated food to manage animals in confinement that they then recognise in the field later to provide tertiary management or capture as required

Discussed in more detail further on; a learned, habituated feature allowing targeted animals to recognise the same food later in the wild, to achieve specific management objectives and ensure adequate nutrition.

During a drought year in the West Nicholson area of Zimbabwe, several herds of sable were caught and resettled on two different farms. The one farm settled them through a release boma where they were introduced to artificial food. The other farm hard released them, directly onto the velt, fortunately where they stayed. Some years later, another drought required them to be supplementary fed. The animals that were soft released and introduced to supplementary feed in the release boma before, survived whereas the others didn't recognise it and subsequently died.

- Other management requirements viz:
  - Returning escapees back to fenced game areas
  - Boundary fence enlargement – see previous layered boundary information above

Relating both situations in terms of the virtual dynamic principles involved; the physical fence that separated them had been established as a virtual boundary. So, despite removing the fence to allow access, animals could not be driven through. They had to be caught and physically carried across or funnelled through a plastic boma that straddled the fence - as detailed earlier - to get them to cross.

- ***Principles established that impact directly on how wildlife populations should be managed for the future***
    - Understanding the dynamic relationship between risk taken and the need to procure – increasing the risk value to ensure more effective repellence

Fully illustrated by the water leak study, undertaken in 2015 where we managed to protect the water leaks from elephants drinking. As available surface water became scarce with dry season progression, the elephant increasingly challenged the intervention in place, finally over riding all our efforts. Interestingly, it was mostly new arrivals that overwhelmed the system, rather than resident herds.

    - Behaviour knowledge provides potential for new 'holistic' management approaches and strategies to augment current tools and strategies - moving from pure mechanical/chemical enforcement to a subtler, less direct intervention thrust by working with naturally occurring mechanisms
    - HWC strongly allied with habituation to improvised food is classified in two categories:
        - Occasional visitors
        - Strongly habituated individuals requiring more extreme measures

Illustrated by the elephant problem facing Chirundu town where the majority of ± 35 elephant were quickly repelled with a couple of treatments. However, there had been five or six other bulls that proved extremely persistent, requiring many more strikes with pepper to finally desist and depart. These individuals all operated alone, taking up to 14 shots each night to stop. Each time, they were effectively repelled and moved out but immediately they returned. After five weeks or so, often heralded with increased aggression, they moved from town and were observed nearby for another few weeks before departing altogether, having finally reversed the level of habituation they achieved. This result clearly demonstrates the 'coping strategy' principle hypothesis severally discussed

- ***Capitalising on the pre-alert factor to trigger repellence*** as indicated by:
    - **The *kuPISA approach* as implemented in Tsholotsho** disrupting passage of elephant from entering cultivated clusters for HWC purposes, placing several lines of challenges across the expected elephant approach in a disorganised way:
    - Considering the possibility, as experienced in Tsholotsho; virtual repellence at one point of the corridor may trigger further repellence along the rest of the virtual boundary formed providing:
        - Potential to manage both HWC and capture management requirements in a holistic manner
    - So, that continued passage forward increases:

        - The alert level and
        - Elevates the risk level potential of having other challenges ahead
        - Capitalising on avoidance behaviour rather than to challenge

It is remarkable how a simple piece of string and staggered creosote poles across elephant approach paths was avoided, keeping out 300 – 500 elephants that amassed within 200 metres of the virtual boundary, adjacent to cropped lands over a 6-week period. The suspicion it generated provided for total avoidance of the whole approach route

        - Increases severity perception of the next challenge ahead
        - Significant improvements to virtual fence perception and establishment
    - Applying repellence to three key positions adjacent to blocks of agriculture or designated 'agricultural clusters':
        - The approach area designated *management area #1*
        - The hard boundary interface *management area #2*
        - Within the crops *management area #3*
    - Constantly altering the approach area (Management area #1) by:
        - Applying new chilli-string technology
        - Continually moving, changing the positions they are set
        - Enforced by a new recently developed integrated array of pepper atomisers and ACE enforcer systems that are regularly changed

The virtual approach used magnified suspicion by elevating the risk factor that plays out in the avoidance factor. This totally disrupted previous knowledge and habituation of the previously remembered access route into Ward 7.The result proved 100% more effective than the physical intervention previously implemented, including the lethal removal of some 14 separate bulls the previous year.

    - Exploring further strategies ambushing all approach paths

My belief is the effective ambushing of approach paths is the main tool promoting the virtual fence phenomenon at the risk change interface, providing the thrust of the kuPISA approach. This approach relies heavily on changing the position and sensory impact of the string frequently, incorporating new novel ways to enforce it. This includes currently non-trialled pepper and sight tools developed to enforce the string position.

    - Providing the *opportunity to establish a virtual boundary* to delineate where animals cannot go from where they can, viz crop clusters, protected areas and corridors
    - Enabling, establishment and the defence of a boundary for HWC purposes mimicking natural holistic occurring boundaries to enforce manmade boundaries in the same way that includes:
        - Boundary establishment and enforcing it
        - Applying the Mhiripiribomba and chilli approach
        - Exploring the possibilities for a wider kuPISA effect beyond the treated area as demonstrated in Tsholotsho discussed

        - Exploiting the kuPISA approach further to determine better mitigating combinations incorporating:
            - Good crop/animal minding
            - Active repellence from crops and livestock
            - Capitalising upon early warning systems
        - Physical chase to boundary, backing off when achieved – employment of specific motorised reaction units as required

Introducing the Tarangire *Kwakuchinja corridor* approach! In the Kwakuchinja corridor, adjacent to Tarangire National Park, the designated land-use plan for the area was for grazing purposes only, allowing the corridor passage of wildlife from the park to access summer grazing outside. This is now ignored and the area, settled and cropped, provides a contradictory land-use plan, which prevents animals from moving through! For the animals, this has forced the complete unlearning of the virtual behavioural knowledge, intended and established that they had habituated to. Attempting now to enforce an about-face, new virtual knowledge function has proved challenging to implement and enforce. Fortunately, to the one side of this disputed corridor is another corridor, less used, which has had to become the new route. The most effective way to reverse this habituation, while enforcing a new one, was to employ a well-versed motorised unit to physically chase animals out from the old corridor whenever they strayed in. This highly mobile, motorised unit, armed with several different tools to consistently locate where the animals were, physically chased them all the way to the park boundary.

The expectation was that consistent disturbance and chase to the virtual boundary, ceasing completely beyond it would engender a new high risk, low risk virtual boundary. Cows and calves quickly responded while the habituated bulls took much longer as expected. As the occupancy of the corridor was seasonally triggered, this must be repeated each year to finally format the new boundary as a new layered reality.

        - Providing the potential to develop new strategies and tools for this including:
            - Chilli string enforcers for ambushing paths discussed
            - Use of drones – although the effectiveness of this is currently disputed
            - Motorised repellence – as implemented in the *Kwakuchinja corridor*
    - Where animals don't know, they don't go!
        - Understanding why certain areas remain unpopulated
            - Re-empathising the role of bachelor male groups?
    - Information transfer management: *presently un-researched hypothesis!* Providing the potential to remove unwanted knowledge baseline entirely from herds (observed when removing herds during capture and the lethal control of baboon)

An interesting possibility, yet to be verified, has been observed while undertaking the control of baboon populations in the Eastern Highlands of Zimbabwe. Here we appeared to have successfully removed the habit from isolated Estates, Imbeza and Tilbury Estates, as previously discussed. While this showed that information could be removed from populations in an area, it failed to address the behavioural trigger, which was geo-location loss and the resulting anxiety, which needs to be addressed. What it does

suggest is the possibility of removing the knowledge of improvised food availability, e.g. from tourist camps and small urban towns.

- Alternatively, providing the possibility for the targeted removal of individuals having undesirable information as implemented against baboon at Nyakavanga, the Stanley Livingstone Lodge in Victoria Falls previously discussed

- Discipline/reminder rule
  - Understanding how the concept of 'natural message centres' work
  - Duplicating them for HWC management purposes

A topic requiring further study and research; e.g. what effect would redistribution of middens have on spatial home range distribution? How could scats be used both to repel and attract carnivores?
See http://www.bpctrust.org/bioboundary-project.asp

- Understanding the effects of confusion, the fine line separating management opportunity from chaos

Unsure of the effect on HWC or on capture directly; it has been used in the past successfully within those management disciplines to temporarily confuse animals, suspending knowledge to enable direct management of them. This suspends geo-location, ethos and pecking order priorities, allowing for deft management of animals before they react to stimuli.

- Complete cessation of normal activities temporally suspended by confusion including geo-location
- Supplying a moment of opportunity, mostly seized for capture purposes and used by law enforcement agencies to terminate illegal intent

Regularly used during capture to separate eland and kudu bulls, e.g. inadvertent mixing of animals.

- Requiring physical boundaries (both multiple sectioned transport crates and plastic sheeting) during this geo-locational loss to effectively channel them.
- *Presently un-researched*, the possibly of blindly following an escape cue *(need to explore this possibility)*

Occurs naturally but yet to be investigated; the following of the up-turned underside of a white tail, e.g. kudu that become totally confused when frightened, requiring a cue to lock onto. It would require a fright, confusing them and triggering the following of a provided cue. Note that startled kudu often run onto the source of the alarm, hence the danger to motorists.

- Providing the potential for a graded response to enable different management strategies depending on alert level sustained
  - < Applying less to provide a temporary response for capture
  - > More to engender more permanence for HWC

        - >> Most to deftly manage problem situations during the heightened confusion that follows

Assumed to be so; all three possibilities require confirmation. While much anecdotal evidence for this observation exists, science has yet to prove or disprove its potential for 'Smart' management application. More thought and explanation are required to explore this theory further through trialling. The ramifications of this possibility are enormous, enabling both the capture of animals and the repelling of them.

It is reasoned, passive capture may be achieved by carefully scrutinising Google Earth, selecting path junctions along the more used conduit paths in suitable habitat to access and build a boma. Progressing outwards; depending on prevailing wind, placing a human scent trail, tear shaped, ballooning out away, surrounding the area the animals mostly occupy, narrowing down to the trap area. In the trap area, would be placed the drop boma, positioned to the side so that animal movement down the path would not discover it. When the target animals are spotted, a diversion wall is activated that directs the animals in to the boma. Loud taxi music and voices are amplified from a vehicle driving along the opposite edge of the ballooned area, triggering general animal movement towards the trap. This concept alerts the animals of pending danger, which the scent trail magnifies, and directs them away down into the trap area.

With respect to HWC, the kuPISA approach that has already alluded to its potential.

Trialling would be necessary to determine its effectiveness and improve upon the approach employing RFID tags at Thetford or a similar venue.

Researching the 'warthog phenomenon'! Warthog are the only species of animal that appear not to be at all concerned when detecting scent! When capturing them for example, they may be driven against the wind into the boma seemingly unconcerned by detecting scent that potentially should alert them of pending danger looming ahead! Even once in the boma, with humans busy closing gates manipulating them, they trot along seemingly un-expectant of the dangers they find themselves in and are headed to. Only when physically approached, do they eventually attack. This is not localised observation but is seen everywhere warthog are captured. In the wild, they are extremely courageous, often confronting lion if they sense they are unable to escape into a hole. Warthog rely on ferocity and a direct challenge, possibly trusting in head armour and formidable incisors to defend themselves as they attempt to charge through the assault.

- Where applicable encouraging 'coping strategies' to stop advanced unwanted habituation
    - Through the appliance of sustained conflict or
    - Finding ways to increase the severity of the disciplinary measures meted out

Strongly habituated elephant bulls are proving difficult to re-educate, resulting often in some of them having to be shot despite repetitive treatment. Employing the Mhiripiribomba requires scaling up the chilli experience for them to remember from. Consideration is being given to knocking the individual down with drugs then exposing sensitive areas to pepper treatment before reviving them. In addition, placing pepper directly to objects regularly challenged to provide an association. This would be a one-

time treatment, presumably rendering them more amenable to chastisement employing the chilli gun. The system has been tried once in the Lowveld with positive results that bears perusing.

- With respect to capture, improving respective wildlife manager's perception of how released animals fare after translocation; to settle in and adapt to new environments, considering previous human habituation/traits /experience that may have impacted upon future adaption.

This is established knowledge although practitioners remain ignorant, still debating the idea. There is scant science supporting it, mostly because of reluctance to consider virtual boundary reality, resulting in many management practices going awry and failing. Had virtual principles that underpin animal behaviour been understood and corrective interim management principles applied, they would have negated adaptive problems that animals and translocation efforts experienced later. Examples of these include:

- Challenges of hand reared rhino calves settling in Matusadona

Routinely, black rhino calves have been reared at Imire Wildlife Park in Zimbabwe then relocated and released in Matusadona National Park. Unfortunately, in the process they have been habituated to human activity while growing up that effectively became imprinted upon them. Regrettably, this resulted in some individuals continuing to seek human company, often moving out of the PA into neighbouring communities that puts them at risk

- Release of lions or other carnivores back to the wild

Another controversial pursuit along the same line; realising the problems of habituation is being undertaken to counter human imprinting. This through an interim learning staging period that decreases exposure to humans while increasing the natural skill factors they require to survive back in the wild.

- Young elephant bulls attacking rhino in Pilansburg South Africa

A further example; elephant reintroduced to Pilansburg were all rehabilitated, orphaned elephant calves now grown to adulthood, forming new herds. There was no mature elephant to foster and train them when young males finally broke away from their natal herds. When experiencing musth and elevated testosterone levels, there were no adult males to counter their experience. The result was aggressive behaviour towards vehicles and rhino, requiring mature elephant to be introduced from Kruger that immediately quelled the problem.

- But also, the reverse experienced, providing constructive opportunity as found treating the foot of an injured cow elephant at Pilansburg

One of the cows settled was bitten on the foot by a hippo, at a contested waterhole. The resulting infection required urgent treatment, despite her being too weak to consider immobilisation. The mahout/trainer who originally trained her, hadn't seen her for 35 years when she was a sub-adult, was located and brought in from Malawi to assist. Despite being aggressive towards any attention given to her, vigorously repelling any help offered, she immediately calmed in his presence. She allowed vets, in

his company, to treat her physically every day until she was restored, despite the obvious pain she was experiencing each day, receiving the treatment!

Principles that provide for two destinct separate management directions - HWC and capture

- ***Habituation the key for future new capture management possibilities:***
    - Employing naturally acquired habituation to movement paths and areas more frequented and enabling specific habituation, to provide for:
        - Trapping purposes - particularly with respect to the capture of carnivores, baboon, bushpig and antelope
        - Enabling the drop boma technique for ***active*** capture that presently has only been used for passive capture
        - Providing the potential to develop cheaper, holistic, less stressful means of passive/active capture (proposed Thetford experiment), manipulating natural movement through concealed drop boma/'mini boma' for capture purposes using the alert cue and the lesser avoidance behaviour principle (see appropriate pp presentation)
            - Providing the potential to 'trick' animals into a capture boma
        - Development of new capture systems employing the plastic boma and/or other attractant tools to capture animals viz:
            - Development of new hippo restraint idea:
                - Leg hold trap on water approach paths
                - Float attached hooks to mark underwater passage along submerged paths

Recent chemical capture using the BAM drug combination has enabled the safe capture of hippo previously deemed too risky. Currently, the situation to enable the darting of targeted hippo must be ideal. This often doesn't occur when dealing with wild populations, necessitating the development of an accompanying physical restraint procedure to guarantee safe, targeted, chemical capture on demand.

- Capitalising on the pre-alert response to maximise negative response that may be harnessed for positive management outcomes.
- Establishing temporary or permanent virtual boundaries dependent upon capture requirement by managing temporary conflict level, used by employing:
    - Smell, sight or noise for a temporary response
    - Elevated to a permanent response by applying conflict and/or repetitiveness
- Understanding and applying sound and sense cues (loud taxi music and verbalisation) to warn and direct animals on
- Enabling the intensive breeding management of selected wildlife viz Sable and Roan antelope by habituating whole herds to new feeding strategies that are recognised by the respective herds later when released back to the wild, to combat problems of poor nutritional uptake that naturally occurs with these

two species, unable to compete directly for natural food in the wild, competing against increased populations of other bulk coarse grazers

A management 'first,' effectively established at Thetford Estates, demonstrates how habituation may be useful to provide for positive management alternatives. Sable are selective grazers not able to compete against high populations of other coarse grazers, requiring a lot more space with less competition. This is not possible on Thetford, necessitating an alternative approach to maximise breeding potential of this currently decimated species. This was achieved by capturing all the sable natal groups and placing them in pens for a year, customising them to provisioned food and the delivery method to provide it. They were then all released back to reoccupy and establish new home ranges. Every day, each herd was visited and supplementary fed, ad lib in the manager's presence, keeping away other species. The method enabled a physical view of each animal, darting and treating any that required attention. Over the next five years, the population increased from 55 to 210 whereas the maximum population achieved before was 70.

Summary: Management scenarios where virtual knowledge may apply, encouraging new research opportunities:

- Better understanding knowledge transfer
  - Between groups/herds
  - Within the group
- Corridor management, fully understanding the dynamics of movement patterns and how they may be manipulated to achieve a management objective
  - The relationship between home range or territories, with corridors, understanding whether boundaries are suspended where they include corridors
    - Providing safe passageway through defended areas which we believe does occur
  - Disruption of paths that animals use to gain access to cropping clusters – corridors (kuPISA)
- Or conversely encouraging movement along paths to enable capture or sampling procedures
- Newer passive /active capture technology:
  - Capitalising upon path junctures as potential ambush capture positions
  - Settling down translocated animals through release bomas rather than direct 'hard' release
    - Enabling management and release strategies
  - Improvement to current understanding and principles applied to general capture
- HWC repellence
  - Highlighting perceived/actual changes necessary to raise suspicion enhancing perceived risk levels to implement the kuPISA approach providing for an effective alternative virtual fence

        - Realising an acceptable compromise between communities and wild animals providing opportunities for both
        - Liberating corridor passages providing age-old access to places animals historically frequented in the past
        - Establishing and maintenance of a virtual boundary and defence of it
        - Rebooting and enforcing boundary knowledge
        - Capitalising on SVBs soft virtual boundaries separating interfaces of contrasting risk to control unwanted passage
        - Applying the discipline reminder rule
        - Removal of 'unacceptable' habituated knowledge
        - Development of tools to enforce the approach paths ambushed ***(See suggested new tools for trialling for the wild meat project 2017)***
        - Raising the banner to terminate unwanted behaviour carried out by strongly habituated individuals, exploiting the 'coping strategy'
    - General management issues, understanding further the principles of:
        - Geo-location, fundamental to animal wellbeing
        - Further study, understanding and application of both sides of the coin in respect to *habituation,* friend or foe?
        - Problem of improvised food availability – fuelled by *the habituation factor!*
        - The role of bachelor herds to disperse wider 'herd knowledge'
        - Understanding how natural dispersal occur in nature
        - The concept of layered boundary knowledge - how it functions and how to exploit this knowledge
        - Recognising that each group/herd display a unique, small but significant behavioural difference from other herds of the same species, derived independently
        - Encouraging or preventing information transfer mechanisms as required
            - Often involving deliberate tumultuous disruption of the herd dynamic in some way as herd leadership naturally endeavour to resist change
            - Eventually sustained over time, behaviour becomes experientially remembered, possibly even affixed to DNA that currently is hotly debated by students of science
        - Enablement the management of intensive breeding opportunities whilst respective herds remain in the wild by first habituating them to an artificial feeding regime.

References:

Jaegger MM and Bruggers RL 1989, *Flocking and Seasonal Movements of Quelea quelea and Agelaraius phoeniceus in Relation to Crop Damage,* Agricultural Zoology Reviews, Vol 3

P. R. K. Richardson, E. C. Conradie, P. A. Olivier, S. C. Rode, S. Ferreira, R. E. Khoury, C. Shutte, B. Loubser 2016 *Virtual Fencing as a New Strategy for Baboon Management,* Human Wildlife Solutions, phil@hwsolutions.co.za, P.O. Box 31150, Tokai, Cape Town, 7966

Jachowski D S; Montgomery R A; Slotow R; Millspaugh J J., 2013 *Unravelling complex associations between physiological state and movement of African elephants* published online DOI: 10.1111/1365-2435.12118

Patton F J; Mulama M S; Mutisya; Campbell P E., 2010 *The effect of removing a dividing fence between two populations of black rhino,* Pachyderm No 47 page 55