

ALTERNATIVE ECOLOGICAL **RISK** ASSESSMENT

An Innovative Approach to
Understanding Ecological
Assessments for
Contaminated Sites



Lawrence V. Tannenbaum

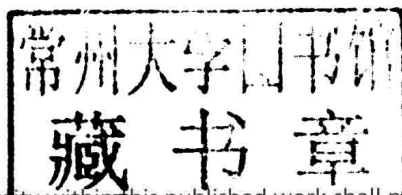
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Lawrence V. Tannenbaum

Army Institute of Public Health
U.S. Army Public Health Command



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Alternative Ecological Risk Assessment

"Truth will sprout from earth, and righteousness will peer from heaven."

Psalms (85: 12)

"... how many times can a man turn his head
Pretending he just doesn't see?"

Bob Dylan ('Blowin' in the Wind')

Excerpt from "Blowin' in the Wind" by Bob Dylan.

Copyright © 1962 by Warner Bros. Inc.; renewed 1990 by Special Rider Music

To my wife, my *aishes chayil*, Chava Esther –
I could only have met the task and succeeded with your
support, constant encouragement, and advice.
May we continue to see our beautiful family grow.

Avi

Preface

There are two sides to every story (or maybe more than two sides). There are different ways to look at situations and different ways to understand phenomena going on around us. It is not only in the realm of interpersonal relationships to which the adage applies; science and its application are areas that are ripe for seeing and explaining things differently. And so this book ... Its purpose is to present a different side of the story for ecological risk assessment (ERA) as applied to contaminated sites that proceed through a process intended to determine if receptors are in harm's way and to take appropriate action if they are.

Having read just this much, one might suppose that the author was looking for a still different angle of ERA on which to write, and perhaps looking to be contrary for the sake of being contrary. That's not the case, however. It's a sad commentary when one has to resort to developing a contrary opinion or understanding in order to arrive at a topic that no one has yet secured. I would most definitely not encourage others to set themselves down to the specific task of finding flaws or shortcomings for the particular scientific field in which they work, all for the purpose of honing in on a topical area that they can uniquely claim as their own. For the book you are holding (dare I say 'kindle-ing', because along with the reference to the trendier means of reading books today, the suggestion could be that the subject book might best be suited for trashing in the fire), the etiology is much more straightforward and genuine. There was no deliberate process of systematic review of ERA for the express purpose of uncovering faults and the like so as to have a sufficiency of material to fill the pages of a book. The material was instead assembled in a casual manner over the years as the author worked at his science.

To me, the author, the observations and analyses I set forth are incredibly obvious and unmistakable. The staunch supporter or defender of common ERA practice will feel quite differently though, and that's fine, for science grows from healthy constructive debate. Perhaps I am completely wrong about every ERA element the book touches on. A reason to think so is that I appear to be the only one giving voice to our having an ERA process that leaves so very much to be desired. Perhaps we are so ingrained in our way of thinking that we never pause to consider other possibilities, and perhaps I am the only one who did pause to so contemplate things. There is the matter too, of not wanting to hear an alternative understanding of it all, and to complete the spectrum, there is the vastly more serious matter of not allowing oneself to hear an alternative analysis, a topic certainly dealt with in the book.

This book's purpose of presenting an alternative understanding of ERA is set forth with the hope that it will pique the minds of those who, in one fashion or another, are involved with ERA as an outgrowth of ecological science. The book is expressly targeted for the serious (college or graduate) student of health risk assessment, environmental science, or ecology, those who work in the ERA field, and those who publish on ERA topics. It should be required reading for regulators who craft and dispense ERA guidance and policy, and who need to hear among other things, why an ERA process isn't needed, not that we have one anyway – alas, not an avant-garde concept to summarily dismiss, but merely an alternative concept to professionally consider.

Lawrence V. Tannenbaum
September, 2012

Acknowledgments

I offer my great thanks to the US Army Institute of Public Health (AIPH; formerly the US Army Center for Health Promotion and Preventive Medicine, and before that still, the US Army Environmental Hygiene Agency) for allowing me, where they could, to test the waters – to conduct studies critical to a bettered understanding of the potential for chemicals in the environment to impact ecological receptors. Special thanks to Dennis Druck for guiding my career especially through turbulent times, and for nurturing my passion to unleash a different perspective so clearly borne out by the studies. I am indebted to the US Army Environmental Command (formerly the US Army Environmental Center) and to Jim Daniels in particular, for funding one-of-a-kind studies that bear up to scrutiny and that are secured in the peer-reviewed literature. Several Army installations provided the necessary funds to carry out work I so badly wanted to have done. I send my appreciation therefore to Picatinny Arsenal (and Ted Gabel), Badger Army Ammunition Plant (and Joan Kenney), and Joint Base Langley Eustis (formerly Fort Eustis; and Joanna Bateman). The list of individuals to thank for allowing RSA (see Chapter 9) to be birthed, cultured, and firmly established, is extensive. There were thinkers, those who supplied the grunt work, and more. The short list runs to: Keith Williams, Brandolyn Thran, Adam Deck, Jeff Leach, Sue Fox, Barrett Borry, John Buck, and the techs from AIPH's Soils Lab.

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An introduction and overview

At the time of writing, I have over 20 years of experience working in the health risk assessment field as it relates to chemically contaminated properties, with a special emphasis placed on ecological risk assessment (ERA). At the beginning of my career in environmental work while with the United States Environmental Protection Agency (USEPA), I was involved with the pre-remedial element of the legendary Superfund program. My duties there largely amounted to verifying the conclusions recorded in preliminary assessments (PA) and site inspections (SI) for the contaminated sites. Most of the documents recommended that the sites advance to more refined tiers of analysis that would permit non-threatening sites to be shifted away from those that seemingly had the potential to truly pose substantial health threats to the human and ecological receptors that contacted them. I'm not certain but it may be that already back then, I pondered if we were ever encountering instances of harm in the ecological receptors that inhabited the sites which were producing substantial scores with the Superfund program's Hazard Ranking System (HRS). In my reviews I had never come across a single PA or SI that had reported tell-tale signs of injury to birds or mammals, the two groups of terrestrial ecological receptors that are routinely evaluated in ERA work. None of the PAs or SIs had described the unsettling discovery of a site devoid of biota, and at no site or anywhere nearby to one, had anyone observed something bizarre and clearly out of the ordinary, such as an accumulation of carcasses or evident signs of rampant disease in an ecological (i.e., non-human) species. To a certain extent, I shelved for a while the need to have my query resolved. If there really were health concerns for site ecological receptors, unaware of these as any of us might be, I reasoned that such would be indirectly captured and later addressed courtesy of the HRS scores. Sites that would advance through the process (and perhaps all the way to the National Priorities List; NPL) due to their high scores, would be there via a ranking scheme that was heavily weighted to human health concerns. Once on the NPL though, the sites would come under greater scrutiny not only for their potential human health concerns, but for any ecological concerns they might bear as well.

About 10 years into my risk assessment craft, having already logged in a number of years with the Army pursuant to my EPA years, and having moved well beyond attending to pre-remedial tasks only, the nagging thoughts returned. For all that I knew of contaminated terrestrial and aquatic sites managed under the related Superfund and Resource Conservation and Recovery Act programs (i.e., valuable and relevant knowledge gleaned from hands-on involvement with the sites, and not just information assimilated through reading work plans and remedial investigations and the like), I could not point to single site that had anything ecologically wrong with it (e.g., vanished populations or species or a lacking detritivore compartment). Site visits didn't suggest anything amiss, and through negotiations with stakeholders of all walks, many insistent that their sites submit to extensive eco-based site cleanups, never once was it suggested that there had been observations of ecological health compromise occurring in the field. [A clarification is in order here. Site visits can very well detect (gross) habitat loss or elimination, as in the "slickens" of toxic waste sediments (i.e., the highly compromised riparian areas) of the Upper Clark Fork River Superfund Site in western Montana, that are directly traceable to the mining, milling and smelting activities that have occurred over many decades (Brumbaugh et al. 1994). Where such massive physical destruction has occurred though, it's understood that the lack of habitat is responsible for the removal of the resident biota of yesteryear. Importantly then, construction projects to restore habitat are the order of the day, and moreover, riparian species aren't at risk. With the habitat they require missing, riparian species are not expected to be present and thus at risk from chemical exposure. It bears mention here too, that while individuals might be quick to cite the Upper Clark Fork River Superfund Site as one having been ecologically wronged, the example is a poor one. This site, the largest geographic Superfund site in the United States, does not typify in the least the sites that are the subject of this book. The overwhelming majority of sites, Superfund or otherwise, are just a handful of acres in size, if that much.

In all fairness, there was no need for the above-mentioned stakeholders to have arrived at such a point about (lacking) observed impacts. For Superfund sites and for others that defaulted to Superfund guidance in the absence of having their own program-specific guidance to follow, it was always a risk-based framework that was in place. Aptly then, the focus was always on what *could* happen to the ecology should a site remain as it was, i.e., in a non-remediated state. Program dictates aside though, I realized that I had nevertheless happened upon a key distinction between the human health risk assessment (HHRA) and ERA processes (discussed below). This distinction in focus, largely centered on spatio-temporal considerations, was eluding the rank and file of health risk assessors. Perhaps it was because I was a risk assessor for both human health and ecological health when most people in the health risk assessment field did just one or the other,

that I was able to secure and frame my observation. Perhaps too there were other reasons why the ERA practitioners were not able to do the same. Surely they'd had ample opportunity to become acquainted with the distinction, for in more recent years I had dosed the ERA landscape with my notion via published peer-reviewed pieces and speaking engagements at professional society conferences. My sense is that ecological risk assessors and ecotoxicologists have gone out of their way to turn a deaf ear to the matter. Although I haven't yet taken the time to prove it, it may be that the very notion – in its ultimate manifestation, that ERAs are unnecessary – repulses this audience; hearing that notion articulated is, at the very least, perceived as a threat to job security. Let us explore the notion, which to my way of thinking is as glaringly obvious as the one essential difference between HHRA and ERA that ecological risk assessors *do* acknowledge, namely that HHRA evaluates just one species, whereas ERA is left to potentially consider all other species that inhabit a site of interest.

On any given day, the prospect of there being a human newcomer to a contaminated property can be realized. Human beings by nature relocate, and frequently do so over considerable distances. This occurs for example, when a family breadwinner accepts a job transfer, triggering a family move out-of-state. Such relocation or repositioning creates new opportunities to arrive at and consistently occupy (through residence or employment) what may later be found to be a contaminated address. It is for this reason that by convention, HHRA's use assumed exposure durations of 25 years for industrial and other workers, and 30 years for residents, i.e., 90th percentile figures for site occupancy that reflect considerable research into human activity patterns (US EPA 1989). So real is the prospect of humans arriving anew to a residence or workplace and to have their full *run of it* there (i.e., to realize such 90th percentile exposure duration terms), that consideration is never given to those who have already been living or working at the site for some time.¹ The salient point is that at best, only a portion of the lifetime of an individual or a population is ever considered for health effects that might crop up; there is no concept of assessing the progeny of those unlucky individuals who might have arrived anew at some contaminated address, and with good reason. Although there may be faint vestiges of the extended family in our country today, where multiple generations live under one roof, for all intents and purposes we do not encounter such site settings. As mentioned earlier, humans

¹ To my mind it is a most unfortunate happenstance that conventional HHRA's for hazardous waste sites do not entertain such exposure scenarios. What though, of the worker employed for the past several years at an industrial park where soil ingestion exposures or inhalation exposures of the site's wind-entrained contaminants have only today been discovered to be unhealthful? We should surely want to know the risks for those seasoned workers who fortunately have not yet presented with illness, and especially when this population is seemingly closer to presenting with illness than are newcomers to the site arriving as you read this! Exploration into these and other neglected scenarios could lead to a utilitarian expansion of the science of HHRA as we currently have it, enhancing our understanding of thresholds-for-effect, latency of effect, and developmental disease.

relocate and reposition. Grown children might find themselves living in the same general area in which they matured, but it's more than highly unlikely that they would be living at the very same contaminated addresses they always knew. Risk assessment's guiding principle of reasonableness (in considering exposure scenarios to evaluate, etc.) would not be met if we were to *de facto* include in our HHRAs, the children, grandchildren, and great grandchildren of the "new arrival" residents and employees described here. What about ecological receptors? Firstly, the ones that might concern us at Superfund-type sites simply do not arrive at settings anew, to experience exposure durations of only singular lifetimes. Additionally and in stark contrast to humans, they do not undergo geographical repositioning on a scale of such magnitude, or at least not in a manner that would exacerbate their degree of contaminant exposure for any given site of interest. A clarification with regard to repositioning over vast reaches is in order here, for many birds are of course, migratory in nature, overwintering at locations that are hundreds and perhaps thousands of miles distant from the areas they occupy in the summer months. The more time a migratory bird is away from a site however, the less appropriate it is for inclusion within an ERA. It is also worth noting at this juncture that, for what should be some rather obvious reasons (discussed later), a bird that does not reside at a contaminated site for a stretch of three or four months or longer is a rather non-desirable receptor of concern to evaluate altogether.

Reduced geographical repositioning in ecological receptors is best demonstrated with an example from mammals. A raccoon or a local population of raccoons will not appear tens of miles away from where once sighted. Raccoons, like all animals, are bound by their biologically dictated habits and behaviors. In a worst-case scenario, this might very well mean that not only raccoons, but a great many other ecological species are effectively *trapped* at contaminated sites of interest, not having the ability to get beyond the site's boundary. In that particular arrangement where a contaminated site is sufficiently large relative to a receptor's home range, the receptor's entire life is lived on contaminated turf. Now we must ask how long do ecological receptors live? For our considered raccoon, a maximum figure might be just over 3 years, with sexual maturity kicking in at shortly past 1 year. And now we must ask how long have sites been contaminated by the time that they come up for assessment within Superfund or any other similarly structured program? The answer here is multiple decades, with 30 years as a vetted figure. Combining this information we find that any raccoons observed at a contaminated site today are, with only minor exception, descendants that are some 10 generations or more removed from the raccoons that inhabited the site when it first became contaminated.

The implications of the above are far-reaching and they set us on an entirely different plane from that on which we routinely express concerns about human exposures to contaminated sites. Whereas the prototypical modeled hypothetical

humans of HHRA are consistently assumed to have had no prior site-specific contaminant exposure, a site's ecological receptors have only known life within a contaminated context.² For those who sense the urge to immediately challenge this because immigration is an undeniable element of a dynamic ecosystem, let them consider two other mainstay species of ERAs that could never have known life elsewhere: earthworms and field rodents. When we encounter these species, well-known to be severely restricted in their horizontal migrations, we do not suppose that they are site newcomers, having recently been air-lifted to the site in question through some revolutionary plot to re-introduce species to areas from which they may have vanished for one reason or another. And so, if we observe any raccoons, earthworms, or field rodents at sites today, some 30 or more years after contaminants have been released, don't we then "see" (effectively "know") that the site is still supporting these species? Several other questions need to be asked now: Could there still be a need to assess raccoons at the site? Isn't the passing of 30 years and 10 generations more than enough for a contaminated site to have elicited an observable toxicological response in the ecological receptors that are "trapped" there? Is anyone suggesting that we wait still longer to see if site ecological receptors ultimately present with observable signs of disease or until their populations plummet?

It might be critical here to acknowledge that ERA practitioners are not known for bemoaning the fact that nearly all the studies that support Toxicity Reference Values (TRVs) are one-generational in nature (Sample et al. 1996). Whether they realize it or not, the masses working ERA are not troubled with developing TRVs from such cohort studies that rarely exceed 1 year in duration. They illustrate this posture when they summarily and confidently conclude that ecological receptors bearing hazard quotients (HQs) greater than 1.0 are at risk for developing deleterious health effects. If we (the author quite obviously, not included in this collective "we") can find merit in employing such TRVs that reflect the toxicological responses of only previously non-exposed animals to a chemical dosing regimen administered over a portion of their lifetime, we should be nothing less than ecstatic to have at our disposal, site fauna that reflect decades and multiple generations of exposure. If we are willing to see it, we have the opportunity at both terrestrial and aquatic sites, to evaluate the very receptors that have been chemically exposed for more generations than any laboratory study could ever rival. An alternative understanding or appreciation of the contaminated site dynamic is in order then. Currently for a site that presents with a suite of contaminants in its media, such as a field where tanker-hauler trucks have had their

² I am reminded of a naysayer, who remarked after a conference presentation I had given, that at a certain contaminated site, a new rookery had only recently been established. I can accept this and other similar occurrences, but I think it only fair to point out how uncommon it is that a site is sufficiently large to support a rookery, a point to be discussed later.

rinsate poured onto the ground over many years, we see it as our job to decipher the potential health effects that the site stands to pose to the unsuspecting biota situated there. A reframed perspective recognizes that when employees of the operation began repeatedly and carelessly allowing the rinsate applications to occur, unbeknownst to them, a toxicity study of exceptionally high quality was getting underway. Unknowingly, the well-meaning employees were initiating a long-term dosing study to the indigenous biota, and often with a well-defined chemical load. In this "study", no animals had to be procured from suppliers nor did they need to be randomized to cages or tanks. No feeding duties had to be assumed, and temperature and lighting settings were a non-consideration. Nature ran the study, and importantly we have the luxury today of reviewing what's happened in the aftermath of a dosing regimen conducted in a natural setting and for a duration that puts any lab-based experimental study design to shame. Consequently, it is far too late to be asking about what *could* happen to the ecological receptors that populate the site. *Risk* assessment for the many sites that share similar histories to this one is no longer what's needed.

More than a decade ago I had yet a third brush with the notion that ecological receptors within a Superfund-type site context fail to bear tell-tale signs of harm due to their chemical exposures. This third occasion profoundly influenced my career path, spurring me on to allocate my available time to exploring the phenomenon of absent health effects in ecological species, with an emphasis placed on elucidating the basis for the absenteeism. In a large way, this book is the product of those explorations that bear on both theory and empirical science. On this fateful third occasion, I was arranging a slide presentation for an ERA course module that I would be teaching. For the first slide of the module I wanted to have a montage of images of the health effects with which ecological receptors contacting or residing at contaminated sites present. I had trouble composing the slide, and could do little more than pull in an image of a cross-bill condition in a gull from the Great Lakes region, and a second image of a frog with a clear case of polymelia (extra limbs). Whereas I wanted a slide that would effectively ring out with "These are the sort of things you can expect to see happen at contaminated sites, and this is why ERA is so necessary", I found that I had hit a brick wall. I thought back to the hundreds of ERAs and related documents I had reviewed over the years. Never had there been a description of what chemically wronged ecological receptors looked like. In my sudden, and fortunately only momentary naivety, I reasoned that ERA boiled down to ecological receptors simply dying off at contaminated sites, this occurring before somatic changes in a critter's external appearance would arise. This would explain why I was having such difficulty in assembling examples of physically altered or deformed organisms. Perhaps then, all I needed for that elusive first slide were two pictures taken from the same contaminated site, arranged side-by-side, one with a bunch of birds or fish, and

one with just a few specimens of these forms (the latter presumably indicating the damage caused by the site over a period of years). But if concern over population loss was what ERA amounted to, where were the accounts of dwindled down or decimated populations at the sites? Surely time enough had elapsed at sites for it to be evident that decidedly lesser numbers now populate them relative to either former times or to what the textbooks have to provide in the way of species density figures. Returning to my senses, I questioned if the prototypical sites being addressed by Superfund actions were even large enough to house sufficiently large populations of any species worth assessing. As the reader will recall, prototypical sites still to this day are of the 5- to 10-acre genre with many far smaller than this.

Still endeavoring to compose the slide, I researched the cross-billed gull photo only to learn from the US Fish and Wildlife Service biologists who had taken it, that the condition was anomalous, if not specious. For approximately a decade, the condition had been observed in the Great Lakes region. It had recently disappeared, never allowing for a good understanding of why the phenomenon had come about altogether. In truth, such a condition even if directly related to contaminant exposure, would *not* have been germane to ERA. Superfund-type ERA sites, the interest of this book, are not the size of US states or of still larger regions encompassing multiple states. Further, no formalized process exists for assessing ecological risk for receptors over such a grandiose scale as the Great Lakes region. Real as the time-limited cross-bill condition in the Great Lakes had been (Giesy et al. 1994), and real as other cross-bill instances that have crept up over the years may have been, never has it been suggested that a singular "site", such as a 10-acre lake, was the causative factor. True as it may be that such compromised birds ultimately succumb from undernourishment due to an impeded ability to consume their foodstuffs, such situations call for forensic ecology and not ERA. Once a toxicological response has been elicited, and certainly when one takes the form of a clearly observable physical manifestation, risk, the probability of a manifestation *arising*, is not what needs to be assessed.

For the polymelic frog image I had intended to use for the slide, I encountered issues similar to those with the cross-billed gulls. News briefs and peer-reviewed articles at the time reported discoveries of classical frog deformities and malformations at an alarming clip. Additionally, causation had already been explained and handily demonstrated in multiple ways, with a shrinking atmospheric ozone layer, and limb bud invasion by parasitic cysts serving as the two triggers dominating the peer-reviewed literature and the growing scientific discussion of the day (Cohen 2001). A flood of northeastern US states reported the phenomenon, with Minnesota garnering perhaps the greatest degree of attention. In all of this, no one was suggesting that environmental contamination was the root cause of the problem, not when these effects appeared over such an extensive area. To suggest