Biological Diversity Study of Terrestrial Arthropods of Selected Sites on the Hanford Reach National Monument

Introduction

Located in the Pasco Basin of the southeast corner of the Columbia Plateau, primarily in Benton, Grant, and Franklin counties, Washington, the Hanford Site and Hanford Reach National Monument comprise over 560 square miles of predominantly shrub-steppe habitat administered by the United States Department of Energy and the United States Fish and Wildlife Service. The land was acquired in 1943 as a national security area for the production of plutonium used in nuclear weapons. Most of the Site has been closed to the public since 1943. Today, Hanford is less known as a site of nuclear weapons development than for its international reputation in nuclear waste management, environmental restoration, and research and development.

From an ecological standpoint, the placing of such a large tract of land virtually off limits to public access for over half a century has preserved a shrub-steppe ecosystem that has otherwise changed radically throughout the surrounding Columbia Plateau. Hanford serves as a refuge for many plants and animals, including insects, that probably were once common throughout the Plateau but today are confined to remaining small, undisturbed tracts of land.

In addition to general surveys (ERDA 1975, Rogers 1979), specific groups of insects studied at Hanford include darkling beetles (Tenebrionidae) (Rickard et al. 1974, Rickard and Haverfield 1965, and Rogers et al. 1978), ground dwelling beetles (Rickard 1970), and grasshoppers (Sheldon and Rogers 1978). Additionally, the Hanford Site was the subject of relatively intensive arthropod surveys (principally insects) from 1994 – 2000. Results of these studies have been published in various Nature Conservancy reports (e.g., Soll et al. 1999) and scientific publications (Grissell and Zack 1996, Newell et al. 2001, O'Brien and Zack 1997, Zack 1998, Zack and Looney 2001, Zack et al. 1998, and Zack et al. 2001.

Purpose and Scope

This study was essentially a continuation of previous entomological diversity surveys conducted on the Hanford Site from 1994 – 2000. Previous studies were conducted on the Fitzner-Eberhardt Arid Lands Ecology Preserve (ALE) and central Hanford. The results of these studies are summarized in the literature cited above. The primary goal of the current study was to continue these entomological diversity studies and to include groups not previously examined. We also chose to continue our examination of the diversity of several large taxa of ground dwelling beetles including darkling beetles (Tenebrionidae) and ground beetles (Carabidae) – these were primary groups of interest in previous studies and we were interested in comparing the fauna of ALE and central Hanford with that of the Wahluke and Saddle Mountain areas. We did not expect significant differences in the fauna between the two areas, but we were hoping to develop a more thorough study for the complete Hanford Site. A large number of other arthropod taxa are taken in pit trapping, the primary means of ground dwelling arthropod collecting, and some of these are treated in this report as independent units (e.g., sun spiders and crustaceans) or as additions to larger databases such as the beetles (Coleoptera). Some of the databases included in this report (e.g., Siphonaptera (fleas) and sun spiders (solifugids) also

incorporate specimens collected from previous Hanford studies (Soll et al. 1999)but which had not been identified until recently.

Beyond the ground dwelling fauna, we wanted to continue our intensive studies of moths – primarily through light-trapping. We were especially interested in survey work on the Wahluke sand dunes, general shrub-steppe, and riparian areas along the extensive irrigation run-off system on both Saddle Mountain and the Wahluke. Although these latter areas are inundated with introduced, exotic vegetation, the presence of this vegetation as food for caterpillars will add to the species richness. In conjunction with our light-trapping for moths, we also collected and processed large numbers of caddisflies, the larvae of which are aquatic. Robert Newell was also conducting studies of one or more aquatic groups of insects.

We primarily focused on ground dwelling beetles and moths as these were groups on which our previous studies (cited above) had concentrated and groups of which we could perform identifications without relying on outside consultants. As this was a single year study, we hoped to maximize output with effort. We chose caddisflies in order to supplement studies that had been conducted by Newell et al. (2001) in the Rattlesnake and Snively Springs areas of ALE. Ground beetles, especially have been a favorite study of those conducting biological diversity studies and would allow for future habitat and regional comparative work.

In 2000, a range fire severely impacted the ALE Preserve and sections of central Hanford. One of the areas affected was one in which we had conducted two years of pitfall collections (see Soll et al. 1999). During the preliminary stages (mid-March through early April) of the current study, we established a series of pitfall traps on the ALE Preserve in the hopes of comparing pre-fire collections with post-fire collections. Because of the limited number of species being encountered in these traps and the distance of these sites from those established North of Columbia River (which we took to be of higher priority) the ALE traps were discontinued in mid-April. We had also hoped to establish a series of pitfall traps and to conduct light-trapping activities along the Hanford Reach shoreline, but access to this area primarily is by boat and thus not within the resources of this study.

The bulk of this report is a listing of the insects thus far collected, identified, and added into the various taxonomic databases (Appendices 1-12). These inclusions represent approximately 50-60% of the insects collected as some are awaiting identification. Groups with the highest percentages of unidentified specimens include moths and beetles while identifications for groups such as fleas and earwigs are complete. As was the case in previous studies a specific level identification of an arthropod is often dependent on a recognized taxonomic expert in that taxon. We view this as extremely important as authoritative identifications are imperative when identifications are made available to the concerned public or those with professional interests. Once a name enters into the available literature it is very difficult to make corrections when they are found to be misidentifications – this is extremely common with insects. These species-specific identifications can be a laborious project, often accomplished only with the aid of taxonomic experts. As an example, we still have literally thousands of insects still awaiting identification from the first studies. Some groups of insects are virtually impossible to identify but we continually seek assistance. We have made few value judgments on the insects thus far collected and identified during this 2002-2003 study. In some cases, we are collecting

"common" species but are obtaining valuable habitat and seasonal data – the type that was used in the many publications (Grissell and Zack 1996, O'Brien and Zack 1997, Zack 1998, Zack and Looney 2001, Zack et al. 1998, and Zack et al. 2001).arising from the first studies. We have collected several taxa that we consider to be new to science or "rare," and these will be elaborated upon in this report.

Methods

On 11 April 2002, three series of 10 pitfall traps were established at the following locations:

1. 46°42.064'N 119°38.271'W. The site is located in the Saddle Mountain area. It is a sage/cheatgrass area with sandy soil.
2. 46°41.496'N 119°35.444'W. The site is located in the Saddle Mountain area at the end of the irrigation runoff. The site is sand with little cheatgrass and various vegetation including some specific to sand dunes. It contains predominantly native vegetation and appears to have suffered little disturbance
3. 46°40.541'N 119°26.949'W. The site is located in the Wahluke Wildlife area near the White Bluffs Ferry landing. The vegetation is mostly introduced weeds including much knapweed.

Pitfall trapping locations were chosen for several reasons. We wanted one or two of the sites to be comparable with sites established on ALE and central Hanford during the 1994-2000 study. Site one above represented such an area. This site was comparable (at least visually) to those previously studied on Gable Mountain and the east end of ALE. Site two above was chosen because of its sandy soil and the presence of small areas of cryptogamic crust. While the dunes on central Hanford were not particularly productive in terms of pit trapping (thus, we chose not to pit sample the Wahluke dunes that are more comparable to the central Hanford dunes) we believed the Saddle Mountain site offered us the ability to sample a sand habitat fauna and, perhaps, a fauna that was associated with the irrigation system. The site we chose allowed us to place five traps in a sand habitat and five traps perpendicular to but approaching the irrigation system.

Site three was located just up from the White Bluffs Ferry landing. This site was chosen because it was a non-sandy soil with more organic matter. Although much of the vegetation at the site is introduced, we believed that the soil and close proximity to water would provide us with a unique fauna. This proved to be the case as it was the only site from which millipedes, centipedes, sowbugs, a species of sun spider, and several ground beetles were taken.

Each series of pitfall traps followed a linear transect. Each was collected on a weekly basis for one year. Samples were removed to the laboratory in Pullman, sorted, prepared, and when identified, recorded in the appropriate taxonomic Excel database. These databases are included in this report as Appendices 1-12. Databases contain identifications, site location, and dates of collection for the period April 2002 – April 2003. All specimens thus far identified are recorded.

On 11 April 2002, we also began to light trap for moths and other light-attracted insects. We used a mercury vapor system, which involves active collecting (i.e., we are there at the light

collecting insects as they arrive) and a series of "black light" traps where the light is placed over a bucket and allowed to capture insects throughout the night. The contents of these traps were then collected the following morning. This allowed for continual trapping throughout the night and allowed us to establish traps in several locations on a single night. The moth fauna changes continuously throughout the season and we were trying to monitor several different habitat types on a semi-continuous basis. Survey sites included the Wahluke sand dunes, several arid shrub-steppe areas, several semi-aquatic areas along the irrigation system, and areas of impoundment in the Wahluke area. We tried to collect each type of habitat every other or every third week depending on our view of the changing fauna. Approximately 15 sites were monitored throughout April 2002 – April 2003.

Findings

Overview of Major Groups

At the time of our last comprehensive report (Soll et al. 1999), we had collected, prepared, and identified 1,536 species of arthropods with several hundred species still awaiting identification. Since our last report, we have added another 143 species to the list making a total of 1,679 species thus far identified. These additions include species identified after 1999 and those thus far identified from the 2002-2003 study. A number of taxa still await identification – we estimate the number at between 200 – 250. These latter taxa are ones for which we have not been able to find competent taxonomists or groups for which taxonomists do not exist. We added another three species new to science since 1999 for a total of 46. As of this report, no new species have been added from our 2002-2003 study. One of the species recognized since 1999 is a species of *Aphodius* (scarab beetle) while the others are a species of *Boreus* (snow scorpionfly) and a parasitic wasp, *Macrocentrus shawi* Ahlstrom. This latter species was just recently described. Additionally, K. G. A. Hamilton, one of our collaborators, has described four new species of leafhoppers. The two new species of *Copablepharon* (Lepidoptera: Noctuidae) are being described in the Moths of America North of Mexico series in a fascicle to be published in late 2004. Species new to science discovered at Hanford are listed in Table 1. This includes species from all years of the Hanford biodiversity study; species thus far named are so indicated. The number of species new for Washington State number between 150-200. New state records are sometimes difficult to ascertain because of the lack of catalogs and checklists. Ongoing identification efforts continue.

One group of extreme interest is spiders (Araneae). We have collected over 600 samples (each being one pit trap catch with a varying number of specimens of spiders) of spiders throughout this project – over 150 from the 2002-2003 study alone. We estimate that there are between 1,500 and 2,000 specimens of spiders in the 2002-2003 samples. We have found an individual willing to identify these spiders, or at least a portion of them, and have sent him approximately 75 samples (approx. 1,000 specimens) from the 2002-2003 study. As of this report, we have not received any results from him. We believe that the identification of spiders will add significantly to our findings from both biodiversity and ecology aspects. Results will be provided to TNC when provided to us and databased.

The major emphases of our activities for 2002-2003 were the moths (through light trapping) and ground and darkling beetles (through pit trapping) as well as a small number of other taxa taken in light and pit traps. Table 2 is a listing of the number of identified arthropod species and the estimated number of taxa remaining to be identified.

Table 1. Arthropod taxa new to science collected at Hanford, 1994-2003.

Coleoptera (Beetles)
- Scarabaeidae
  - *Aphodius* sp. 1
  - *Aphodius* sp. 2
  - *Glaresis* sp.

Diptera (True flies)
- Anthomyiidae
  - *Paradelia* sp.
- Asilidae
  - *Efferia* sp. 1
  - *Efferia* sp. 2
- Dolichopodidae
  - *Asyndetus* sp.
  - *Sympycnus* sp.
  - *Thrypticus* sp.
- Sarcophagidae
  - *Blaesoxipha* sp.
  - *Eumacronychia* sp.
  - *Senotainia* sp.

Homoptera (Leafhoppers)
- Cicadellidae
  - *Auridius ordinatus crocatus* Hamilton
  - *Aceratagallia compressa* Hamilton
  - *Aceratagallia zacki* Hamilton
  - *Ceratagallia vipera* Hamilton

Hymenoptera (Bees, Wasps, and Ants)
- Andrenidae
  - *Andrena* sp.
  - *Perdita* sp.
- Braconidae
  - *Macrocentrus shawi* Ahlstrom
- Colletidae
  - *Colletes* sp.
- Megachilidae
  - *Osmia* sp. 1
  - *Osmia* sp. 2
- Perilampidae
  - *Perilampus* sp.

Lepidoptera Moths)
- Coleophoridae
  - *Coleophora* spp. 1-12
- Noctuidae
  - *Copablepharon* sp. 1
  - *Copablepharon* sp. 2
  - *Oncocnemis parvacana* Troubridge and Crabo
  - *Protogygia* sp.
  - *Spaelotis bivaca* Lafontaine
- Scythrididae
  - *Arenoscythris* sp. 1
  - *Arenoscythris* sp. 2
  - *Asymmetrura* sp.
  - *Neoscythris* sp.

Mecoptera (Scorpionflies)
- Boreidae
  - *Boreus* sp.

Solifugae (Sun Spiders)
- ? genus sp. 1

Treatments of Individual Orders

Crustacea – Sowbugs

It appears that a single species of sowbug occurs at our pitfall site near the White Bluffs Ferry landing. The accompanying database is a phenological perspective of the species at this site. We have not yet been able to identify the species but it is probably a common one. Sowbugs are omnivores in their feeding habitats and like more moist soils higher in organic content. This is the only site on the Monument where we collected sowbugs. Still, we believe that sowbugs would be common inhabitants in all similar environments, which are probably common throughout the Monument.

Order Scorpiones – Scorpions

Only a single species of scorpion, *Paruroctonus boreus* (Girard), is found on the Hanford Site and throughout eastern Washington. As in previous studies, the species is common in shrub-steppe environments, especially those in which cheatgrass is not a significant portion of the ground cover. It is possible that as a large predator, the scorpion has difficulty navigating through dense cheatgrass. We currently have a manuscript in preparation documenting these habitat differences (Zack and Looney, in prep.). On the Wahluke and Saddle Mountain areas where cheatgrass is present but in low density, the scorpion was found in both shrub-steppe habitats sampled through pit traps but was rarely found in the habitat near the White Bluffs Ferry landing. Although this latter habitat contains no cheatgrass whatsoever, it is probably soil structure (less sandy) and higher moisture content that limits scorpions.

Order Solifuge – Sun Spiders

Sun spiders are an unusual group of predatory arthropods that have very serious (painful) bites but no toxic effects. They are not commonly collected and their distributions, especially in Washington State, are in need of study. Their taxonomy is not well understood. Dr. Jack Brookhart of the Denver Museum of Natural History has identified sun spiders collected during the current and previous studies. The results of his efforts are delineated in the appropriate database. Noteworthy is the fact that only adult males (rarely females through association) are capable of being identified to species. This can complicate faunistic efforts as most collections consist of immatures and females as is evident in the database. Two species have been identified from Hanford. Both of these species are listed as species of concern in British Columbia (http://www.landtrustalliance.bc.ca/registry) but, their distribution and abundance in Washington State is virtually unknown. Additionally, Dr. Brookhart has found a species new to science from our material that he is currently describing. This information will be made available to TNC when made available to us. It is not recorded in the current database as the material has yet to be returned.

Order Dermaptera – Earwigs

There is a single species of earwig, *Forficula auricularia* L., in the central basin of Washington (including the Hanford Site). They can be common in pitfall traps and we maintained records in order to obtain habitat and season information. Our findings certainly indicate that they are more common in moist and in the case of this study, disturbed areas. An introduced species that is widespread throughout the United States and Canada, moisture is probably the primary requirement that limits its distribution on the Site.

Order Orthoptera – Grasshoppers and Relatives

Little attempt was made to document grasshoppers, crickets, and relatives. One of the ground crickets – *Stenopelmatus fuscus* Haldeman - was commonly taken in the pit traps and we kept phenological information for this species.

Order Hemiptera – True Bugs

While significant resources were expended on true bugs during previous Hanford studies, we did not do so during the current faunal investigation. However, we have chosen to institute a database and record the small amount of material collected as we plan on continuing true bugs studies in the Wahluke and Saddle Mountain areas. We will include the large number of specimens of aquatic bugs that were taken at light traps, these specimens have been processed but not yet identified. During the last weeks of the current study, we made significant efforts to collect specimens from aquatic habitats themselves. Most of the temporary irrigation pools found on Saddle Mountain do not contain significant numbers of such insects. However, permanent irrigation waters, especially the series of canals with natural bases and shorelines, have significant numbers of aquatic bugs. Our primary mission in this sampling was to locate specimens of a naucorid bug (creeping water bug) that was recorded from a pond on central Hanford (Emery and McShane 1978). The closest area from which this bug is known, is extreme

southern Idaho. Our knowledge of this group indicates that if the insect does occur at Hanford, the irrigation canals would be the best place to look. However, we conducted an intensive search for the bug and did not find it - we believe that the Hanford records are in error. It appears as if Emery and McShane (1978) misidentified a number of insect taxa but we have been unable to locate voucher material.

Order Trichoptera – Caddiflies

Caddisflies are a group of insects with aquatic larvae and moth-like adults. Newll et al. (2001) studied the caddisflies of the Rattlesnake and Snively Spring systems. They recorded 26 species, 11 of which were new records for the state of Washington. We chose to continue this study hoping to sample from the Columbia River and the irrigation system of canals, ponds and lakes found throughout the Saddle Mountain and Wahluke wildlife areas. We should note, however, that adults are collected at light traps and it is impossible to know from what aquatic source they derive; adults are attracted to lights, as are moths. After collection, adults were separated from moths, sorted, and sent to Dr. David Ruiter for identification. We have collected at least 34 species. We did not collect (as of this report) nine of the 26 species collected by Newell et al. (2001). It is possible that these later species solely are associated with spring systems such as Rattlesnake and Snively. We collected 13 species that were not taken by Newell et al. (2001). We believe that six or seven of these species represent new records for Washington but this needs to be verified by a search of the literature.

Order Lepidoptera – Moths

The collection and identification of moths can provide significant information to those contemplating land use and land disturbance as these insects often are closely tided to host plants (as larvae). And, as host plant availability changes throughout the season, so will the appearance and abundance of certain species. Not all species hold to this general concept, as some can be rather ubiquitous in their acceptance of host plants. This, however, is the exception rather than the rule. Thus, in order to take full advantage of their potential as indicator species, it is important to conduct monitoring throughout the complete season. Additionally, it can be important to study a fauna for several seasons due to the physical and climactic events that affect plant occurrence and abundance. The sand dune habitats on both the north and south sides of the River provided several distinctly sand dunes species that are not found anywhere else on the Site and are rare off of the Site due to habitat degradation (based on our collecting of dune habitats throughout the state). Examples are presented in the Conclusions Section of this report.

Moths and butterflies were a primary concern of previous Hanford studies; numerous new state records and new species were discovered. We hoped that slight habitat differences including aquatic vegetation associated with the irrigation runoff and numerous species of trees and shrubs not found in abundance in previous sampling sites would provide a number of species not previously associated with Hanford. Additionally, we hoped to repeat the finding of numerous rare or new species.

Because of the one year duration of this study, we decided not to concentrate on one or two sites as was done in previous studies. Instead, we trapped in approximately 15 different locations.

Still, we tried to concentrate on three primary habitat types: sand dunes, riparian zones (especially wooded riparian zones), and more typical shrub-steppe. The principal method of collecting moths was light traps; trapping was conducted on a weekly to biweekly schedule depending on weather and moon phase. Three to nine traps were used depending on the number of individuals collecting on that specific week. The more traps available on a given week, the more habitat types were sampled (e.g., sand dunes, shrub-steppe, riparian area). However, each habitat type was collected at least once ever two to three weeks depending on our judgment of how the fauna was changing.

Because of the extensive moth collecting conducted on ALE and central Hanford from 1994-2000, we did not expect to discover many species new to science or new state records during the 2002-2003 study. Still, two significant finds were discovered. One is a new species of *Arenoscythris* (Scythrididae) from the Wahluke sand dunes. It is very noteworthy as another, but different, new species of *Arenoscythris* previously was found on the central Hanford dunes. The second significant find was three specimens of the noctuid moth, *Protogygia comstocki*, were taken on the Wahluke sand dunes. These are the first specimens of this moth taken in Washington since the 1950's – this may represent one of the few remaining populations in Washington. Several of the new species of *Coleophora* (Coleophoridae) discovered in previous studies were again found during this project. Almost all of this material has been sent to Dr. Jean-Francois Landry of the Canadian National Collection in Ottawa, Ontario. We are hoping that he will begin to describe some of these species in the near future.

Numerous species not collected on ALE or central Hanford were collected, especially in wooded areas adjacent to irrigation runoff streams or ponds. For the most part these are common species that would be found in this type of riparian zone habitat throughout eastern Washington. This habitat, however, is rare on the Hanford Site.

Order Coleoptera – Beetles

The beetles were of significant concern in previous studies and the number of species collected and identified would attest to this (Soll et al 1999). During the current study, beetles primarily were taken through pit trapping. As in previous studies, we wanted to collect information that would add to our diversity, abundance, and phenological understanding of ground beetles (Carabidae) and darkling beetles (Tenebrionidae). The species richness of ground and darkling beetles was lower than that encountered during previous Hanford studies, but that was to be expected because of the significantly smaller number of habitats sampled and the single year of sampling during the current study. One darkling beetle not found in previous studies was discovered in pit traps located at the White Bluffs Ferry site, which is still awaiting identification. Additionally, a single specimen of the ground beetle, *Pseudaptinus tenuicollis*, was also discovered at the Ferry site location. The finding of this beetle represents a significant range extension from southern Idaho – nothing is known of its distribution or habitat preferences in Washington. Also, we consistently collected the rare beetle *Cononotus lanchesteri* (Zack and Looney 2001) at one of the pit trap sites. This beetle is known only from Hanford in Washington State but appears to be somewhat widely distributed on the Site.

Order Hymenoptera – Bees, Wasps, and Ants

Our main concentration in this order was ants and bees. We wanted to collect diversity as well as phenological data. As of this report, the ants have been submitted to Dr. David Smith of the United States National Collection of Insects in Washington, DC. We do not expect any significant findings from a rarity standpoint. The bees are still being processed and will be submitted to several collaborators in the very near future.

Significant Findings from 2002-2003

Table 2 presents the number of species captured and identified in each of the major taxonomic groups surveyed. It also presents an estimate of the number of species captured but remaining to be identified.

Table 2. Number of species level identifications (number of species identified followed by approximate number of species remaining to be identified – 2002-2003 study).

Phylum Arthropoda
- Class Malacostraca
  - Isopoda – sowbugs; 1 and 0 (Appendix 1)
- Class Arachnida
  - Araneae – spiders; 0 and 50-100
  - Scorpiones – Scorpions; 1 and 0 (Appendix 2)
  - Solifugae - sun spiders; 2 and 2 (Appendix 3)
- Classes Diplopoda (millipedes) and Chilopoda (centipedes); 4 and 3 (Appendix 4)
- Class Insecta
  - Coleoptera (beetles) 78; 50-75 (Appendix 5)
  - Dermaptera (earwigs) 1; 0 (Appendix 6)
  - Hemiptera (true bugs) 3; 10-20 (Appendix 7)
  - Hymenoptera (bees, wasps, and ants) 12; 30-40 (Appendix 8)
  - Lepidoptera (moths) 236; 50-75 (Appendix 9)
  - Orthoptera (crickets and grasshoppers) 2; 2-3 (Appendix 10)
  - Siphonaptera (fleas) 2; 0 (Appendix 11)
  - Trichoptera (caddisflies) 34; 0 (Appendix 12)

Total taxa 376; 197-318

The most significant aspect of this study was the addition of diversity data from the Wahluke and Saddle Mountain sections of the Hanford Reach National Monument habitats not previously sampled. Numerous species not previously known from Hanford (especially in the orders Trichoptera - caddisflies and Lepidoptera - moths) have been added to the list and can be found in the accompanying databases. The results presented in this report should be considered preliminary as numerous species are still awaiting identification; we believe it is in these specimens that the “unusual” and significant finds will be made.

One significant find is a second new species of *Arenoscythris* (Lepidoptera: Scythrididae) from the sand dunes located on the Wahluke refuge. This is significant as we previously discovered a new species on the sand dunes located on central Hanford. Although capable of flight, these moths fly only a few inches over the substrate. The finding of this second species may be an indication of the separation of these dunes systems for an extensive period of time. It is also a reason to conduct a more through search of the dunes for more species of interest.

We added one new order of insects (Trichoptera – caddisflies) that was not studied by us in the past but was studied for the Rattlesnake and Snively Springs areas by Newell et al. (2001). Thirty-four species of caddisflies were collected during 2002-2003 (see discussion of caddisflies); we are estimating that 6-7 of these will prove to be new state records for Washington.

Relationship to Previous Findings

The primary purpose of this study (2002-2003) was to add to the biological survey begun in the mid-1990s. As those studies occurred over a period of six years, we did not expect to add a significant number of species, new species, or new records for Washington State. We chose sites that would allow us to collect further phenological data on several major groups of beetles including ground and darkling beetles as well as sites that would aid our significant efforts to survey and document the moth fauna. We chose not to try to study a large number of groups, which would probably have provided us with further records of relatively common insects. Still, we have collected and processed approximately 12,000 specimens.

Because of the amount of baseline data that we now possess and because of the presence of authoritatively identified voucher material, we were able to make many identifications quickly and at Pullman. This is evident in the number of species found in our beetle and moth databases for 2002-2003. It is difficult to say whether the Wahluke and Saddle Mountain areas are more or less diverse than those of central Hanford and ALE because of the number of species remaining to be identified (especially in the non-noctuid moths) and the one-year duration of the current study as opposed to the over six years of data collection in the past. As in previous studies we found that general shrub-steppe habitat has a relatively distinctive fauna, which will depend on the amount of degradation within the habitat. In general, it appears that the shrub-steppe in the Wahluke and Saddle Mountain areas is more degraded than that of ALE. Several species that were rarely or unexpectedly encountered (e.g., snow scorpionflies (Mecoptera: Boreidae) and a winter scarab (*Aphodius* new species – Coleoptera: Scarabaeidae) were not found north of the river. Additionally, the species richness of ground dwelling beetles is less in the Wahluke and Saddle Mountain areas. Still, evaluation is tentative as it is based on only one-year of study and, in relation to previous studies, a much smaller number of sampling sites. The boreids are moss feeding insects that are certainly associated with areas of crytogamic crust. While there was some crust in the areas sampled through pit trapping, it was not extensive. Perhaps a more thorough search of the Wahluke and Saddle Mountain sites would provide habitat for the boreids.

The moth fauna of the Wahluke and Saddle Mountain regions also appears to be comparable to that found in previous studies. We have not collected or identified as many species, but that is

probably an artifact of less collection time and a lesser number of habitats surveyed. Additionally, our moth sampling was primarily conducted through light trapping and we did not sample day-active species – this group of species, however, is small. We have already identified over 200 species of moths and have another 50-75 awaiting identification. We did find a greater number of moths that are associated with trees and riparian areas as these habitats are more common on the north side. Several groups of moths such as pyralids, geometrids, and micromoths will be sent to cooperators willing to identify them in the very near future. These results will be made available to TNC when available to us.

In previous management recommendations (Soll 1999) it was stated that we should try to retain populations of milkweed on the North Slope. Milkweed is the primary food source for monarch butterfly larvae, the Northwest populations of which have been declining recently. Milkweed is very common along the irrigation canals and ponds on the Saddle Mountain Wildlife area. Even though we searched milkweed throughout the season, we never encountered the larvae of monarch butterfly. Although these areas appear to be perfect for larval development, it may be that they have not yet been "discovered" by adults – the number of monarchs may be a low point in long-term population cycles.

Several of the species new to science found during previous studies have been described. These species are delineated in Table 1. Several others are in the process of being described at this time.

Conclusions

Throughout the Hanford studies, insects have proven to be a source of biological wealth and information. Indeed, the diverse insect fauna was pointed out as one of the reasons that portions of the Hanford site were designated as a national monument in 2000 (Presidential Proclamation 7319 of June 9, 2000). Insects not only are important as organisms of basic study, but they also have current economic influence as pests and beneficials. Our studies continue to indicate that Hanford is unusual in its lack of pest but abundance of native species. A simple example would be the small number of agriculturally important species of moths collected through light trapping activities. Species such as corn earworm, alfalfa looper, celery looper, and the numerous cutworms that make up the bulk of trap samples outside of the Site, are collected at Hanford, but in small numbers. And, although this assertion is unsubstantiated by rigorous testing, we have done an extensive amount of moth trapping on both Hanford as well as in agricultural and urban situations. We believe that this certainly reflects the relatively non-degraded status of the Hanford Site.

Even though we have conducted significant and extensive biological diversity studies of the Site, we still know very little concerning the arthropod fauna. We continue to find species new to Washington State and new to science. We would expect these finds to continue and accelerate if longer term studies were conducted, especially as they centered on lesser studied taxa – our studies have really emphasized groups about which we know the most (e.g., moths, beetles). But, we also have tried to emphasize groups for which we could provide the most beneficial information over the shortest period of time. We have collected and processed large numbers of insects and arthropods in the little known groups (e.g., spiders) and we hope to identify and

evaluate these organisms in the future; these finds will add significantly to our understanding of the biological diversity of the Hanford Site and its distinctive nature.

The Hanford Site in general represents an area in which it appears as if we are seeing as close to a pre-European colonization fauna as would be found anywhere in eastern Washington. Although direct comparisons are difficult to make because of the lack of similar studies off of the Site, several examples can be delineated. Several groups of insects and other arthropods appear to be associated with extensive areas of cryptogamic crust. Although they were not collected for analysis, the mite and Collembola (springtail) fauna represented significant portions of pit fall samples where the crust was intact and were virtually non-existent in samples where the crust had been destroyed. While not sampled during the 2002-2003 study, snow scorpionflies (*Boreus*: Mecoptera: Boreidae) show the same contrast between areas with an intact crust and those without. The larvae of these small insects feed on moss and are not found in areas where the crust has been destroyed. During our 1994-2000 sampling, we collected four species of *Boreus* on ALE – one of which is a species new to science. And although antidotal, when the material was identified, we were told by our collaborator Dr. Norman Penny (the world authority on the group) that this was the only site known to him from which four species had been recorded!

A similar finding to that of the snow scorpionflies exists for bees. When one collects off of the Site, one of the most commonly encountered species of bee is the honeybee, a domesticated introduced species. Honeybees were collected very rarely on the Site during both the 1994-2000 and 2002-2003 studies while numerous species of wild bees were common. We believe that this is a reflection of the increased amount of native vegetation on the Site and its distance from urban or agricultural areas where honeybees are most common. (See Soll et al. 1999 for a discussion of wild bees – the bees from the 2002-2003 study have not yet been identified).

Perhaps one of the treasures of the Hanford Site is the extensive, virtually undisturbed sand dune habitat found within the Hanford Reach National Monument. We spent considerable time and effort surveying the moth fauna of the dunes on central Hanford (1994-2000) and in the Wahluke Wildlife area (2002-2003). At least four species new to science have been discovered on the dunes (*Arenoscythris* spp. 1 & 2 (Scythrididae) and *Copablephron* spp. 1 & 2 (Noctuidae)) as well as *Protogygia comstocki* (Noctuidae) which has not been found in Washington since the 1950s. These findings are significant when one considers that other sand dune habitats in central Washington (e.g., those at Vantage and Washtucna) have been extensively surveyed for noctuid moths. We believe that several other families of moths will provide the same types of "finds" once they are more extensively sampled off of the Site.

Further Inventory Needs

Recommendations for further work in the Wahluke and Saddle Mountain areas would include:

?Continued survey work for moths. Because of our expertise and a perceived need, we have concentrated on moths throughout our Hanford studies. Survey work in riparian zones and "forested" areas is needed, as is further work on the sand dunes. The sand dunes have an extensive and distinct fauna, especially of moths, and should probably be the subject of weekly

to biweekly collecting for at least one season if not several. A number of species new to science (e.g., *Copablepharon* spp. 1 & 2 and *Arenoscythris* spp. 1 & 2) as well as several rarely collected species (e.g., *Protogygia comstocki*) have already been taken.

?A series of pitfall traps was established near the White Bluffs Ferry landing. This is a disturbed area with some introduced vegetation but also is more naturally riparian being along the Columbia River. Perhaps because of this it has a distinct fauna not found in general shrub-steppe. We believe that more of these areas need to be surveyed. Access to less modified sites (especially those along the River) is limited and difficult being accessible only through boat, but some of these should be explored.

?We did not survey through pit trapping or other means in riparian areas along the extensive irrigation runoff system found through the Wahluke and Saddle Mountain areas. There is probably a distinct fauna associated with this area that should be examined.

?We did not survey the irrigation systems themselves. The canals, ponds, and lakes will have a distinctive aquatic fauna that has been little sampled at Hanford – because there is so little of it. On ALE and central Hanford, the aquatic environments and their surrounding riparian areas were found to have a very distinctive fauna.

?Areas of the Hanford Reach National Monument should be considered for long-term entomological (arthropod) diversity studies. The collection and preparation of insects is a very time intensive activity; the tremendous number of species within any large system, their varied habits, and methods of collection make it impossible to obtain a true indication of the breath of species diversity unless a multiyear study is conducted. This was certainly evident during insect studies of ALE and central Hanford (Soll et al. 1999).

Management Recommendations

?Consistent with findings on central Hanford, the sand dunes host a distinct fauna of moths that are nowhere else on the Site. These dunes should be maintained in as natural a state as possible.

?The Monument maintains an active program of herbicide usage in order to control invasive, noxious weeds. One of the areas that we surveyed that was relatively disturbed and would probably be an area of herbicide use, was the collecting site near the White Bluffs Ferry. And, while the Ferry site does appear to have a relatively distinct ground beetle fauna, most of this fauna is common to disturbed areas throughout the Site and should not be considered at risk.

Literature Cited

Emery, Richard M. and M C. McShane. 1978. Comparative ecology of nuclear waste ponds and streams on the Hanford site. PNL-2499. Pacific Northwest Laboratory, Richland, Washington.

Energy Research and Development Administration (ERDA). 1975. Final Environmental Statement, Waste Management Operations. ERDA-1538, Vol. 2, Energy Research Development Administration, Richland, Washington.

Grissell, E. E. and R. S. Zack. 1996. Torymidae (Hymenoptera) new to Washington State. Proceedings of the Entomological Society of Washington 98: 827-828.

http://www.landtrustalliance.bc.ca/registry. The Land Trust Alliance of British Columbia. ©2002.

Newell, R. L., D. Ruiter, and D. Strenge. 2001. Adult caddisfly (Trichoptera) phenology in two cold-desert endorheic spring-streams in Washington State. Pan-Pacific Entomologist 77: 190-195.

O'Brien, C. W. and R. S. Zack. 1997. Weevils new to the state of Washington (Coleoptera: Curculionidae). Pan-Pacific Entomologist 73: 58-59.

Rickard, W. H. 1970. The distribution of ground-dwelling beetles in relation to vegetation, season, and topography of Rattlesnake Hills, southeastern Washington. Northwest Science 44: 107-113.

Rickard, W. H., J. H. Cline, and R. O. Gilbert. 1974. Pitfall trapping and direct counts of darkling beetles in cheatgrass communities. Northwest Science 48: 96-101.

Rickard, W. H. and L. E. Haverfield. 1965. A pitfall trapping survey of darkling beetles in desert steppe vegetation. Ecology 46: 873-877.

Rogers, L. E. 1979. Shrub-inhabiting insects of the 200 area plateau, southcentral Washington. PNL-2713. Battelle-Pacific Northwest Laboratory, Richland, Washington.

Rogers, L. E., N. Woodley, J. K. Sheldon, and V. A. Uresk. 1978. Darkling beetle populations (Tenebrionidae) at the Hanford Site in southcentral Washington. PNL-2465. Battelle-Pacific Northwest Laboratory, Richland, Washington.

Sheldon, J. K. and L. E. Rogers. 1978. Grasshopper food habits within a shrub-steppe community. Oecologia 32: 85-92.

Soll, J., J. A. Hall, R. Pabst, and C. Sooper, eds. 1999. Biodiversity inventory and analysis of the Hanford Site – Final report 1994-1999. The Nature Conservancy of Washington.

Zack, R. S. 1998. Shore flies (Diptera: Ephydridae) of the Hanford Site, Washington. Northwest Science 72: 127-141.

Zack, R. S. and C. N. Looney. 2001. A new record of *Cononotus lanchesteri* Van Dyke (Coleoptera: Pyrochroidae: Agnathinae) in Washington State with notes on habitat. Coleopterists Bulletin 55: 67-69.

Zack, R. S. and C. N. Looney. In preparation. Notes on *Paruroctonus boreus* (Girard) (Scorpionida, Vejovidae) in central Washington.

Zack, R. S., C. N. Looney, M. E. Hitchcox, and J. P. Strange. 2001. First occurrence of Leptopodidae in Washington State (Hemiptera: Heteroptera) with notes on habitat. Pan-Pacific Entomologist 77: 47-50.

Zack, R. S., N. D. Penny, J. B. Johnson, and D. L. Strenge. 1998. Raphidioptera and Neuroptera from the Hanford Site of southcentral Washington State. Pan-Pacific Entomologist 74: 203-209.

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