Sponsoring scientists Busby and Jacobson will provide Leopold with the mentorship and nurturing environments in which to pursue independent research, develop professional skills, and prepare for a future independent research career. Busby and Jacobson have expertise in the specific research areas that Leopold seeks to develop in the proposed research: leaf microbiome ecology and plant genomics, respectively. Combined with Leopold’s existing expertise and training in microbial community ecology, this project will propel Leopold’s independent research career linking the fields of plant genomics and microbial community ecology.

**Sponsors’ research**

Busby is an Assistant Professor in the Botany and Plant Pathology Department at Oregon State University (OSU). Research in her labfocuses on plant-fungal interactions, ecology and evolution of the leaf microbiome, and plant disease. Current research seeks to determine the factors structuring communities of non-pathogenic fungi that live in plants, endophytes, and to test how endophytes influence plant disease severity. This involves working in a variety of wild and crop plant pathosystems, including *Populus trichocarpa*. Research on *P. trichocarpa* is an ongoing focus in the lab and has involved productive collaborations with the Biosciences Division at Oak Ridge National Laboratory (ORNL) for several years. The Busby lab is supported by the NSF (1714276 and pending), DOE (219086), Agricultural Research Foundation (8689A), and Joint Genomes Institute (1665). There is no overlap between the objectives of these projects and those proposed by Leopold.

Jacobson is a Computational Systems Biologist in the Biosciences Division at the Oak Ridge National Laboratory. Research in the Jacobson labfocuses on developing and applying mathematical, statistical and computational methods to complex biological datasets.  In particular, the lab has been developing novel methods for Genome-Wide Association Studies (GWAS) of complex microbial communities. The Jacobson lab is supported by the Center for Bioenergy Innovation (DOE) and the Plant Microbe Interface SFA (DOE). There is no overlap between the objectives of these projects and those proposed by Leopold.

**Fellow’s connection to sponsors’ research**

Leopold’s proposed research directly addresses the primary objectives of the National Plant Genome Initiative, i.e., enhancing the application of genomics for agriculture, and creating open-access tools to enhance knowledge sharing. Specifically, his research seeks to develop and openly share analytical approaches for identifying plant genes that impact microbial community assembly in a globally important crop plant (*Populus*). This research will help to elucidate the genetic basis of plant-associated microbial communities, and will inform plant breeding for beneficial microbiomes in agriculture.

A primary research goal in the Busby lab is to determine the genetic basis of plant disease modification by fungal leaf endophytes. While greenhouse and common garden studies have shown that endophyte community composition, and disease modification by endophytes, can vary among tree genotypes, research in the Busby lab has not identified specific plant genes influencing the assembly of leaf microbial communities, nor tested the sensitivity of these genetically-based interactions to variation in the environment, microbial species pool, or ecological priority effects. Dr. Leopold’s research is therefore complementary (and does not overlap) with ongoing efforts in the Busby lab. Dr. Leopold will bring expertise to the Busby lab in two new areas – theoretical microbial community ecology and plant genomics. Other postdocs, graduate students and undergraduates in the lab will benefit from this influx of new ideas, and opportunities to collaborate with Dr. Leopold on side-projects stemming from his proposed experiments.

One of the primary goals in the Jacobson lab is to determine the host genes responsible for the presence or absence of all taxa in its phytobiome. These associations between genes and taxa form a rich systems biology model of the innate immune system of a plant. To date, the Jacobson lab has been using metatranscriptomics collected from one location to achieve these goals. The addition of Leopold’s OTU data from multiple environments to determine GxE effects followed up by greenhouse experimentation will thus be complementary (and does not overlap) with ongoing efforts in the Jacobson lab. Leopold’s project will additionally create opportunities for collaboration with postdocs, graduate students and undergraduates in the Jacobson lab.

**Mentoring plan**

Primary sponsor Busby and Leopold have created a mentorship plan that addresses Leopold’s needs in research, teaching, and career development skills. This plan is based on an evaluation of Leopold’s strengths and weaknesses in disciplinary knowledge, teaching, mentorship, communication, and grant writing. Throughout the fellowship period Busby and Leopold will meet on a regular basis to discuss progress toward mutually agreed upon goals for research, publication, presentations, proposals, and teaching that reflect specific needs.

Busby will provide training in the essential tools and techniques required for working with leaf microbes (Leopold’s previous research is with mycorrhizal fungi) as well intellectual guidance and support. In weekly meetings Busby and Leopold will discuss experiments, results, interpretations, current literature, manuscript preparation and obstacles. Busby will provide guidance to Leopold as he mentors undergraduate and graduate student projects in the lab that are directly related to the proposed project. These projects will allow Leopold to extend the reach and impact of his research while also gaining valuable experience in mentoring students. Finally, as Leopold prepares to transition to an academic position, Busby will provide guidance and perspective based on her recent experience navigating the academic job market.

Leopold’s collaboration with co-sponsor Jacobson will help him to acquire novel skills and training in plant genomics. Leopold will work with Jacobson to associate phenotypic data on microbial communities with the extensive genomic data previously collected by ORNL. Leopold will make a one-week visit to Jacobson at ORNL in each of the three years of his fellowship. On his visits he will learn more about the computational pipelines involved and collaborate on the analysis and interpretation of GWAS-based systems biology models. These visits will also provide Leopold with opportunities to get involved in other ORNL-based projects focused on the poplar phytobiome.

**Resource available to the Fellow**

*Research*: At OSU, Leopold will be provided with an environment that is collaborative, interdisciplinary, and technically adequate to complete the proposed research. In particular, Leopold will have access to laboratory, computer and library services as well as the necessary common garden, greenhouse and laboratory space to perform the proposed research. Additionally, Busby has start up funds that can be used to support Leopold’s proposed research. At ORNL, Leopold will have access to results run on one of the world’s most advanced supercomputers for use in data analysis. This level of computing power is necessary given the scale of his project (thousands of plants and associated phenotypes, millions of variable genomic regions).

*Professional development*: Busby will provide Leopold with opportunities to present his research at national and international scientific conferences. Though Busby’s involvement (coPI) in NSF IOS 1714276 RCN: AgMicrobiomes: An Interdisciplinary Research Network to Advance Microbiome Science in Agriculture, Leopold will interact with international leaders in agricultural microbiome research. He will meet new collaborators and colleagues at RCN meetings; these networking opportunities will be essential as he begins to navigate the job market. Additionally, Leopold will lead an RCN workshop on methodological advances in the use of multivariate microbial community data for GWAS.

*Teaching and mentorship*: At OSU, Busby and Leopold will develop a module on microbial community ecology for Busby’s course, Biology 371: Ecological Methods (22 students). Leopold will additionally give a guest lecture on innovations in plant breeding for sustainable agriculture in Biology 301: Human Impacts on Ecosystems (130 students). As described above, Leopold will mentor undergraduate and graduate students in side-projects related to the proposed research. Finally, Leopold will be encouraged to improve upon additional profession development skills (e.g., negotiation, time management) in workshops hosted by the Oregon State University Postdoctoral Association.

**Limitations on Fellow**

No limitations will be placed on Leopold’s research following the fellowship. To the contrary, Leopold can take cultivars, culture collections, microbial community datasets, SNP data, and collaborative partnerships forged during his postdoc to a future faculty position.