USE OF GIS IN DETERMINING DEVELOPMENT EFFECTS ON WILDLIFE IN OAK WOOLANDS

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Over half of California's 673 species of terrestrial vertebrates (amphibians, reptiles, birds, and mammals) spend at least part of their annual cycle in oak woodland — more than in any other major habitat type in the state (Ohmann and Mayer 1987). Yet, little information is available on how species of oak woodland wildlife responds to residential development, the leading cause of loss of oak woodlands. Home building and other types of development converted about 41,000 ha during the period from 1969 to 1982 and, as of 1985, 110,000 ha were in the process of conversion (Bolsinger 1988).

To assist assessment of the impacts of development in oak woodlands, we are developing a software product using GIS technology. We've named the software "DEWOW," an acronym for Development Effects on Wildlife in Oak Woodlands. This paper describes our prototype and the basis of its development.

DEWOW PREMISE, STUDY AREA, AND DEVELOPMENT LEVELS

Premise

DEWOW was developed and operates under the premise that development impacts habitat components — food, cover, and water — needed by wildlife. Wildlife may respond spatially and numerically to these habitat changes (Fig. 1.). The response depends on the particular habitat requirements of the wildlife species and the level of the development. A wildlife species is usually most vulnerable when a large amount of the animal's home range is affected. Some species are capable of adjusting their home range, but usually this option is limited by occupancy and the habitat quality of surrounding areas.

Study Area

To develop DEWOW, we used the Hardwood Maps (Pillsbury et al. 1991 to select the oak woodland in Calaveras and Amador Counties, California. This area was selected because it is of workable size, has GIS information available, and development pressure is a concern due to its possible impacts on oak woodland habitats and associated wildlife.

Levels of Residential Development

Three density levels of development were used in DEWOW: high, medium, and low. These levels are given in the county General Plans for Calaveras and Amador County and are typical of those given in other county General Plans.

High Density. — Parcel size is 2 ha or less. The number of dwellings ranges from one to many units. DEWOW assumes that at this level of development, the oak woodland habitat has been altered greatly from removal of most native vegetation, land grading, construction of buildings and roads, landscaping, and introduction of exotic vegetation and domestic pets. Alterations are assumed over the entire parcel. This level of development could be characterized as a residential subdivision.

Medium Density. — Parcel size is 2-16 ha. Typically, one to several buildings are constructed and land alterations occur over a small portion of the parcel compared to a subdivision (high density level). Most environmental alterations are adjacent to residences.

Low Density. — Parcel size is greater than 16 ha. Residential development is limited typically to one or two residences and a few agricultural buildings. DEWOW presumes little habitat alteration.

METHODS

The WHR lists a total of 273 terrestrial vertebrate wildlife species for oak woodland of Calaveras and Amador Counties (California Wildlife Habitat Relationships [WHR] Microcomputer Database) (Timossi and Barrett 1992). Ten species were selected from these for DEWOW based on availability of information, taxon, sensitivity to development, and the importance of oak woodland habitat to the

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species. Under the premise that habitat alteration due to development affects wildlife numerically and spatially, for each of the 10 species, we determined the following:

- Factors of development which will have an impact on the species
- Habitat requirements of the species and habitat and interspecies relationships
- Location where development well affect the species' habitats
- Degree of the changes to the selected species

Sources of Information

Wildlife Habitat Relationships. — We used the Wildlife habitat Relationships (WHR) System (Airola 1988) to identify wildlife species' preferences for oak woodlands and critical habitat elements for the 10 wildlife species in the DEWOW System. The California Natural Diversity Data Base (NDDB) (Anon. 1994a) and CAL VEG (Parker and Matyas 1979) were also consulted, but these were not used for the GIS.

Workshop. — A one-day workshop was held where 11 wildlife biologists gave presentations on their areas of expertise in habitat fragmentation and degradation. They also provided input on DEWOW's approach and a hypothetical study of the preparation of a report to a county Board of Supervisors on the effects on wildlife of carrying out the county's 20-year plan.

Wildlife Experts. — Once background information on home range, food, cover, and water needs was obtained for each of the 10 wildlife species, Wildlife Expert Surveys were conducted to document species' sensitivities to habitat disturbance. Surveys consisted of 20-min. telephone conversations with 63 wildlife experts in the Western U.S. and 5 one-on-one meetings at universities and state natural resources agencies in California.

Literature. — Expert sources were supplemented with literature from journals, proceedings of wildlife conferences, ecological references, and landscape ecology publications. Additionally, citations from unpublished theses, in-house reports from resource agencies, and several special interest groups, foundations, institutions, and societies were consulted.

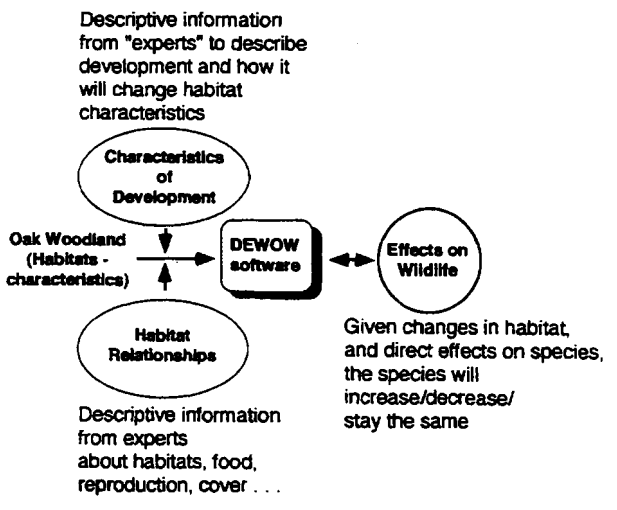

Fig. 1. DEWOW takes information from wildlife experts and the literature, processes it, and displays the results.

Oak Habitat Classifications

Cover types for DEWOW were derived from those of WHR (Mayer and Laudenslayer 1988) and the Western Sierra Nevada (WSN) (Verner and Boss 1980). In cases where these classifications did not coincide with the Hardwood Maps (Pillsbury et al. 1991), they were placed, subjectively, under the appropriate Pillsbury et al. (1991) Maps classification:

- Blue Oak (*Quercus douglasii*) Woodland
- Blue Oak-Grey Pine (*Pinus sabiniana*) Woodland
- Valley Oak (*Q. lobata*) Woodland
- Montane Hardwood
- Interior Live Oak (*Q. wislizenii*)/Canyon Live Oak (*Q. chrysolepis*) Woodlands

Cover density classifications for DEWOW were derived using WHR and WSN in a manner similar to cover type and placed within the appropriate Pillsbury et al. (1991) cover density category:

- Scattered (< 10% Canopy Closure)
- Low (10-33% Canopy Closure)
- Medium (34-75% Canopy Closure)
- High (≥ 76% Canopy Closure)

Habitat Preferences

For each of the wildlife species used in DEWOW, habitat suitability was identified as "preferred" or "secondary." These classifications were derived subjectively using the habitat suitability ratings given in WHR and WSN. Suitability classifications given in WHR are "high," "medium," and "low" for three functions: cover, feeding, and reproduction. WSN classifications rank habitat suitability "optimal," "suitable," and "marginal." The WHR "high" and WSN "optional" rankings were usually placed under "preferred" in DEWOW, and the WHR "medium" and "low" rankings, and WSN "suitable" and "marginal" rankings, were placed under the DEWOW "secondary" habitat.

Rule Development

Habitat classifications and preference information were used to develop expert rules for DEWOW. Rules were often constrained by information in the GIS data base and by the availability of information to describe development and wildlife interactions in oak woodlands. For example, habitat elements and features such as understory, vernal pools, habitat corridors, acorn woodpecker (*Melanerpes formicivorus*) granary trees, rock outcrops, litter, downed woody material, and snags are not currently in GIS format.

RESULTS

DEWOW Structure

DEWOW uses the Arc Macro Language (AML) tools within ARC/INFO (Anon. 1995) to construct the user interface and do the data analysis. The structure uses the ARC/INFO data set COVERAGE, which contains all habitat characteristics of animals found in oak woodlands. The DEWOW software, through a Graphical User Interface (GUI), allows an analyst to enter the habitat characteristics of a species and the relationship of development to the species. DEWOW determines the location of the habitat from the data set COVERAGE and how development will affect the habitat.

DEWOW Session

The results of a DEWOW session produce both area statistics of the changes to the habitat of the species and a map on the computer screen of the spatial distribution of the changes. Fig. 2 illustrates the process DEWOW uses to process the criteria and produce the results. Figure 3 displays a portion of a California central coast watershed species map produced by DEWOW.

DISCUSSION AND CONCLUSIONS

What DEWOW Can Do

The DEWOW prototype defines suitable oak woodlands habitat based on the criteria selections made by the user. These criteria can be changed as new information becomes available. DEWOW takes the data layers and the criteria from the wildlife experts and predicts where potential habitat could be. It then makes a determination of where development will affect wildlife and predicts what will happen to the wildlife species (increase, decrease, or stay the same) if development occurs within that habitat. DEWOW could be used by land-use planning and wildlife management agencies as a first attempt to predict wildlife responses to development. Criteria used in the model include:

- ••Oak species
- ••Percent slope
- ••Aspect
- ••Elevation
- ••Cover density, stream, road, and development buffers

DEWOW results should be supplemented with other data and information because many factors which impact wildlife, such as adjacencies of human impacts on the environment, habitat juxtapositions, and habitat elements are not included in this version of the model.

Further Information and Data Needs

Wildlife Data. — Field research leading to predictive data on responses of wildlife to residential development in oak woodlands is limited. Only recently have the responses of deer (Smith et al. 1989) and of birds (Scott 1993) to housing development in oak woodland been reported. To

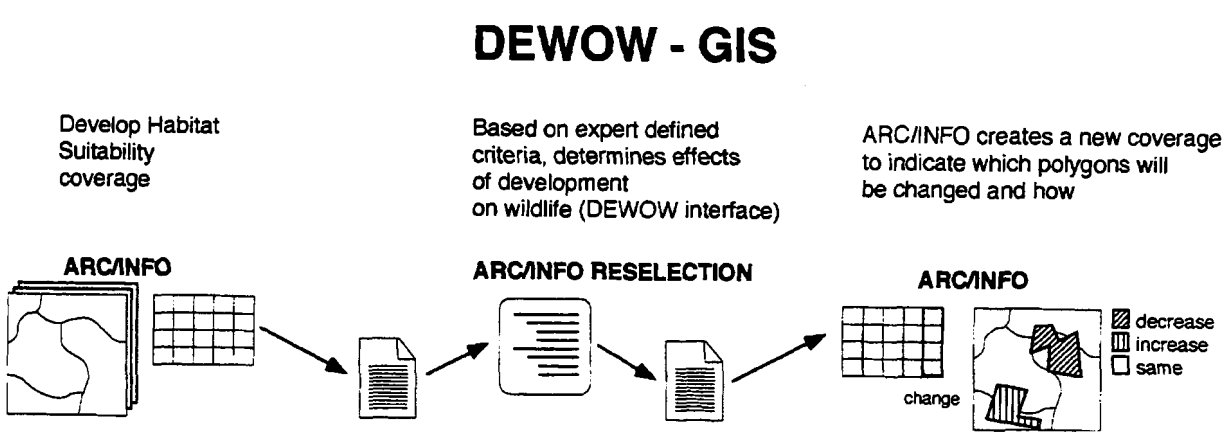

Fig. 2. Structure of the DEWOW software.

date, no information is available on other groups of terrestrial vertebrates nor on any invertebrate taxa. Therefore, predictions are necessarily limited of what will happen to the particular wildlife in a given area when a specific type of development occurs.

Understory Information. — Many species of birds, small mammals, lizards. and snakes depend on the understory in oak woodlands for food, cover, and reproduction. Suitable habitat models for rodents, lizards, snakes, salamanders, and ground-nesting birds require information based on understory. However, the data are not in GIS format for most areas.

Vegetation Mapping Precision. — The Pillsbury et al. (1991) hardwood mapping data layer used by the DEWOW System used aerial photography and a minimum mapping unit of 16 ha. Any smaller oak woodland stands therefore are not mapped. The California Department of Forestry and Fire Protection (CDF) recently has updated the Hardwood Maps (Anon. 1994b) using LANDSAT Imagery and a minimum mapping unit of 2 ha. Use of this data will increase the accuracy and use of GIS modeling tools like DEWOW.

Specifications of Development Characteristics. — Clear descriptions of the categories of residential developments will be helpful for land-use planners, environmental coordinators, wildlife managers, and biological consultants in predicting changes to the landscape. In most county General Plans, residential development is categorized as "rural residential," "suburban," and other broad categories. The General Plans provide only maximum housing density. To spatially model how development affects wildlife, maps of existing and proposed development need to be generated with sufficient level of detail and descriptions of the development categories in terms of the actual number of houses, anticipated alterations of vegetation and wildlife responses, percent area paved, and other physical and biological changes to the landscape.

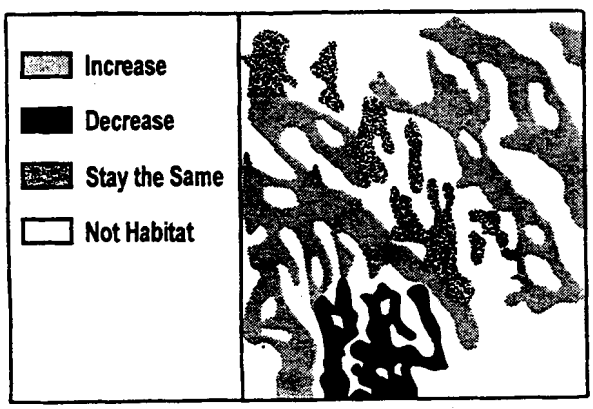

Fig. 3. A portion of a watershed located in coastal central California showing oak woodland habitat where a wildlife species is predicted by DEWOW to increase, decrease, or stay the same.

The Future

This paper is a report on work in progress. Recently, DEWOW incorporated the ARC/INFO GRID format. This gives the DEWOW System more flexibility and speed which makes the large data base more manageable. Use of GRID also facilitates adjacency modeling. The authors welcome information and ideas from readers on ways to make DEWOW and other such models better predictors of the response of wildlife to development in California's oak woodlands.

ACKNOWLEDGMENTS

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